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Business cycle synchronization: A regional perspective

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Abstract: Turmoil in euro area once more forces EU authorities to rethink future of further monetary integration. One of the most commonly used criterions for successful monetary in contemporary research is business cycle synchronization (BCS). Though BCS has been vastly described at country level, not as much attention has been put on the degree of BSC at regional level. Topic is important for 2 main reasons. The first is that determining degree of BCS at regional level can help in assessment of monetary policy effectiveness at country level, as well as giving point of reference for evaluation of perspective costs of participation in monetary union. The second is that there is theoretical dispute within the optimum currency areas literature between 'European Commission' and "Krugman" view that can be resolve a great deal trough regional analysis. In order to assess BCS in EU Hodrick-Prescott, as well as Christiano and Fitzgerald filter to time series of real GDP for 24 countries, 82 NUTS 1, 242 NUTS 2 and 1264 NUTS 3 regions over the period of 1998-2010. Data was later used to create bilateral measures of BSC, which gave 276 observations on country level, 3321 on NUTS 1, 29161 on NUTS 2 and 798216 on NUTS 3 level. Results of the analysis support "European Commission" view and show very high degree of BSC within EU countries. Country level analysis also reveals that within the EU there exist group of countries that could form effectively working monetary union based on BCS criterion.

Introduction

Turmoil in euro area once more forces EU authorities to rethink future of further monetary integration. One of the most commonly used criterions for successful monetary integration in contemporary research is business cycle synchronization (BCS). This paper tries to assess the degree of business cycle synchronization at regional NUTS 1, 2 and 3 level and for country pairs. This analysis allows to assess the extent to which each of the national central banks, as well as European Central Bank can conduct monetary policy effectively. The higher is the business cycle synchronization between two countries/regions the better it the ability of central bank to conduct common monetary policy for these two countries/regions.

This article proposes measure of business cycle synchronization base on correlation coefficient of deviations of cyclical component of real GDP from trend. Than measure is used to check what groups of countries can introduce common currency at relatively low cost. Same measures are used to check monetary policy effectiveness within countries.

Section 1 presents literature review, which is mostly concentrated around theory of optimum currency areas and business cycle synchronization at country and regional level. Section 2 presents data source and methodology used to construct the business cycle synchronization measure. Section 3 presents results and section 4 concludes.

1. Literature Review

The prospect of monetary unification in economics is usually considered in context of theory of optimum currency areas (OCA) based on seminal works of Mundell (1961), McKinnon (1963) and Kenen (1969). Nowadays 'New' theory of optimum currency areas (Tavlas, 1993) also considers more dynamic approach closely related to works of Krugman (1993) as well as Frankel and Rose (1998) and their *'The Endogeneity of the Optimum Currency Area Criteria'* hypothesis as well as Mundell (1973a, 1973b). Both international (Grubel, 1970; Mongelii, 2002 and 2008; Tavlas, 2008) and Polish (Nowak, Ryć, Żyżyński, 1999; Łon, 2007; Lis, 2008; Żyżyński 2009 and 2011; Osiatyński, 2011) economists have discussed potential benefits and costs of introducing common currency on the theoretical level. More complex measure of countries readiness to form a monetary union has been proposed by Bayoumi and Eichengreen (1997), who introduced unified index based on nominal exchange rate volatility, trade intensity, trade similarity (intra-industry trade intensity) and differences in real GDP growth rate.

Empirical research in this area is very complicated due to problems with measurement of potential costs and benefits. For this reason researchers focus their attention on testing conclusions from OCA theory using two main approaches. In both cases authors try to find similarities in either economic shocks or business cycle – if there are strong monetary policy and externally flexible exchange rate are becoming very effective tool of common central bank.

The first one uses Structural Vector Auto Regression models (Blanchard, Quah, 1989; Taylor, 2004) for identification of economic shocks and was firstly utilized for OCA purposes by Bayoumi, Eichengreen, (1993). They examined demand shocks among European countries and US census regions, and found out that regions in US are characterized by higher degree of cohesion. Using similar approach Dumitru and Dumitru (2011) found significant role of idiosyncratic demand shocks among European countries, even some of the core countries. Beck and Janus using SVAR approach find low correlation of economic shocks among Euro Area countries (2013) and find high degree of synchronization of shocks for V4 countries (2014).

The second approach is concentrated on business cycle synchronization (BCS), and the literature on BCS has put high interest on parts of determinants. Using multi-equation approach Imbs (2004) find evidence for trade, inter-industry trade, structural similarity and financial integration are positively influencing BCS using data on Developed countries and states in USA. He also finds evidence for Endogeneity: direct and indirect of trade and financial linkages on business cycles synchronization. Results have been later reproduced on sample of European countries by Siedschlag (2010), as well as Dées and Zorell (2011). Kalemli-Ozcan, Papaioannou and Peydro (2009), in contrast with Imbs, find that financial integration influence business cycles synchronization negatively using single equation approach. They argue that cross-section analysis suggests positive impact of financial integration on business cycles synchronization, but panel approach reveals opposite effect. Beck (2013) using multi-equation approach intermediate effects of GDP per capita distance trough structural similarity on business cycle synchronization and Chang, Kim, Tomljanovich and Ying (2013) impact of similarities in ruling parties.

Complex analysis with sensitivity checks (Leamer and Leonard, 1981; Leamer 1983, 1985; Levine and Renelt, 1992; Sala-I-Martin, 1997a, 1997b) has been performed for BSC by Baxter and Kouparitsas (2004). They employ extreme bounds analysis to several potential determinants of business cycles synchronization, but beside the gravity variables they found only trade significant. In more recent approach Böwer and Guillemineau (2006) using the same methodology but focusing their attention on the Euro Area, found only trade, economic specialization at industry level, fiscal deficits, price competitiveness and stock market differentials to be significant business cycles synchronization determinants. In yet another attempt to use extreme bound analysis Sachs and Schleer (2013) obtained significant results for institutional similarities and directions of structural reforms, but find trade, structural similarities and fiscal and monetary policy similarities insignificant in many of their specifications. Beck (2013) using Sala-I-Martin version of extreme bound analysis found robust impact of structural similarities and GDP *per capita* distance on BSC.

Gogas (2011) using one equation approach find positive effects of introducing common currency on BSC using sample of twelve European countries. On the other hand, Bordo and Helbling (2010) argue that increasing business cycles synchronization is a worldwide phenomenon. Lehwald (2012) using Bayesian dynamic factor model, argues that great part of increased business cycles synchronization among Euro Area countries comes from worldwide tendencies rather than ongoing integration.

All research mentioned above was taking into consideration only countries as a unit of measurement. As noticed by Alesina and Barro (2002), number of countries in the world is changing, but does not necessarily mean that the number of OCAs is changing with them. So country perspective instantly eliminates the possibility of OCAs being within countries or amongst parts of countries. In order to assess that lower level of aggregation is required – regional perspective. For these reasons this paper tries to concentrate on regional business cycles synchronization which did not have as much attention in the literature.

Artis, Dreger and Kholodilin (2009) find no evidence on convergence of regional business cycles for European regions and for USA, and claim that BSC have been stable over 1982-2007. Correia, and Gouveia (2013) examined business cycle synchronization in Portuguese regions between 1988-2010 and concluded that it has decreased over the period. Anagnostou, Panteladis and Tsiapa (2012) in comprehensive research find for 14 European countries differences in regional BSC that could be explain by trade and differences in the level of development. Marino (2013) on the sample from 12 European countries found that changes in regional business cycle synchronization could be explained by distance and differences in economic structure.

2. Data and measurement

In investigation only European countries with data available on regional level were taken into considerations. List of all the countries and number of different NUTS 1,2,3 regions along with the number of possible pairs is available in table 1.

For countries quarterly data about nominal GDP and price level (2005=100) from the first quarter of 1998 to the first quarter of 2014 obtained from Eurostat was used. Data was seasonally adjusted with X-13 ARIMA. For regions (NUTS 1,2,3) annual data about nominal gross value added (GVA) and price level was collected. Due to lack of data about the prices at regional level data for national price level has been used as a deflator. This is a common practice in regional research,

Table 1. Data description

Name	Country	NUTS 1	NUTS 2	NUTS 3
Belgium	1	3	10	42
Bulgaria	1	2	6	28
Germany	1	16	31	427
Greece	1	4	12	50
Spain	1	7	17	51
France	1	8	20	96
Italy	1	5	21	104
Hungary	1	3	6	20
Holland	1	4	12	38
Austria	1	3	9	34
Poland	1	6	16	66
Romania	1	4	8	42
Finland	1	2	4	19
Sweden	1	3	8	20
UK	1	12	36	130
Czech	1	-	8	11
Denmark	1	-	5	10
Ireland	1	-	2	8
Portugal	1	-	5	27
Slovenia	1	-	2	12
Slovakia	1	-	4	7
Estonia	1	-	-	5
Latvia	1	-	-	6
Lithuania	1	-	-	10
Sum (countries/regions)	**24**	**82**	**242**	**1263**
Maximum number of pairs	**276**	**3321**	**29161**	**796953**
Data Frequency	**quarterly**	**annual**	**annual**	**annual**
nominal GDP/GVA Source	**Eurostat**	**Cambridge Econometrics**		
P (national level) source	**Eurostat**	**Penn World Table**		
Period for filtration	**1998q1-2014q1**	**1991-2010**		
Period for correlation	**1998q1-2010q4**	**1998-2010**		

Source: own arrangement

(example: Sachs, Sala-I-Martin, 1991). GVA data comes from Cambridge Econometrics and for the price level from Penn World Table 8.0, both cover 1991-2010 period. For comparisons between countries and regions data for 1998-2010 has been used. Longer periods have been used in order to get better results from Hodrick-Prescott filter. For the same reason quarterly data was used for GDP and prices and national level.

To justify usage of detrending methods tests for the presence of unit root has been used. Since Nelson and Plosser (1982) there has been substantial disagreement over the nature of the GDP trend (Rudebusch, 1993) – whether it is deterministic or stochastic. Due to that fact ADF (Said, Dickey, 1984) test was performed with two variations of the following equation[1]:

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{i-p} + \varepsilon_t \tag{1}$$

where ΔY_t denotes change in real GDP, α is a constant term (drift), βt is a deterministic trend, δ is coefficient on lagged real GDP and γ_i is coefficient on ith lag of change in real GDP and ε_t is a residual term. Number of lags has been chosen with Schwarz information criterion. In the first specification deterministic trend is ignored, but included in the second. Diebold and Senhadji (1996) shown that whether these test detect presence of deterministic or stochastic trend depends on analyzed time period – the longer the higher the chance of encountering deterministic trend. This implies that for used periods used in this paper the test is expected to be biased towards stochastic trend. Presence of the trend was also confirmed with KPSS (Kwiatkowski et al, 1992) test. Results for specification without deterministic trend for countries have been presented in table 2. Results for regions at NUTS 1 level are in the appendix. Due to too high number of observations (242 for NUTS 2 and 1260 for NUTS 3) results for lower levels are of disaggregation are not presented, but confirm presence of trend in the data.

ADF test detects presence of unit root in time series for all countries except Portugl and Spain – two geographical close countries that have experienced significant turmoil during recent crisis. According to KPSS test results unit root is present in cases of all countries. Results for the specification (1) are presented in table 3.

For specification (1) ADF test shows presence of unit root in time series for all countries. KPSS shows presence of unit root in all cases except for Germany. This result along with the analysis of p values in both specifications, gives strong support to deterministic trend only in instance of Germany, though evidence for stochastic trend can be found. Table 3 shows that deterministic trend is

[1] Case with no dritf is not considered due to increasing nature of real GDP

significant also for Bulgaria, Estonia, Greece, Poland, Romania and Slovakia. In most of the case result point to stochastic trend and drift. As mentioned above this result was expected because of not long enough time period. This result has consequences for measurement of business cycle component and final result. It points out to changes in trend underlying GDP. This difficulty is addressed and overcame later in the text.

Table 2. Results of unit root test: specification (1) without βt (ADF H_0: series has a unit root; KPSS H_0: series is stationary)

Country	ADF	t-1	d(-1)	d(-2)	d(-3)	d(-4)	d(-5)	d(-6)	d(-7)	d(-8)	C	KPSS
Austria	0.398	0.084									0.050	I(1)***
Belgium	0.451	0.104	0.00	0.84							0.075	I(1)***
Bulgaria	0.449	0.103	0.56								0.031	I(1)***
Czech	0.628	0.201	0.00								0.099	I(1)***
Denmark	0.305	0.055									0.047	I(1)**
Estonia	0.634	0.206	0.01								0.112	I(1)***
Finland	0.277	0.048	0.07								0.035	I(1)***
France	0.219	0.034	0.01								0.023	I(1)***
Germany	0.833	0.473									0.390	I(1)***
Greece	0.137	0.018	0.78	0.15	0.49	0.80	0.01	0.02			0.021	I(1)*
Holland	0.174	0.025	0.00								0.020	I(1)***
Hungary	0.362	0.072	0.00								0.052	I(1)***
Ireland	0.111	0.014									0.005	I(1)***
Italy	0.265	0.045	0.00								0.043	I(1)*
Latvia	0.365	0.073	0.05	0.00							0.053	I(1)***
Lithuania	0.781	0.369	0.02								0.203	I(1)***
Poland	0.996	0.317									0.532	I(1)***
Portugal	0.015	0.001									0.001	I(1)**
Romania	0.651	0.219	0.44								0.130	I(1)***
Slovakia	0.946	0.928									0.393	I(1)***
Slovenia	0.395	0.083	0.15	0.01							0.064	I(1)***
Spain	0.069	0.008	0.00								0.005	I(1)***
Sweden	0.769	0.354	0.29	0.00	0.18	0.00	0.22	0.42	0.02	0.00	0.197	I(1)***
UK	0.358	0.071									0.039	I(1)***

Table presents p values for ADF test as well as for all variables.
*/**/*** denotes 0.1/0.05/0.01 significance level for KPSS statistic

Source: own calculations

For regions KPSS test find unit root for every region at NUTS 1 level. ADF test fails to find unit root at 5% level of confidence for 5 regions, namely: Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt (all Germany) and Alföld és Észak (Hungary). This results point to the presence of trend in analyzed data set, and allows proceeding with filtering.

In order to extract cyclical and trend component of real GDP time series high pass Hodrick-Prescott (HP) filter has been used. HP filter assumes time series (y_t) can be divided into cycle component (c_t) the trend component (g_t):

$$y_t = c_t + g_t \qquad for\ t = 1,2, \dots, T. \tag{2}$$

The HP filter extracts trend component by solving following mathematical programing problem (Hodrick, Prescott, 1997):

Table 3. Results of unit root test: specification (1) (ADF H_0: series has a unit root; KPSS H_0: series is stationary)

Country	ADF	t-1	d(-1)	d(-2)	d(-3)	d(-4)	d(-5)	d(-6)	d(-7)	d(-8)	C	t	KPSS
Austria	0.598	0.052									0.039	0.120	I(1)*
Belgium	0.378	0.020	0.00								0.015	0.053	I(1)**
Bulgaria	0.962	0.438	0.52								0.220	0.761	I(1)**
Czech	0.947	0.359	0.00								0.233	0.582	I(1)**
Denmark	0.847	0.162									0.128	0.822	I(1)**
Estonia	0.321	0.015	0.03	0.43	0.01						0.009	0.054	I(1)**
Finland	0.871	0.188	0.07								0.124	0.676	I(1)**
France	0.589	0.050	0.00								0.037	0.169	I(1)**
Germany	0.121	0.003	0.01								0.003	0.005	I(0)
Greece	0.999	0.556									0.619	0.000	I(1)***
Holland	0.938	0.325	0.00								0.250	0.957	I(1)**
Hungary	0.803	0.128	0.00								0.079	0.564	I(1)***
Ireland	0.785	0.116									0.037	0.768	I(1)***
Italy	0.855	0.170	0.00								0.134	0.277	I(1)***
Latvia	0.423	0.025	0.04	0.00							0.015	0.134	I(1)**
Lithuania	0.804	0.129	0.01								0.076	0.204	I(1)**
Poland	0.627	0.059	0.17	0.54	0.10						0.037	0.058	I(1)**
Portugal	0.750	0.098									0.060	0.105	I(1)***
Romania	0.396	0.022	0.91								0.013	0.045	I(1)**
Slovakia	0.701	0.080									0.050	0.075	I(1)*
Slovenia	0.778	0.113	0.11	0.00							0.070	0.388	I(1)**
Spain	0.983	0.651	0.01								0.310	0.177	I(1)***
Sweden	0.725	0.091	0.18	0.00	0.06	0.00	0.31	0.31	0.01	0.01	0.070	0.122	I(1)*
UK	0.800	0.126									0.078	0.416	I(1)***

Table presents p values for ADF test as well as for all variables.
*/**/*** denotes 0.1/0.05/0.01 significance level for KPSS statistic

Source: own calculations

$$\min_{\{g_t\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} (y_t - g_t)^2 + \lambda \sum_{t=1}^{T} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \right\}. \quad (3)$$

In that context HP filter can be seen as a generalization of the exponential smoothing procedures used analyzed by Brown (1962). If c_t and the second differences of g_t are normally and independently distributed, HP filter is an optimal filter (Rawn, Uhlig, 2002). λ is a parameter penalizing for variability of the trend component and its value is given by:

$$\lambda = \frac{\sigma_c^2}{\sigma_{\Delta^2 g_t}^2}, \quad (4)$$

which is the ratio of variance in the cyclical component to variance of the second differences in the trend component. The higher the value of λ the smoother the trend component is becoming and becomes OLS estimate as λ approaches ∞. The value has been set to 1600 for quarterly and for 100 to annual data, which are values recommended by the authors as well as commonly used in the most of business cycles literature (eg. Backus, Kehoe, 1992). Great advantage of Hodrick-Prescott filter is the fact that it directly corresponds to commonly used in the economic literature definition of business cycle as a: *movements about trend in gross national product* (Lucas, 1977).

Finally cyclical component c_t is divided by the trend component $g_t$to create time series of deviations of cyclical part of real GDP from trend part, or in other words deviations o cyclical GDP from the natural level:

$$dev_t = {}^{c_t}/_{t_t}. \quad (5)$$

This transformation deals with the problem of stochastic trend, cause cyclical component is scaled by trend component.

For each pair of countries/regions i and j for each level of aggregation separately the value of the correlation coefficient is calculated for data obtained with HP (hp_{ij}) filter. This measure takes values from -1 to 1, where 1 reflects perfect business cycle synchronization. Because BCS can be analyzed using at least two countries, unit used in this research is pairwise oriented. Advantage of that approach is that number of observations (o) for a given number of countries/regions (n) is given by:

$$o = \frac{n(n-1)}{2}, \tag{6}$$

so for 24 countries gives 276, for 82 NUTS 1 gives 3321, for 242 NUTS 2 gives 29161, 1263 NUTS 3 gives 796953 observations. In case of NUTS 3 one can be sure that all asymptotical theorems work very well. The rest of the reasoning is based on values of these results.

3. Results

Descriptive statistics for values of *hp* measure for region pairs at NUTS 1, 2 and 3 are presented in table 4. The headers of columns with „IN" present results only for pairs of regions inside the countries (Polish region with Polish region, German with German, but not Polish with German).

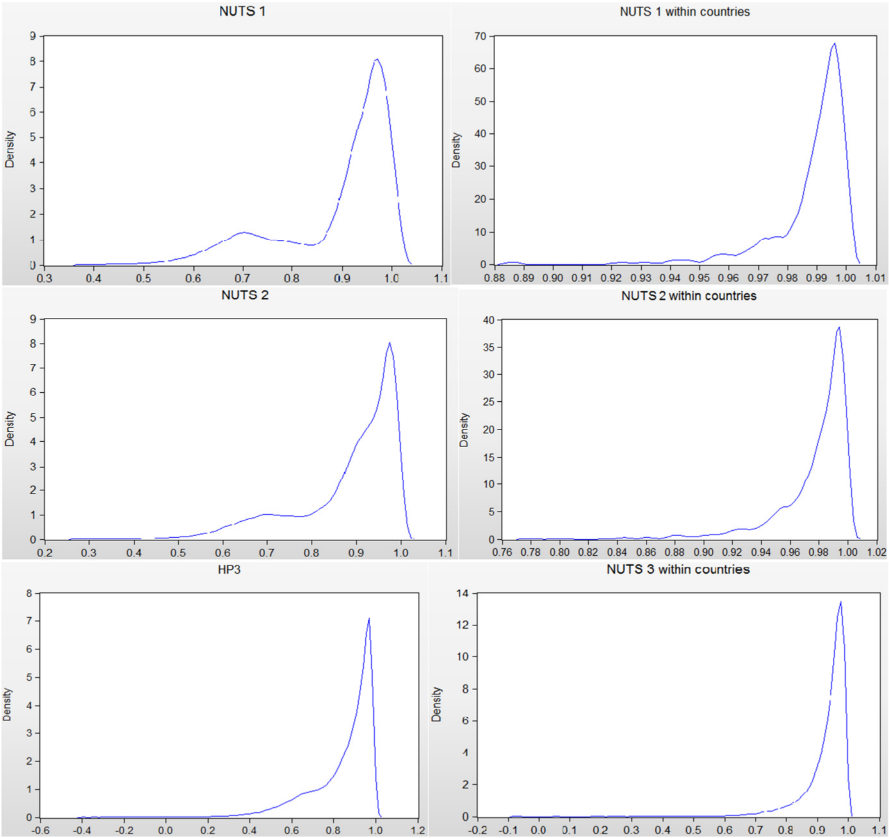
Table 4. Descriptive statistics of *hp* for NUTS 1, 2 and 3 region pairs: all and within countries.

Statistic	NUTS1	NUTS1IN	NUTS2	NUTS2IN	NUTS3	NUTS3IN
Mean	0.89	0.99	0.88	0.98	0.85	0.93
Median	0.94	0.99	0.92	0.99	0.90	0.95
Maximum	1.00	1.00	1.00	1.00	1.00	1.00
Minimum	0.40	0.89	0.29	0.78	-0.39	-0.08
Std. Dev.	0.12	0.01	0.12	0.03	0.15	0.07
Skewness	-1.38	-3.03	-1.40	-2.45	-1.60	-2.59
Kurtosis	3.96	16.86	4.40	11.17	5.80	13.76
Jarque-Bera	1178	2784	11866	7992	602586	703580
P(J-B)	0.00	0.00	0.00	0.00	0.00	0.00
Sum	2962	289	25681	2064	675351	110500
Sum Sq. Dev.	44.57	0.05	392.55	1.35	16873.30	515.73
Observations	3321	292	29161	2112	795691	118449

Source: own calculation

Degree of business cycle synchronization is very high at all three levels of aggregation though the highest is at NUTS 1 level (0.89). Average value of *hp* is decreasing with disaggregation, which is expected result. Nevertheless this very high value for all three levels of disaggregation indicate that conduction of monetary policy would be on average rather effective judging from region perspective. On the other hand distribution in all cases is far from normal, which might indicate that there is some systematic factor attributing to skewness. For this reason statistics were calculated separately for pairs of regions within countries. Mean values within countries are significantly higher – by approximately 0,1 for NUTS 1 and NUTS 2 and 0,08 NUTS region pairs. Standard deviation for "inside" pairs is on the other hand significantly lower, approximately by factor of 12, 4 and 2.1 for NUTA 1, 2 and 3 region pairs respectively.

Figure 1. Kernel Densities for NUTS 1, 2 and 3 region pairs: all and within countries.



Source: own calculation

Conclusions from table 4 are supported by comparison of the distribution between al pairs of regions and pairs within counters. Kernel densities for region pairs are presented in figure 1.

Distributions for all and inside pairs are not normal and I get more concentrated around mean with the level of aggregation, which can be attributed to the sample size changes. Distribution for "inside" pairs is more concentered and covers only very high values of correlation coefficient. These results suggest that business cycle of regions inside countries are on average more synchronized than those of regions from different countries. This result contradicts "Krugman's View" which states that elimination of barriers to all economic activities (ex. Trade, mobility of labor and capital) leads to higher degree of concentration of economic activity due to internal and external economies of scale. These in turn leads to higher specialization, fragility of regions exports to changes in demand and lower business cycles synchronization with other regions. Obtained result shows that regions are characterized by very high degree of business cycle synchronization, especially within countries. This also supports “European Commission View”. Further economic integration by eliminating barriers to economic activity and introducing similar policies – *ergo* making groups of countries more like one country – will lead to tighter business cycle synchronization and can make common monetary policy effective.

Table 5. Descriptive statistics of *hp* for pairs of countries and NUTS 3 level pairs within Poland, Germany, France and UK.

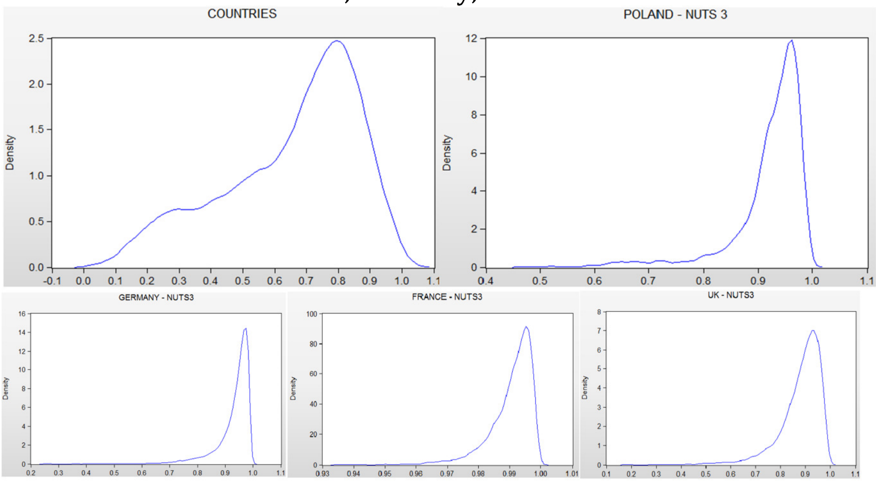
Statistic	COUNTRIES	POLAND	GERMANY	FRANCE	UK
Mean	0.65	0.92	0.93	0.99	0.88
Median	0.71	0.94	0.95	0.99	0.90
Maximum	0.95	1.00	1.00	1.00	1.00
Minimum	0.11	0.47	0.25	0.94	0.18
Std. Dev.	0.21	0.07	0.06	0.01	0.08
Skewness	-0.80	-2.58	-2.38	-2.04	-1.94
Kurtosis	2.61	11.23	10.97	9.77	8.67
Jarque-Bera	31	8424	327137	11875	16490
P(J-B)	0.00	0.00	0.00	0.00	0.00
Sum	180	1975	84843	4517	7377
Sum Sq. Dev.	11.71	10.09	332.78	0.23	60.11
Observations	276	2145	90951	4560	8385

Source: own calculation

Results for regions are very different from pairs of countries, which are presented in table 5. Mean value of correlation coefficient for country pairs is equal 0.65, which is lower by 0.3 from NUTS 3 region pairs. Standard deviation is equal to 0.21, which in turn indicates lower concentration of the results. Distribution is not normal what can be seen from kernel densities in figure 2. Distribution almost entirely covers only values from 0 to 1. This suggests that in total business cycle synchronization among European countries is fairly strong, but degree differs significantly between pairs. The highest density of observations is around 0.75 what strengthens the point.

Table 5 also displays descriptive statistics for NUTS 3 region pairs inside Poland, Germany, France and UK. Result for these countries confirm that in all cases monetary policy can be implemented very effectively. This is especially true in case of France where mean value of *hp* measure is equal 0.99 with standard deviation equal to approximately 0.01 Degree of business cycle synchronization is also very high for Poland with mean of 0.92 and standard deviation of 0.07. Distribution in all cases is not normal, what can be seen in figure 2. Kernel distributions for regions inside countries are very concentrated and cover only very high values of correlation.

Figure 2. Kernel Densities for country pairs and pairs of regions at NUTS 3 level inside: Poland, Germany, France and UK.



Source: own calculation

Results of the detailed analysis are presented in tables 6 trough 9. For each country possible partners for monetary union are arranged according to *hp* measure in a descending order. NUTS 1/2/3 denotes average value for region pairs inside this country at a different 1/2/3 level of aggregation, while mean denotes average value with all countries. If country has higher business cycle synchronization with some other country than with other country than between regions inside it, than this country is a good partner to form monetary union with. In other words monetary policy could be implemented in this two countries, as effectively as for regions of one country – costs of participation in monetary union do not apply. This criterion is extremely rigorous and has been met only in couple of cases.

Values of correlation coefficient for NUTS 1, 2 and 3 level region pairs is higher than with any other country in case of Belgium, Greece, Poland, Spain, Holland, Hungary, Sweden, UK, Romania, France, Austria, Czech, Denmark, Ireland, Portugal, Slovakia, Slovenia, Estonia

Table 6. Ordered values of *hp* measure with all possible partners and inside countries at NUTS 1, 2 and 3 levels for Belgium, Bulgaria, Finland, Germany and Greece.

No.	Belgium		Bulgaria		Finland		Germany		Greece		Poland	
0	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp
1	**NUTS 1**	**1.00**	**NUTS 1**	**0.95**	**NUTS 2**	**0.97**	**NUTS 2**	**0.99**	**NUTS 1**	**0.98**	**NUTS 1**	**0.99**
2	**NUTS 2**	**0.99**	**NUTS 2**	**0.93**	**France**	**0.92**	**NUTS 1**	**0.98**	**NUTS 2**	**0.96**	**NUTS 2**	**0.98**
3	**NUTS 3**	**0.98**	**Lithuania**	**0.80**	**NUTS 3**	**0.92**	**Italy**	**0.95**	**NUTS 3**	**0.88**	**NUTS 3**	**0.92**
4	**France**	**0.92**	NUTS 3	0.79	**Germany**	**0.90**	**France**	**0.94**	Slovakia	0.56	Belgium	0.77
5	**Austria**	**0.91**	Spain	0.75	**Italy**	**0.90**	**NUTS 3**	**0.93**	Spain	0.50	Holland	0.76
6	**Italy**	**0.89**	Romania	0.74	**Spain**	**0.89**	**Austria**	**0.91**	Czech	0.49	Austria	0.71
7	**Germany**	**0.88**	Slovenia	0.74	**NUTS 1**	**0.89**	**Finland**	**0.90**	Bulgaria	0.48	Slovenia	0.69
8	**Holland**	**0.86**	Finland	0.70	**Austria**	**0.88**	**Belgium**	**0.88**	Slovenia	0.46	Spain	0.68
9	**Sweden**	**0.85**	Czech	0.70	**Slovenia**	**0.88**	**Holland**	**0.87**	Lithuania	0.44	France	0.64
10	**Denmark**	**0.85**	Slovakia	0.70	**Denmark**	**0.87**	**Denmark**	**0.87**	Latvia	0.41	Czech	0.64
11	**Finland**	**0.85**	Latvia	0.66	**Sweden**	**0.86**	**Spain**	**0.86**	Poland	0.39	Germany	0.63
12	**Spain**	**0.82**	UK	0.63	**Belgium**	**0.85**	**Sweden**	**0.85**	UK	0.35	Finland	0.61
13	Slovenia	0.79	Estonia	0.61	**UK**	**0.84**	**Slovenia**	**0.85**	Romania	0.33	Ireland	0.59
14	Ireland	0.79	Austria	0.60	**Czech**	**0.84**	**Czech**	**0.80**	mean	0.32	Denmark	0.58
15	Poland	0.77	Hungary	0.59	**Holland**	**0.83**	Ireland	0.76	Holland	0.31	Italy	0.58
16	Czech	0.77	Mean	0.58	**Estonia**	**0.82**	Estonia	0.74	Estonia	0.30	mean	0.54
17	UK	0.71	Holland	0.56	**Latvia**	**0.80**	mean	0.74	Austria	0.30	UK	0.53
18	mean	0.70	Denmark	0.55	Lithuania	0.78	UK	0.73	Finland	0.28	Sweden	0.53
19	Hungary	0.70	France	0.54	Ireland	0.77	Latvia	0.73	Germany	0.25	Portugal	0.48
20	Latvia	0.67	Germany	0.54	mean	0.77	Hungary	0.72	Belgium	0.23	Latvia	0.48
21	Portugal	0.66	Italy	0.49	Hungary	0.77	Portugal	0.71	Hungary	0.22	Bulgaria	0.45
22	Estonia	0.65	Greece	0.48	Bulgaria	0.70	Poland	0.63	Ireland	0.22	Hungary	0.40
23	Lithuania	0.51	Poland	0.45	Slovakia	0.66	Lithuania	0.63	Italy	0.22	Greece	0.39
24	Slovakia	0.46	Belgium	0.45	Portugal	0.64	Slovakia	0.58	Denmark	0.22	Estonia	0.39
25	Bulgaria	0.45	Ireland	0.44	Poland	0.61	Bulgaria	0.54	France	0.19	Lithuania	0.37
26	Greece	0.23	Sweden	0.43	Romania	0.44	Romania	0.32	Portugal	0.15	Slovakia	0.36
27	Romania	0.19	Portugal	0.31	Greece	0.28	Greece	0.25	Sweden	0.11	Romania	0.23

Source: own calculation

and Lithuania. Bulgaria has *hp* value for NUTS 3 “inside” equal to 0.79, while with Lithuania 0.8, so this country is a suitable candidate for monetary union with Bulgaria. Germany has higher value of *hp* with Italy and France than for region pairs at NUTS 3 level of aggregation

(0.93). Latvia is characterized by very low value of correlation coefficient for pairs of NUTS 3 regions within countries (0.75) in comparison with other countries. This indicates that from regional perspective monetary policy cannot be implemented very effectively (especially in comparison with other countries). Values of *hp* for Latvia with Estonia, Lithuania, Hungary, Czech Republic, UK, Spain, Finland, Slovenia, Denmark, Ireland (in descending order) are higher than for within country NUTS 3 level region pairs. This means that possible number of candidates for monetary union with Latvia is quite extensive. In case of Finland *hp* with France is higher than for inside regions at NUTS 3 level inside countries (0.92), and with Germany, Italy and Spain is higher for than for NUTS 1 level regions. This indicates 4 very good candidates to form monetary union with Finland.

Table 7. Ordered values of *hp* measure with all possible partners and inside countries at NUTS1, 2 and 3 levels for Spain, Holland, Hungary, Italy, Sweden and UK.

No.	Spain		Holland		Hungary		Italy		Sweden		UK	
0	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp
1	**NUTS 1**	**1.00**	**NUTS 1**	**0.99**	**NUTS 1**	**0.98**	**NUTS 1**	**1.00**	**NUTS 1**	**0.98**	**NUTS 1**	**0.99**
2	**NUTS 2**	**0.99**	**NUTS 2**	**0.97**	**NUTS 2**	**0.96**	**NUTS 2**	**0.99**	**NUTS 2**	**0.97**	**NUTS 2**	**0.96**
3	**NUTS 3**	**0.97**	**NUTS 3**	**0.97**	**NUTS 3**	**0.90**	**NUTS 3**	**0.98**	**NUTS 3**	**0.95**	**NUTS 3**	**0.88**
4	**Slovenia**	**0.92**	**Spain**	**0.88**	**Estonia**	**0.87**	**Germany**	**0.95**	**France**	**0.89**	**Finland**	**0.84**
5	**Austria**	**0.90**	**France**	**0.88**	**Latvia**	**0.86**	**France**	**0.94**	**Denmark**	**0.88**	**Estonia**	**0.83**
6	**Finland**	**0.89**	**Germany**	**0.87**	**Lithuania**	**0.82**	**Finland**	**0.90**	**Italy**	**0.87**	**Latvia**	**0.82**
7	**Czech**	**0.89**	**Austria**	**0.87**	**Denmark**	**0.80**	**Belgium**	**0.89**	**Finland**	**0.86**	**Lithuania**	**0.81**
8	**Holland**	**0.88**	**Belgium**	**0.86**	Sweden	0.79	**Austria**	**0.88**	**Belgium**	**0.85**	**Spain**	**0.81**
9	**France**	**0.87**	**Slovenia**	**0.84**	Czech	0.79	**Denmark**	**0.88**	**Germany**	**0.85**	France	0.79
10	**Germany**	**0.86**	**Finland**	**0.83**	UK	0.79	**Sweden**	**0.87**	**Austria**	**0.82**	Sweden	0.79
11	**Denmark**	**0.86**	**Denmark**	**0.82**	Finland	0.77	**Spain**	**0.84**	Hungary	0.79	Hungary	0.79
12	**Italy**	**0.84**	**Italy**	**0.81**	Italy	0.75	**Holland**	**0.81**	UK	0.79	Denmark	0.77
13	**Belgium**	**0.82**	**Portugal**	**0.80**	France	0.74	**Czech**	**0.81**	Estonia	0.78	Slovenia	0.77
14	**Latvia**	**0.81**	Czech	0.77	Austria	0.73	**Ireland**	**0.80**	Ireland	0.75	Italy	0.76
15	**UK**	**0.81**	Poland	0.76	Spain	0.73	Slovenia	0.78	Czech	0.74	Czech	0.75
16	mean	0.77	Sweden	0.70	Germany	0.72	Estonia	0.78	Spain	0.74	Austria	0.75
17	Ireland	0.77	Ireland	0.70	Slovenia	0.71	UK	0.76	Slovenia	0.72	Germany	0.73
18	Estonia	0.77	mean	0.69	Belgium	0.70	Hungary	0.75	Latvia	0.71	Ireland	0.71
19	Lithuania	0.76	UK	0.63	Ireland	0.69	Latvia	0.74	Holland	0.70	Belgium	0.71
20	Bulgaria	0.75	Latvia	0.59	mean	0.66	mean	0.73	mean	0.68	mean	0.70
21	Sweden	0.74	Bulgaria	0.56	Bulgaria	0.59	Portugal	0.69	Lithuania	0.60	Slovakia	0.65
22	Hungary	0.73	Slovakia	0.53	Slovakia	0.57	Lithuania	0.63	Portugal	0.58	Holland	0.63
23	Slovakia	0.68	Estonia	0.53	Holland	0.51	Poland	0.58	Poland	0.53	Bulgaria	0.63
24	Poland	0.68	Hungary	0.51	Poland	0.40	Slovakia	0.53	Slovakia	0.47	Poland	0.53
25	Portugal	0.60	Lithuania	0.48	Romania	0.36	Bulgaria	0.49	Bulgaria	0.43	Portugal	0.40

26	Greece	0.50	Romania	0.32	Portugal	0.24	Romania	0.25	Romania	0.23	Romania	0.37
27	Romania	0.50	Greece	0.31	Greece	0.22	Greece	0.22	Greece	0.11	Greece	0.35

Source: own calculation

Table 8. Ordered values of *hp* measure with all possible partners and inside countries at NUTS1, 2 and 3 levels for Romania, France, Austria, Czech Republic, Denmark and Ireland.

No.	Romania		France		Austria		Czech		Denmark		Ireland	
1	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp
2	**NUTS 1**	**0.96**	**NUTS 1**	**1.00**	**NUTS 1**	**1.00**	**NUTS 3**	**0.97**	**NUTS 2**	**0.99**	**NUTS 2**	**0.97**
3	**NUTS 2**	**0.95**	**NUTS 2**	**1.00**	**NUTS 2**	**0.99**	**NUTS 2**	**0.96**	**NUTS 3**	**0.99**	**NUTS 3**	**0.90**
4	**NUTS 3**	**0.87**	**NUTS 3**	**0.99**	**NUTS 3**	**0.98**	**Spain**	**0.89**	**France**	**0.93**	**Denmark**	**0.83**
5	Bulgaria	0.74	**Germany**	**0.94**	**Belgium**	**0.91**	**Slovenia**	**0.87**	**Sweden**	**0.88**	**France**	**0.81**
6	Lithuania	0.54	**Italy**	**0.94**	**Germany**	**0.91**	**Denmark**	**0.84**	**Italy**	**0.88**	**Italy**	**0.80**
7	Spain	0.50	**Denmark**	**0.93**	**France**	**0.90**	**Finland**	**0.84**	**Germany**	**0.87**	Belgium	0.79
8	Slovenia	0.45	**Finland**	**0.92**	**Spain**	**0.90**	**Latvia**	**0.83**	**Finland**	**0.87**	Austria	0.79
9	Finland	0.44	**Belgium**	**0.92**	**Finland**	**0.88**	**Estonia**	**0.82**	**Spain**	**0.86**	Latvia	0.78
10	Austria	0.39	**Austria**	**0.90**	**Italy**	**0.88**	**Italy**	**0.81**	**Austria**	**0.85**	Finland	0.77
11	UK	0.37	**Sweden**	**0.89**	**Holland**	**0.87**	**Germany**	**0.80**	**Belgium**	**0.85**	Spain	0.77
12	Hungary	0.36	**Holland**	**0.88**	**Slovenia**	**0.86**	**Austria**	**0.80**	**Czech**	**0.84**	Germany	0.76
13	Czech	0.35	**Spain**	**0.87**	**Denmark**	**0.85**	France	0.79	**Ireland**	**0.83**	Estonia	0.75
14	mean	0.34	**Ireland**	**0.81**	**Sweden**	**0.82**	Hungary	0.79	**Holland**	**0.82**	Sweden	0.75
15	Greece	0.33	**Slovenia**	**0.80**	**Czech**	**0.80**	Lithuania	0.78	**Estonia**	**0.81**	Czech	0.73
16	Latvia	0.33	UK	0.79	Ireland	0.79	Belgium	0.77	**Slovenia**	**0.80**	UK	0.71
17	France	0.33	Czech	0.79	UK	0.75	Holland	0.77	**Hungary**	**0.80**	Holland	0.70
18	Germany	0.32	Estonia	0.75	mean	0.74	Slovakia	0.75	Latvia	0.79	Slovenia	0.70
19	Holland	0.32	mean	0.74	Latvia	0.73	UK	0.75	UK	0.77	Hungary	0.69
20	Estonia	0.31	Hungary	0.74	Hungary	0.73	Sweden	0.74	mean	0.73	mean	0.65
21	Slovakia	0.28	Latvia	0.72	Poland	0.71	mean	0.74	Lithuania	0.65	Poland	0.59
22	Italy	0.25	Portugal	0.71	Estonia	0.71	Ireland	0.73	Portugal	0.59	Lithuania	0.58
23	Sweden	0.23	Poland	0.64	Portugal	0.66	Bulgaria	0.70	Poland	0.58	Slovakia	0.47
24	Poland	0.23	Lithuania	0.61	Lithuania	0.64	Poland	0.64	Slovakia	0.57	Portugal	0.46
25	Denmark	0.22	Bulgaria	0.54	Bulgaria	0.60	Portugal	0.49	Bulgaria	0.55	Bulgaria	0.44
26	Belgium	0.19	Slovakia	0.50	Slovakia	0.54	Greece	0.49	Romania	0.22	Greece	0.22
27	Portugal	0.18	Romania	0.33	Romania	0.39	Romania	0.35	Greece	0.22	Romania	0.12
28	Ireland	0.12	Greece	0.19	Greece	0.30						

Source: own calculation

Even though there are possible partners for monetary union in case of Bulgaria, Germany, Latvia and Finland none of them are conceding – there is not even one pair of countries that could form monetary union at virtually no loss in monetary policy effectiveness. But criterion used here was extremely rigorous, especially if one takes a closer look at values of *hp*, one can see that they are very high in many cases. Values of *hp* measure above 0.8 were denoted in bold.

Table 9. Ordered values of *hp* measure with all possible partners and inside countries at NUTS1, 2 and 3 levels for Portugal, Slovakia, Slovenia, Estonia, Latvia and Lithuania.

No.	Portugal		Slovakia		Slovenia		Estonia		Latvia		Lithuania	
1	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp	Partner	hp
2	**NUTS 2**	**0.99**	**NUTS 2**	**0.96**	**NUTS 2**	**1.00**	**NUTS 3**	**0.96**	**Estonia**	**0.92**	**NUTS 3**	**0.90**
3	**NUTS 3**	**0.96**	**NUTS 3**	**0.93**	**NUTS 3**	**0.99**	**Latvia**	**0.92**	**Lithuania**	**0.89**	**Latvia**	**0.89**
4	**Holland**	**0.80**	**Lithuania**	**0.80**	**Spain**	**0.92**	**Hungary**	**0.87**	**Hungary**	**0.86**	**Estonia**	**0.87**
5	France	0.71	Slovenia	0.77	**Finland**	**0.88**	**Lithuania**	**0.87**	**Czech**	**0.83**	**Hungary**	**0.82**
6	Germany	0.71	Czech	0.75	**Czech**	**0.87**	**UK**	**0.83**	**UK**	**0.82**	**UK**	**0.81**
7	Italy	0.69	Latvia	0.73	**Austria**	**0.86**	**Czech**	**0.82**	**Spain**	**0.81**	**Bulgaria**	**0.80**
8	Belgium	0.66	Bulgaria	0.70	**Germany**	**0.85**	**Finland**	**0.82**	**Finland**	**0.80**	**Slovakia**	**0.80**
9	Austria	0.66	Spain	0.68	**Holland**	**0.84**	**Denmark**	**0.81**	**Slovenia**	**0.80**	Finland	0.78
10	Finland	0.64	Estonia	0.67	**Denmark**	**0.80**	Italy	0.78	Denmark	0.79	Slovenia	0.78
11	Spain	0.60	Finland	0.66	**France**	**0.80**	Sweden	0.78	Ireland	0.78	Czech	0.78
12	Denmark	0.59	UK	0.65	**Latvia**	**0.80**	Spain	0.77	NUTS 3	0.75	Spain	0.76
13	Sweden	0.58	Germany	0.58	Belgium	0.79	Ireland	0.75	Italy	0.74	Denmark	0.65
14	Slovenia	0.58	mean	0.57	Italy	0.78	France	0.75	Germany	0.73	mean	0.65
15	Czech	0.49	Hungary	0.57	Lithuania	0.78	Germany	0.74	Austria	0.73	Austria	0.64
16	Poland	0.48	Denmark	0.57	Slovakia	0.77	Slovenia	0.71	Slovakia	0.73	Italy	0.63
17	mean	0.47	Greece	0.56	UK	0.77	Austria	0.71	France	0.72	Germany	0.63
18	Ireland	0.46	Austria	0.54	mean	0.75	mean	0.68	Sweden	0.71	France	0.61
19	UK	0.40	Holland	0.53	Bulgaria	0.74	Slovakia	0.67	mean	0.70	Sweden	0.60
20	Slovakia	0.32	Italy	0.53	Sweden	0.72	Belgium	0.65	Belgium	0.67	Ireland	0.58
21	Bulgaria	0.31	France	0.50	Estonia	0.71	Bulgaria	0.61	Bulgaria	0.66	Romania	0.54
22	Estonia	0.25	Ireland	0.47	Hungary	0.71	Holland	0.53	Holland	0.59	Belgium	0.51
23	Latvia	0.24	Sweden	0.47	Ireland	0.70	Poland	0.39	Poland	0.48	Holland	0.48
24	Hungary	0.24	Belgium	0.46	Poland	0.69	Romania	0.31	Greece	0.41	Greece	0.44
25	Romania	0.18	Poland	0.36	Portugal	0.58	Greece	0.30	Romania	0.33	Poland	0.37
26	Lithuania	0.18	Portugal	0.32	Greece	0.46	Portugal	0.25	Portugal	0.24	Portugal	0.18
27	Greece	0.15	Romania	0.28	Romania	0.45						

Source: own calculation

Chosen value of 0.8 is somehow arbitrary but expresses rather high degree of business cycle synchronization. Taking this value as a point of reference Poland do not find any suitable partners to form monetary Union with. The highest value of *hp* is observed with Belgium and its equal to 0.77. Similar situation can be seen in instance of

Greece, which have the worst results among all examined countries. In other words Greek business cycle is very poorly synchronized with cycles all of analyzed countries – monetary policy that is optimal for any o these countries would be inappropriate for Greece.

Using 0.8 as references value some countries have rather big number of possible candidates for introduction of a common currency: Belgium (9 countries), Finland (14), Germany (11), Spain (12), Holland (10), Italy (11), France (12), Austria (12), Denmark (15) and Slovenia (10). Numbers for other countries are not as big, but still many pairs of countries with highly synchronized business cycle can be found. This also indicates that a lot of countries from Euro Area form organism that can be considered quite close to optimum currency area. Germany, France, Italy, Austria, Belgium, Holland, Spain, Austria and Finland constitute such an entity – optimal monetary policy for one of these countries is very close to optimal policies for all others. Unfortunately same thing cannot be said about other members of Euro Area with Greece being a leading outlier.

4. Conclusions

Extraction of cyclical components with Hodrick-Prescott filter from real GDP time series in order to obtain correlation coefficient of deviations of cyclical component from trend resulted in obtaining 276 measures for country pairs, as well as 3321, 29191 and 796953 measures for NUTS 1, 2 and 3 level region pairs respectively. Analysis reveled that average value of *hp* measure for countries and NUTS 1, 2 and 3 regions are equal to 0.65, 0.89, 0.88 and 0.85 respectively. This shows that business cycle synchronization at regional level is generally higher than at country level, but is mostly driven by high degree of business cycle synchronization among regions within countries. This result contradicts "Krugman's View" which states that elimination of barriers to all economic activities leads to higher degree of concentration of economic activity due to economies of scale. These in turn leads to higher specialization, fragility of regions exports to changes in demand and lower business cycles synchronization with other regions. To the contrary it gives support to "European Commission View". Further economic integration by eliminating barriers to economic activity and introducing similar policies – *ergo* making groups of countries more like one country – will lead to tighter business cycle synchronization and can make common monetary policy effective.

Very restrictive criterion that used comparisons of business cycle synchronization at regional level within countries with country level correlations was used to access whether two countries can enter monetary union with each other with virtually no cost of monetary policy effectiveness loss. This restrictive criterion showed that 4 countries have candidates for effective monetary union formation, namely: Bulgaria, Finland, Germany and Latvia. On the other hand requirement must be fulfilled for two countries – and that criterion was not met. Using less restrictive criterion of correlation coefficient equal to 0.8 it turned out that a lot of countries have many good candidates to introduce common currency with. For example: Belgium (9 countries), Finland (14), Germany (11), Spain (12), Holland (10), Italy (11), France (12), Austria (12), Denmark (15) and Slovenia (10). Numbers for other countries are not as big, but still many pairs of countries with highly synchronized business cycle can be found. This also indicates that a lot of countries from Euro Area form organism that can be considered quite close to optimum currency area. Germany, France, Italy, Austria, Belgium, Holland, Spain, Austria and Finland constitute such an entity – optimal monetary policy for one of these countries is very close to optimal policies for all others. Unfortunately same thing cannot be said about other members of Euro Area with Greece being a leading outlier.

Results also show that Polish National Bank can use monetary policy very effectively, no matter what regional level of aggregation is used as reference point. On the other hand values of business cycle synchronization for Poland and other countries are very low. This indicates that there are no good candidates to form monetary union with Poland. Poland is also second outlier, after Greece, of the analyzed group. This result should not worry cause low degree of business cycle synchronization with other European countries can be attributed to well economic performance of Poland during recent crisis.

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APPENDIX

Table A1. ADF and KPSS result for NUTS 1 region real GDP time series.

Country	Region name	ADF	KPSS	Country	Region name	ADF	KPSS
Belgium	Région de Bruxelles-Capitale	0,939	I(1)**	Italy	Nord Est	0,332	I(1)**
Belgium	Vlaams Gewest	0,854	I(1)**	Italy	Centro (IT)	0,699	I(1)**
Belgium	Région Wallonne	0,934	I(1)**	Italy	Sud (IT)	0,598	I(1)**
Bulgaria	Severna and iztochna Bulgaria	0,953	I(1)**	Italy	Isole (IT)	0,675	I(1)**
Bulgaria	Yugozapadna and yuzhna	0,996	I(1)**	Hungary	Közép-Magyarország	0,952	I(1)**
Germany	Baden-Württemberg	0,811	I(1)**	Hungary	Dunántúl	0,723	I(1)**
Germany	Bayern	0,880	I(1)**	Hungary	Alföld és Észak	0,045	I(1)**
Germany	Berlin	0,560	I(1)*	Holland	Noord-Nederland	0,908	I(1)**
Germany	Brandenburg	0,012	I(1)**	Holland	Oost-Nederland	0,890	I(1)**
Germany	Bremen	0,963	I(1)**	Holland	West-Nederland	0,825	I(1)**
Germany	Hamburg	0,906	I(1)**	Holland	Zuid-Nederland	0,790	I(1)**
Germany	Hessen	0,911	I(1)**	Austria	Ostösterreich	0,839	I(1)**
Germany	Mecklenburg-Vorpommern	0,010	I(1)**	Austria	Südösterreich	0,777	I(1)**
Germany	Niedersachsen	0,908	I(1)**	Austria	Westösterreich	0,906	I(1)**
Germany	Nordrhein-Westfalen	0,863	I(1)**	Poland	Centralny	0,940	I(1)**
Germany	Rheinland-Pfalz	0,883	I(1)**	Poland	Poludniowy	0,937	I(1)**
Germany	Saarland	0,787	I(1)**	Poland	Wschodni	0,860	I(1)**
Germany	Sachsen	0,009	I(1)**	Poland	Pólnocno-Zachodni	0,943	I(1)**
Germany	Sachsen-Anhalt	0,007	I(1)**	Poland	Poludniowo-Zachodni	0,977	I(1)**
Germany	Schleswig-Holstein	0,952	I(1)**	Poland	Pólnocny	0,881	I(1)**
Germany	Thüringen	0,191	I(1)**	Romania	Macroregiunea unu	0,365	I(1)**
Greece	Voreia Ellada	0,664	I(1)**	Romania	Macroregiunea doi	0,353	I(1)*
Greece	Kentriki Ellada	0,473	I(1)**	Romania	Macroregiunea trei	0,860	I(1)**
Greece	Attiki	0,671	I(1)**	Romania	Macroregiunea patru	0,705	I(1)**
Greece	Nisia Aigaiou, Kriti	0,486	I(1)**	Finland	Manner-Suomi	0,961	I(1)**
Spain	Noroeste	0,804	I(1)**	Finland	Åland	0,976	I(1)**
Spain	Noreste	0,960	I(1)**	Sweden	Östra Sverige	0,989	I(1)**
Spain	Comunidad de Madrid	0,708	I(1)**	Sweden	Södra Sverige	0,971	I(1)**
Spain	Centro (ES)	0,996	I(1)**	Sweden	Norra Sverige	0,427	I(1)**
Spain	Este	0,875	I(1)**	UK	North East (ENGLAND)	0,898	I(1)**
Spain	Sur	0,789	I(1)**	UK	North West (ENGLAND)	0,786	I(1)**
Spain	Canarias (ES)	0,757	I(1)**	UK	Yorkshire + Humber	0,756	I(1)**
France	Île de France	0,872	I(1)**	UK	East Midlands (ENGLAND)	0,864	I(1)**
France	Bassin Parisien	0,581	I(1)**	UK	West Midlands (ENGLAND)	0,485	I(1)**

France	Nord - Pas-de-Calais	0,759	I(1)**	UK	Eastern	0,817	I(1)**
France	Est	0,321	I(1)**	UK	London	0,958	I(1)**
France	Ouest	0,662	I(1)**	UK	South East	0,764	I(1)**
France	Sud-Ouest	0,861	I(1)**	UK	South West (ENGLAND)	0,870	I(1)**
France	Centre-Est	0,871	I(1)**	UK	Wales	0,828	I(1)**
France	Méditerranée	0,945	I(1)**	UK	Scotland	0,982	I(1)**
Italy	Nord Ovest	0,575	I(1)**	UK	Northern Ireland	0,628	I(1)**

Source: own calculation