I. CLUSTERIZATION, PERSISTENCE, DEPENDENCY AND VOLATILITY OF BUSINESS CYCLES IN AN ENLARGED EURO AREA[1]

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Abstract

The aim of this study is to estimate the degree of synchronization between the business cycles of the the most integrated seven CEE economies with the Euro Area, according to methods which are less used in the economic literature, some of them being proposed by Darvas and Szapáry (2004). In this study we have identified the main causes of the divergences between the business cycles in an enlarged Euro Area, using different methods such as cluster analysis, OLS regression, the 1st order autocorrelation coefficient, the SVAR decomposition and the standard deviation. Applying this analysis to all the seven CEE economies, it results in higher costs of the euro adoption in the case of Bulgaria and Romania and lower costs for Hungary, Czech Republic and Poland, respectively.

Keyword: business cycle synchronization; Euro Area; SVAR model; volatility; cluster analysis

JEL Classification: E32, F44

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1 ***Acknowledgement:*** *This paper represents a partial dissemination of the postdoctoral research project CNCSIS, HUMAN RESOURCES type, "Macroeconomic modeling of the relationships between the asymmetric shocks, convergence of business cycles and mechanisms of adjustment in the context of Romania's adhesion to the euro area", No 78/03.08.2010, Project Manager Marinaş Marius-Corneliu.*

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I. Introduction

At first glance, the proposed research topic could seem inappropriate during a period characterized by increasing skepticism with regard to the creation of the European Monetary Union and by the perspective of very severe fiscal arrangements, which would increase the costs of joining the Euro Area. Nevertheless, this issue is relevant not only for the admission to the Euro Area of all the CEE economies, but also in the context of increasing trade and financial integration of these economies with those from the monetary union. The seven CEE economies which have been included in the analysis are highly integrated, especially with the Euro area core countries and the dependence on them emphasized especially along with the occurrence of the economic crisis. For example, more than 50% of these CEE countries' exports are made to the core of the monetary union (Germany, France, Italy, the Netherlands and Austria) and more than 70% of the total stock of foreign direct investments comes from the same economies. Thus, the opportunity of admission to the Euro Area of the countries from Central and Eastern Europe should be explained by means of the business cycles synchronization with the Euro Area core countries (Darvas and Szapáry, 2005; Fidrmuc and Korhonen, 2006).

The synchronization of the business cycles represents one of the most important criteria of an optimum currency area, as it is influenced both by the structural and development gaps between economies and by the degree of economic integration between them. On the one hand, a lower real convergence with the Euro area will generate a higher asymmetry of shocks and it will reduce the correlation with the business cycles of the monetary union. The lower the synchronization is, the more the asymmetric impact of the common monetary policy will be and it will not result in the stabilization of all economies participating to the monetary union. The tendency of the monetary policy is to be counter-cyclical for the economies constituting the Euro Area core and it tends to be rather pro-cyclical for the economies which are divergent from the core, and this will not allow their macroeconomic stabilization. *This approach is a pessimistic one for the CEE economies which show a low real convergence with the Euro Area core, because it anticipates raising costs of the single currency.* The pessimistic view is also reinforced by the Krugman specialization hypothesis (1993), according to which the common currency will cause the intensification of the intra-industry trade and the decrease in the business cycles synchronization.

Nevertheless, the consequences of the previous approach may be influenced by the process of economic integration with the countries from the monetary union core. Generally, *the increase of the trade and financial integration with these economies will increase the correlation with their business cycles, which will decrease the costs of the common currency*. This more optimistic approach is also supported by the endogeneity hypothesis (Frankel and Rose, 1998), which asserts that the common currency will generate more commercial and financial linkages and an a higher ex post business cycles synchronization. Consequently, *the CEE economies which are less convergent with the Euro Area core may adopt the common currency if they become more economically integrated with the monetary union*. As a matter of fact, the European monetary union consists of heterogeneous economies and it is prone to asymmetric shocks, respectively to a two speed convergence of business cycles. The economies from the Euro Area core are highly economically integrated, while some of the periphery countries, such as Greece, are not synchronized with the monetary union. Under these terms*, the CEE economies which are more synchronized with the Euro Area core will obtain higher benefits as a result of joining the monetary union, while giving up the national currency will be more costly for the economies which are more convergent with the periphery*.

In order to assess the degree of the business cycles synchronization between seven CEE countries, the Euro Area core and periphery countries, we have structured this paper in three main parts. The first part is a synthesis of the results obtained in the economic literature which analyzed the relation between economic integration, adoption of the common currency and correlation of the business cycles. In the second section, we have presented the methodology to calculate the first principal component of the four econometric filters (Hodrick-Prescott, Band Pass, Beveridge-Nelson and Quadratic trend) used to extract the business cycles of the analyzed economies. The analysis is based on quarterly data for the entire period 1998:1-2011:1 and for its two sub-periods – 1998:1-2004:4 and 2005:1-2011:1, respectively. In the last part, we have used five estimation methods for the synchronization of the business cycles which are less used in the economic literature. By means of these methods we have made the classification of the CEE economies into four clusters, we have determined the persistence, respectively the volatility of their business cycles and we have assessed the dependence on the Euro area business cycle.

II. Economic literature

This section presents the main results obtained in the economic literature which studied both the way in which the business cycles have been identified and also the methods to estimate the correlation between the business cycles. The easiest way to identify the cyclical synchronization of an aggregate indicator, such as the GDP, is to extract its cyclical component and to calculate the statistical correlation between the business cycles, by means of the Pearson or Spearman coefficients. This method was used by authors such as Artis and Zhang (1997) Fidrmuc and Korhonen (2003), Darvas and Szapáry (2005), Levasseur (2008), Kappler et al. (2008), Gogas and Kothroulas (2009) and Dumitru and Dumitru (2010).

Some authors, such as Micco and others (2003), Baldwin (2006), Afonso and Furceri (2007) and Mink and others (2007) have estimated that the adoption of the common currency led to the intensification of trade relations and to higher convergence of the business cycles in the Euro Area. However, Gayer (2007) showed that business cycles in Greece, Finland, Belgium and Ireland were divergent from the Euro Area. Aguiar-Conraria and others (2008) have studied the correlation between the business cycles by means of the wavelet transformation and they identified a convergence of the peripheral economies to the Euro Area core, but at different speeds. To confirm this assumption, we have included the main conclusions of the Kappler et al. (2008). According to these authors, the following clusters of monetary union countries exist: 1. Austria, Germany and the Netherlands; 2. France, Belgium, Italy and Spain; and 3. Greece and Portugal.

The studies analyzing the synchronization of the business cycles between the new member countries and the Euro Area outlined inferior results if compared to the Euro Area core, that is, superior in comparison with some peripheral economies, such Greece. The results showed that there is no homogenous cluster of the new member countries, but most of them are rather correlated with Germany than with the Euro Area (Boone and Maurel, 1999). Artis and others (2004) and Darvas and Szapary (2004) estimated that there was a high correlation between GDP, output and export in the case of Hungary, Poland, Slovenia and the Euro Area. Carmignani (2005) estimated that Hungary and Poland only have business cycles which are highly correlated with the Euro area, while the other new member countries registered insignificant correlation coefficients. According to a meta-analysis of the correlation of the business cycles, Firdnuc and Korhonen (2006) showed that Hungary, Slovenia and Poland were the economies most correlated with Euro Area. Savva and others (2007) estimated that most of the new member countries doubled their correlation with the Euro Area, in comparison with the early ’90s, and some of them passed from a negative to a positive correlation. Levasseur (2008) considered that the fast adoption of the Euro currency by Poland, Slovakia, Estonia and Latvia colud be a good option for them. Albu (2008) identified a convergence of the long-run dynamics of structural changes with EU-27, which is a condition for higher business cycle synchronization in a larger monetary union. Dumitru and Dumitru (2010) estimated that the synchronization of the business cycles rose in all the new member countries starting with 2003, Romania recording the lowest correlation with the Euro Area, while the Czech Republic and Slovenia were characterized by a high correlation with the monetary union.

III. Principal component analysis

In this study, we have used four econometric filters and a consensus method in order to extract the trend and the business cycle (the cyclical component of the GDP). The changes of the trend are explained as being the result of the factors which influence the long-run aggregate supply (the capital stock, the labour supply, total factor productivity) and the variation in the cyclical component is caused by the short-term shocks of demand and supply. Most of methods for extracting the business cycle were used by Canova (1998) in the case of USA. The author concluded that the features of the business cycles change significantly according to the quantitative and qualitative techniques used, but each filter extracts various types of GDP data series. Darvas and Vadas (2005) have used five univariate filters in order to extract the cyclical component of the GDP - the segmented deterministic trend, the HP filter, the BP filter, the Beveridge-Nelson decomposition and the Wavelet transform. The standard methods for extracting of the business cycle have been reviewed by Purica and Caraiani (2009). In this paper, we have used four filters summarized below:

1. **Hodrick-Prescott filter (HP),** aimes to solve a problem regarding the minimization of a function referring to the mean square deviation of the cyclical component and to the changes in the increasing pace of the trend:

$$HP = \min_{y_t^*} \{ \sum_{t=1}^{T} [(y_t - y_t^*)^2 + \lambda \cdot \sum_{t=1}^{T} [(y_t^* - y_{t-1}^*) - (y_{t-1}^* - y_{t-2}^*)]^2 \} \quad (1)$$

Where: T represents the total number of observations; y_t – time series; y_t^* - the trend of the time series; $y_t - y_t^*$ is the cyclical component of the time series; λ - the trend component's smoothness degree, which can be interpreted as the importance given to the comparative variability of the trend according to the variation towards the trend (the cyclical component).

2. **Band Pass filter (BP)**, which decomposes the time series into components with periodic fluctuations, each of the components corresponding to a certain frequency/periodicity. The filter isolates the cyclical component of a variable, assuming that it develops in a medium frequency band, of which duration has been previously settled and which excludes the frequencies exceeding that band – the high and the low frequencies. The economic literature considers that the frequency band is between 1.5 and 8 years, corresponding to 6 – 32 quarters.

3. **Beveridge-Nelson decomposition (BN)**, which is based on the hypothesis that an ARIMA (p, 1, q) process can be described as a sum of the stochastic trend and a stationary component by which the Stochastic trend is defined as a *random walk*. Considering a general ARIMA model (p, 1, q), it will have the following form:

$$\alpha(L) \cdot \Delta y_t = c + \beta(L) \cdot e_t \qquad (2)$$

$$\alpha(L) = 1 - \alpha_1 \cdot L - \alpha_2 \cdot L^2 - ...... - \alpha_p \cdot L^p$$

$$\beta(L) = 1 - \beta_1 \cdot L - \beta_2 \cdot L^2 - ...... - \beta_q \cdot L^q$$

where: the terms α and β are less than unit, and p and q represent the exponents corresponding to the terms AR and MA. In a Wold representation, the ARIMA model may be written under the form of a moving average, as it follows:

$$\Delta y_t = \mu + \gamma(L) \cdot e_t \text{, where } \gamma(L) = \alpha(L)^{-1} \cdot \beta(L) = \sum_{j=0}^{\infty} \gamma_j \cdot L^j \qquad (3)$$

The Beveridge Nelson decomposition will be given by the following equation:

$$y_t = y_0 + \delta \cdot t + \gamma(1) \cdot \sum_{j=1}^{t} e_j + \sum_{k=0}^{\infty}(- \sum_{j=k+1}^{\infty} \gamma_j) \cdot L^k \cdot e_t \qquad (4)$$

The first two terms refer to the deterministic trend, the third term refers to the stochastic trend and the last one is related to the cyclical component of the GDP.

4. **Quadratic trend filter (QT)**, which can be used if the growth rate of the GDP has increases and decreases, and in such a case the trend will record minimum/maximum points. The trend may be described under the form of a square polynomial function related to time: $y_t^* = a + b \cdot t + d \cdot t^2$. The GDP will be written as a sum of the two components – the trend and the business cycle –, the second component actually being the residual of the following equation:

$$y_t = a + b \cdot t + d \cdot t^2 + c_t \qquad (5)$$

In order to achieve a composite indicator of the business cycles, we have used the **method of the principal components**, its goal being to identify the common factors occurring in the business cycles which have been extracted according to the four previous methods. The principal component analysis (PCA) transforms k explanatory variables between which there is a high correlation in k new variables without correlation between them. The initial explanatory variables are data series referring to the business cycles extracted by means of the four methods (HP, BP, BN and QT) for each economy included in analysis. The number of the principal components will be equal to the previous variables and they will be marked as PC1, PC2, PC3 and PC4, writing them under a form of a matrix, as it follows:

$$\begin{bmatrix} PC1 \\ PC2 \\ PC3 \\ PC4 \end{bmatrix} = \begin{bmatrix} e_{11} & e_{12} & e_{13} & e_{14} \\ e_{21} & e_{22} & e_{23} & e_{24} \\ e_{31} & e_{32} & e_{33} & e_{34} \\ e_{41} & e_{42} & e_{43} & e_{44} \end{bmatrix} \cdot \begin{bmatrix} HP \\ BP \\ BN \\ QT \end{bmatrix} \quad (6)$$

where: e_{ij} (i, j de la 1 la 4) represent the components of a eigenvector, of which length is equal to unit and which has the propriety of orthogonality. PC1 is the component, which catches the most of the variation of the business cycles determined by means of the four methods. The methodology is explained in detail in Dinu et al. (2012).

3.1. Data series

In order to estimate the degree of synchronization between the business cycles, we have used the composite data series of the first principal component (PC1) for seven CEE economies (Romania, Bulgaria, Hungary, Slovakia, Slovenia, Czech Republic and Poland), for five Euro Area core economies (Germany, France, Italy, Netherlands and Austria), for four periphery economies (Spain, Portugal, Greece and Ireland), and for the Euro area as a whole. The original data series was quaterly GDP from Eurostat database, expressed in constant prices (millions of Euro), with base year 2000. The period is 1998:Q1-2011:Q1, namely 53 observations, except for Greece, in which case there is a shorter availability of data (starting with 2000 Q1). Before extracting the cyclical component, we have used the TRAMO/SEATS procedure from EVIEWS 7 software to eliminate the seasonality of data. After this process, we have used the logarithm of the GDP data series and we have applied the Hodick-Prescott, Band-Pass, Quadratic Trend and Beveridge-Nelson filters to extract the cyclical component (the output gap or the business cycle).

IV. The business cycles synchronization

To estimate the business cycles synchronization between the seven CEE economies and the core and the Euro Area periphery respectively, we have used a few methods seldom used in the economic literature. These methods do not explain synchronization according to the statistical correlation between the business cycles, as in the classical approach, but according to concepts such as clusterization, persistence, dependence and volatility of the business cycles. This section presents the results obtained after using five methods.

The first one refers to the cluster analysis, which aims to classify the 16 EU economies into four country clusters, according to the Ward algorithm. The second method implies the regression of the business cycle for each economy according to the autoregressive component and to the Euro Area's business cycle. The degree of persistence of the business cycle may be determined according to the autoregressive component, its similar levels constituting a condition for the sustainability of a monetary union. The national business cycle dependence on that of the Euro area is explained by means of the coefficient of elasticity between the two variables. The third method implied the identification of the impulse-response functions of the CEE economies' business cycles to the Euro Area common shocks and to the shocks which are specific to each economy, respectively. These functions were created according to SVAR models in which we have included the business cycles of the Euro Area and of the CEE economies. The obtained results allowed us to identify both the persistence of the national business cycles and also the dependence on the shocks in the Euro Area, these aspects also resulting, under a different form, after applying the previous method. The fourth method refers to the calculation of the first order statistical autoregressive coefficient, its goal being to estimate, in a different way, the degree of persistence of the business cycle. The last method refers to the identification of the volatility related to the business cycles according to the standard deviation.

4.1. Cluster analysis

The objective of this method is to identify the clusters of countries between which we find the lowest differences related to macroeconomic evolution, in other words those between which there is the highest synchronization. In order to determine the clusters, we have applied the Ward method, according to Graff (2006). Its starting point is the Euclidean distance, according to which the distance between two variables x and y is equal to the square root of the sum of the squares of the differences between the values of those variables: $d(x,y)=\sqrt{\sum_i (x_i - y_i)^2}$

The Ward algorithm calculates the average and the Euclidean distance for all the clusters which can be created according to the available set of variables. Then, the clusters are determined according to the criterion referring to the lowest increase in the Euclidean distance, in order to maximize homogeneousness. The function of the linkage between two clusters will show the increase in the error sum of squares (ESS) after their merging into one. This algorithm continues by successively identifying the clusters in several stages, but minimizing the ESS increase each time, during each stage. Initially, each variable is a cluster, and ESS is zero. For a variable X with n values, ESS is the sum of the squares for the deviations from the average of each value, and it is given by the following equation:

$$ESS(X) = \sum_{i=1}^{n} (x_i - \frac{1}{n}\sum_{j=1}^{n} x_j)^2 \quad (7)$$

The function of the linkage between two clusters X and Y, the one that measures the distance between them, may be written as it follows:

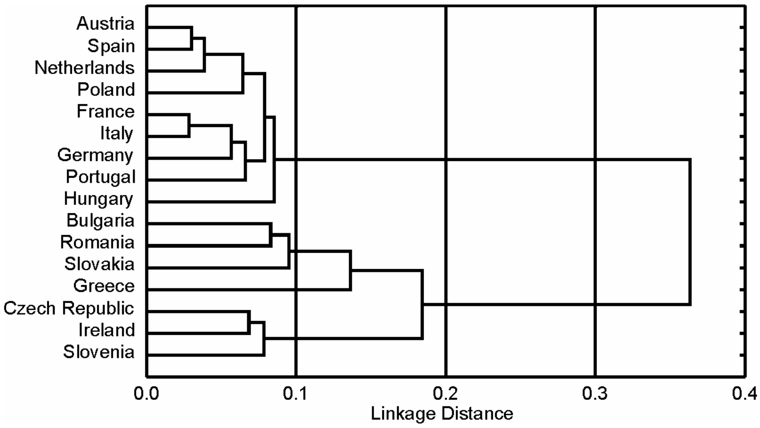
$$D(X,Y) = ESS(XY) - [ESS(X) + ESS(Y)] \quad (8)$$

where: XY represents the combined cluster resulted from the merging of the clusters X and Y. In contrast to other methods used to find the clusters concentrating on the distance between them, the Wald method maximizes the homogeneity within the clusters resulted from the merging of the clusters. This is the reason why the identification of the clusters by means of the Ward method represents an appropriate procedure to determine the synchronization of the business cycles.

Within this study, we have used the composite business cycle of the first principal component (PC1). The cluster analysis has been made both for the entire period 1998-2011, and also for its two sub-periods, in order to identify the changes in the structure of the clusters starting from 2005. The figure below presents a chart of the clusters identified by means of the dendrogram, an instrument that allows the clustering of the 16 national economies according to the linkage distance. The longer the horizontal lines are, the more significant the differences from a certain cluster will be.

Figure 1

Clusters identified with the Ward method (1998-2011)



Among the economies included in the analysis, Greece had the highest divergence relative to the other economies or to the clusters created from them. At the lowest aggregation level, there are four clusters consisting of two economies, as the others do not belong to any cluster. The most synchronized clusters of economies during the period 1998-2011 were Austria-Spain, France-Italy, Bulgaria-Romania and the Czech Republic-Ireland. Four clusters of three and four countries were identified at the next level of aggregation. The most synchronized economies are: Austria-Spain-the Netherlands, France-Italy-Germany, Bulgaria-Romania-Slovakia and the Czech Republic-Ireland-Slovenia. The economies which do not belong to any cluster are Poland, Portugal, Hungary and Greece. At higher aggregation levels, we may identify three clusters, which catch the higher synchronization of Poland and Hungary with the five Euro Area core economies. The core of the monetary union is homogenous, but the other two clusters of economies are heterogeneous, the CEE economies and the periphery ones respectively belonging to all the three clusters. At the highest aggregation level, there are two big clusters, one of them being focused on the Euro Area core economies and the other one consisting of the CEE and periphery economies only.

In order to outline the dynamics of the clusterization process, we have used the previous procedure in order to create a hierarchy of the 16 economies, before and after the end of 2004. This threshold catches both the impact of joining the European Union of five out of the CEE economies and also the influence of the quite high growth rates of these economies. We have retained an intermediate aggregation level with four clusters, the results being included in Table 1. At a superior aggregation level, there will be two clusters, the core, consisting of clusters 1 and 2 and the periphery, including clusters 3 and 4.

Table 1

Clusterization of the 16 economies during the two sub-periods

		1998:1-2004:4	2005:1-2011:1
Cluster 1	Core cluster	Austria, France, Spain, Slovenia, Poland, Ireland	Austria, Netherlands, Spain, France, Italy, Poland, Portugal
Cluster 2		Germany, Italy, Netherlands Portugal	Germany, Hungary
Cluster 3	Periphery cluster	Bulgaria, Hungary, Czech Republic	Bulgaria, Romania, Czech Republic, Ireland, Slovakia, Slovenia
Cluster 4		Greece, Romania, Slovakia	Greece

According to the analysis based on sub-periods, it results that there was a high heterogeneousness persistence of the four clusters and a quite low one in the case of the core-periphery cluster. Thus, not all the periphery economies of the Euro Area are part of the periphery cluster, as this cluster does not include all the seven CEE economies. Since 2005, Greece has had a economic evolution divergent from the rest of the EU, while the other two economies of cluster 4 (Romania and Slovakia) of the first sub-period have become more synchronized with other economies, such as Ireland, Slovenia and the Czech Republic. Along with joining EU, Hungary has become more synchronized with the economies constituting the core cluster, especially with Germany. On the contrary, Slovenia has become more correlated with the periphery cluster, despite the fact that it adopted the common European currency in 2007r. The same assertion is also valid for Slovakia, which continued to remain an economy less synchronized with the rest of the Euro Area even after 2005. Nevertheless, the lower synchronization of the two CEE economies may be diminished by a higher economic flexibility, which is specific to the smaller economies.

4.2. Regression between business cycles

This method implies OLS regression, which helps to determine both the persistence of the national business cycles and the dependence on the business cycle of the Euro Area as a whole. If the elasticity coefficients indicating the persistence and the dependence are more similar to those from the Euro Area core, the synchronization of the business cycles will be higher, and the decision to adopt the single currency will be less costly. The form of the regression equation is:

$$OG_{X,t} = \alpha + \beta \cdot OG_{EA,t} + \sum_{i=1}^{n} \gamma_i \cdot OG_{X,(t-i)} + \varepsilon_t \qquad (9)$$

where: OG – output gap (business cycle);

β – degree of dependence between the business cycles of the economies X and that of the Euro Area (EA)

γ_i – degree of persistence of the business cycle for the economy X;

n – the maximum autoregressive lag of the business cycle for the country X.

The coefficients γ_i indicate *the degree of persistence of the national business cycles*, namely the way the business cycle reacts according to its lagged values. The effect of any shock upon the business cycle depends on its degree of persistence – for a persistent series, the shock will have an impact on a longer time, while for a low persistent series the shock will be more quickly neutralized. In terms of business cycles synchronization it is important to have a similar persistence level, namely a quite consistent response to certain shocks. Theoretically, the more flexible economies will record a lower persistence of the business cycle, while the shocks will be more persistent in more rigid economies.

We have tested the OLS regression equation for each of the 16 economies included in this study. For most of the economies, we have used the business cycle of the first principal component and we retained one autoregressive lag only for them. As for Poland, Slovenia and Greece the estimated models have been statistically invalidated (occurrence of error autocorrelation and non-stationarity of the autoregressive model, respectively), we have used, in their cases, the business cycle extracted with HP filter. The results obtained after achieving the 16 OLS regressions are characterized by a high degree of significance (according to the R-squared adjusted) and by the absence of autocorrelation error (according to the values of the Durbin-Watson coefficient). The obtained results are included in table 2.

Table 2

OLS regression of the national business cycles

Dependent variable: OG_i							Number of years when a 1-unit shock continues to exceed 0.5 – according to AR(1)
Country i	Constant	OG_{EA}	AR(1)	AR(2)	Adjusted R-squared	Durbin-Watson stat	
Romania	-0.02***	0.77	0.94		0.89	1.99	3
Bulgaria	0.00***	0.49	0.90		0.85	1.72	1.75
Czech Republic	0.00***	0.92	0.87		0.92	1.90	1.25
Poland/	0.00***	0.38	0.86		0.83	1.88	1.25
Slovakia	0.00***	1.17	0.82		0.83	1.90	1
Slovenia/	0.00***	1.38	0.65	0.16***	0.88	1.88	0.5
Hungary	0.00***	1.07	0.76		0.88	1.84	0.75
Greece/	-0.02***	0.38**	0.98	-0.06***	0.70	2.02	9.75
Ireland	0.00***	0.99	0.89		0.94	1.72	1.5
Portugal	0.00***	0.63	0.77		0.86	2.01	0.75
Spain	0.00***	0.62	0.93		0.96	2.07	2.5
Italy	0.00***	0.88	0.69		0.97	2.03	0.5
Germany	0.00***	1.37	0.90		0.97	1.87	1.75
France	0.00***	0.72	0.78		0.98	1.70	0.75
Austria	0.00***	0.86	0.70		0.96	1.84	0.5
Netherlands	0.00***	0.90	0.88		0.97	1.72	1.5

Note: / HP filter; *** - insignificant at the thresholds of 1%, 5% or 10%; **- significant at the threshold of 10%.

Making an analysis of the *dependence on the Euro Area business cycle*, according to the value of the β coefficients, it results that four economies (Slovenia, Germany, Slovak and Hungary) had an inelastic business cycle, so that an expansionary gap of 1% of the monetary union led to a positive national gap exceeding 1%. Among the other economies of Euro Area, Ireland is characterized by a similar reaction to the macroeconomic situation of the entire Euro Area (β=0.99), while inelastic business cycles are recorded by France, Portugal and Spain, namely a lower dependence on the business cycle of the Euro Area as a whole. The obtained results confirm the fact that Greece is totally unsynchronized with the rest of the EuroArea, this aspect being also outlined by means of the previous method for determining the degree of business cycles synchronization. The heterogeneity of the business cycle's dependence which occurs inside the Euro Area is also obvious in the case of the CEE economies. Except for the economies highly dependent on the business cycle of the Euro Area, there are also other economies, such as Poland and Bulgaria, which are more dependent on domestic conditions and less on the EMU ones.

Making an analysis for the values corresponding to the coefficients of *persistence of the business cycles* included in Table 2 results a high heterogeneity both between the core and the periphery countries of the Euro Area, and also between of the seven CEE economies. For an optimum monetary union, there should be a persistence which is quite close to the national business cycles according to the one period lagged shocks, and this will encourage a higher synchronization between the business cycles. For example, Greece and Romania have recorded the highest values, while Slovenia was characterized by the lowest persistent business cycle. A higher persistence coefficient may suggest both a low capacity to neutralize negative shocks during recession periods and also the occurrence of a multiplying effect of the positive shocks during the economic recovery periods. According to the autoregressive coefficient, we have calculated the time interval when one unit shock persists until it becomes half. This interval is approximately 10 years in the case of Greece, 3 years in Romania, 2.5 years in Spain and only 0.5 years in Slovenia, Austria and Italy.

4.3. The SVAR models

In this section, we have applied a methodology used by Giannone and Reichlin (2006), Keppler and others (2008) and Bencik (2011), which implies the creation of an impulse-response function to the shocks which are specific to each CEE economy, and to the shocks coming from the Euro Area. According to this methodology, we may express both *the persistence of the business cycle of a CEE economy*, and also *the dependence of the business cycle of each CEE economy on that of the Euro area*. The hypothesis of this approach is that the Euro area economies are influenced by common shocks, and the impact of the CEE economies' shocks upon them is ignored. On the contrary, the CEE economies are influenced both by the Euro Area common shocks and also by the inside shocks which are specific to each economy. In order to identify the functions of impulse-response, we have created a VAR model for the business cycle of a CEE economy and another one for the Euro Area, each of the models meeting all the validity conditions. The general form of the model is:

$$\begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = \sum_{i=1}^{n} A_i \begin{bmatrix} OG_{EA,t-i} \\ OG_{X,t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \qquad (10)$$

where A_i is a matrix of the form 2x2, and ε represents the residuals of the output gaps which have a general matrix of variance-covariance. Equation (10) is equivalent with:

$(I - \sum_{i=1}^{n} A_i \cdot L^i) \cdot \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix}$, where *I* is an identity (2x2) matrix:

$$I = A(L) \cdot B(L)$$

$$A(L) = (I - \sum_{i=1}^{n} A_i \cdot L^i);\ B(L) = \sum_{i=0}^{\infty} d_i \cdot L^i$$

where L^i is a lag operator $L^0\varepsilon_t = \varepsilon_t$; $L^1\varepsilon_t = \varepsilon_{t-1}$; $L^2\varepsilon_t = \varepsilon_{t-2}$....

Equation (10) may be re-written under the following form:

$$B(L) \cdot A(L) \cdot \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = B(L) \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \Rightarrow \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = B(L) \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} = \sum_{i=0}^{\infty} d_i \cdot L^i \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \quad (11)$$

The VAR model will change into a structural form, the structural shocks (u_t) being directly associated with the vector of the output gaps. To obtain the structural form of the VAR model (equation 12), we have multiplied the equation (10) with P^{-1}, where P is a 2x2 parameter matrix.

$$P^{-1} \cdot \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = P^{-1} \cdot \sum_{i=1}^{n} A_i \cdot \begin{bmatrix} OG_{EA.t-i} \\ OG_{X,t-i} \end{bmatrix} + P^{-1} \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \Rightarrow$$

$$\begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} - P^{-1} \cdot \begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} + P^{-1} \cdot \sum_{i=1}^{n} A_i \cdot \begin{bmatrix} OG_{EA.t-i} \\ OG_{X,t-i} \end{bmatrix} + P^{-1} \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \Rightarrow$$

$$\begin{bmatrix} OG_{EA,t} \\ OG_{X,t} \end{bmatrix} = \sum_{i=0}^{n} C_i \cdot \begin{bmatrix} OG_{EA,t-i} \\ OG_{X,t-i} \end{bmatrix} + \begin{bmatrix} u_{EA,t} \\ u_{X,t} \end{bmatrix} \qquad (12)$$

Where:

$C_0 = I - P^{-1}$; $C_i = P^{-1}A_i$ i = 1, n

The following equation describes the relationship between the residuals of the VAR model and the common shocks, respectively those which are specific to an economy X:

$$\begin{bmatrix} u_{EA,t} \\ u_{X,t} \end{bmatrix} = P^{-1} \cdot \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} \Rightarrow \begin{bmatrix} \varepsilon_{EA,t} \\ \varepsilon_{X,t} \end{bmatrix} = P \cdot \begin{bmatrix} u_{EA,t} \\ u_{X,t} \end{bmatrix} \qquad (13)$$

Where P matrix is:

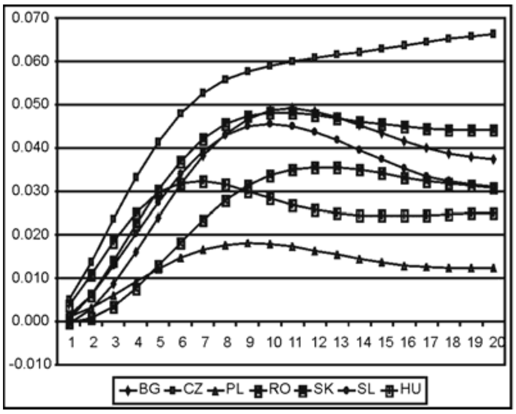
$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix}$$

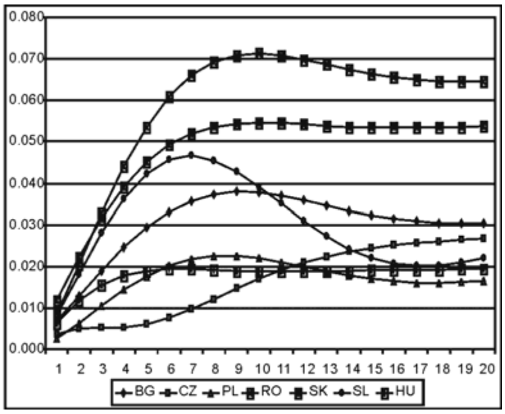
According to equation (13), it results that 4 constraints are necessary in order to identify the four elements of matrix *P*. Two of them refer to normalization of the shocks (*$u_{EA,t}$ and $u_{X,t}$*) variance. The usual convention in the VAR models is the unit variance, which, along with the orthogonality hypothesis will allow to identify the third constraint P'P=Σ, where Σ is the matrix of the covariance for the VAR model residuals. The last constraint refers to the absence of influence from the shocks which are specific to the

CEE economy (X) upon the Euro area economies, namely $P_{12}=0$.
Once identified the structural shocks (u_{EA} and u_X), we have created the impulse-response functions of the business cycles for the seven CEE economies according to the two shocks. The charts below present the accumulated response on 20 quarters of the national business cycles to a structural shock of a standard deviation, coming from the Euro area, respectively a country specific shock.

Figure 2.1. **Figure 2.2.**

Accumulated response of the CEE business cycles to the Euro area shocks and to the internal shocks





The business cycle of the Czech Republic reacts to the shocks from the monetary union, both on short-term and also after the 20 quarters, being the only economy in which the influence is not diminished at the end of the interval. Thus, a positive shock of one standard deviation led to an increase in the business cycle by more than 0.06 after 11 quarters. The lowest dependence on the shocks of the Euro Area is recorded by Poland, their influence decreasing after 9 quarters and settling about 0.01 after 20 quarters. Making a comparison with the results of section 4.2, we notice that the CEE economies which are currently highly dependent on the business cycles of the Euro Area (Hungary, Slovakia, Slovenia and Czech Republic) are characterized by the highest dependence on the shocks of the monetary union on short term. Nevertheless, after the 20 quarters since the occurrence of the shock, its influence is quite low in Slovenia and in Hungary. As for the internal shocks which are specific to each CEE economy, Romania and Slovakia have the most persistent business cycles. In other words, the evolution of the two economies responds to a greater extent to the domestic shocks, compared to the other CEE countries. Thus, a positive shock of 1 standard deviation is transmitted to the business cycle with an influence at least 0.05 standard deviation, thus becoming persistent. If we compare the intensities of the two structural shocks, the result is that Romania's economy is more dependent on the domestic conditions, while the Czech Republic, Slovenia and Bulgaria respond more to the shocks coming from the Euro area and less to the domestic ones.

4.4. Autocorrelation coefficient method

According to Darvas (2004), the persistence of the business cycles may also be identified according to the first order autocorrelation coefficient. This coefficient is identified under the form of simple correlation between the coefficient for the first N-1 observations of the business cycle (t=1,2,....,N-1) and the next N-1 observations (t=2,3,....,N). The higher this coefficient the business cycle more persistent will be. We found this coefficient both for the entirely analyzed period, and also for two sub-periods in order to outline the change in persistence of the business cycles since 2005 (Table 3).

Table 3

The 1st order autocorrelation coefficient of the business cycles

	1998:1-2011:1	1998:1-2004:4	2005:1-2011:1
Romania	0.93	0.78	0.94
Bulgaria	0.91	0.47	0.94
Czech Republic	0.92	0.94	0.91
Poland	0.92	0.91	0.94
Slovakia	0.87	0.61	0.91
Slovenia	0.91	0.78	0.91
Hungary	0.84	0.59	0.86
Greece	0.91	0.75	0.92
Ireland	0.94	0.91	0.95
Portugal	0.86	0.85	0.86
Spain	0.94	0.89	0.94
Italy	0.90	0.90	0.90
Germany	0.87	0.88	0.87
France	0.91	0.92	0.91
Austria	0.93	0.94	0.92
Netherlands	0.92	0.93	0.91
Euro area (17 members)	0.90	0.92	0.90

During the entire period 1998-2011, Hungary, Portugal, Slovakia and Germany recorded the lowest persistent business cycles, while Spain and Ireland were characterized by a high persistence. Nevertheless, the differences between the economies included in the analysis are quite low, suggesting a quite similar transmission of the shocks upon the national business cycles. Making a comparison with the level recorded by the Euro Area, most of the new member countries (except for Slovakia and Hungary) and of the cohesion countries (except Portugal) have more persistent business cycles. If we make a comparison between the persistence levels of the two sub-periods, it results that the Euro Area has become a more homogenous union since 2005. In the case of the EMU-12 countries (except Greece), no significant changes in the persistence coefficient have occurred since 2005, if compared to the period ending in 2004, all the Euro Area core economies recording a low tendency to decrease the persistence of the economic shocks.

The most important changes in the persistence of the business cycles have occurred in five CEE economies. Thus, the persistence of the business cycles has significantly increased in Bulgaria, Romania, Slovakia and Slovenia, along with the emphasis on the economic integration with the Euro Area economies, as the degree of persistence is a little higher than in the economies of the monetary union core. As a consequence, the economic integration of the CEE economies generated the emphasis on their recessionary or inflationary gaps. In the absence of internal mechanisms for the adjustment of the shocks, the adjustment of the main trade partners becomes extremely important, and usually they are economies belonging to the Euro Area core. Thus, the settling of the recessionary gap in a CEE country may be more easily achieved by expanding the Euro Area core, similar to the way in which a prolonged recession may be the consequence of the restrictive policies promoted in economies such as Germany, France or Italy.

4.5. Standard deviation of the business cycles

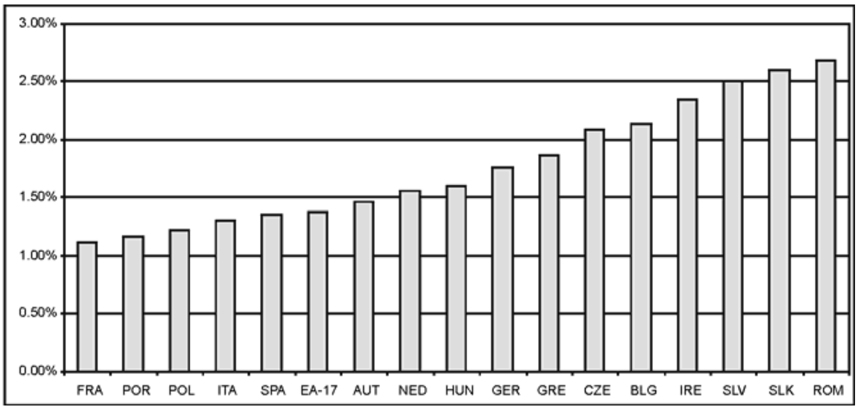
The standard deviation represents an adequacy instrument to estimate the volatility of the business cycles. Generally, the advanced economies are characterized by a tendency to decrease the volatility of the business cycles, especially since the middle of the ’90s, this process being called the „Great Moderation” by Blanchard and Simon (2001). The main factors generating a higher stability of the business cycles were the decrease in volatility of the exchange rates, the enhancement of the trade and financial integration and a better management of the monetary-fiscal mix, which decreased the amplitude and the frequency of the macroeconomic shocks. Kappler and others (2008) estimated the decrease in volatility of the business cycles for the countries of the monetary union core, especially after introducing the common currency, while the CEE economies have a quite high cyclical volatility. Male (2010) estimated that the output is, on average, twice as volatile in the emerging countries if compared to the advanced economies, as volatility is in inverse relation with an economy's development level. According to Loayza *et al.* (2007) the volatility differences are caused by the low neutralization capacity of the shocks by the emerging economies, as well as by the differences related to the economic opening, the size of an economy or the degree of financial intermediation.

Estimating the standard deviation for the business cycles of the 16 economy and of the Euro Area, it results a lower volatility of the periphery countries compared to that of the economies of the Euro Area core (Figure 3).

The monetary union faced a recessionary gap until the beginning of 2006, especially as a result of the structural rigidity occurring in the economies constituting the core of the monetary union. The reforms implemented in the labour market, in the common market and the international financial position allowed to the Euro Area to enter an expansionary gap which increased at the beginning of 2008. Among the economies constituting the Euro Area core, Germany recorded the highest inflationary gap during the first quarter of 2008, but it also had a faster response to the neutralization of the recessionary shock induced by the economic crisis. Consequently, the increase in the German economic flexibility generated a higher volatility of the business cycles, which is higher than the average of the Euro Area. Other economies, such as France, Portugal and Italy had a standard deviation of maximum 1.3%.

Figure 3

Volatility of the business cycles



The CEE countries are characterized by different real convergence speeds towards the EU levels, having a distinct exposure to external shocks, generally, a low adjustment capacity. Thus, the standard deviation of Poland's business cycle was 12% lower than that of the Euro Area, while the business cycles of Romania and Slovakia had a double volatility compared to that of the monetary union (about 2.6%). The most volatile CEE economies have been those which recorded the highest rates of economic growth during the period 2004-2008. Along with the liberalization of the capital accounts and with the accession to the EU, the new economies benefited from significant capital flows, which generated, in most cases (except Poland), overheating. Thus, at the beginning of 2008, Slovakia and Romania recorded the highest values for the inflationary gaps (6.8%, respectively 6.7%). Nevertheless, the capital flows increased the CEE countries' exposure to external shocks, so that the contagion of the economic crisis induced a more significant contraction of the economies which had previously recorded a larger expansion.

V. Conclusions

This study extends the significance of the business cycles synchronization concept, which is usually measured by statistical correlation. Thus, we have identified the clusterization tendencies in an enlarged Euro Area, the dependence on the business cycle of the Euro Area, the degree of business cycles persistence and their volatility. Each of the five used methodologies outlined the fact that the current Euro Area has a core-periphery heterogeneous structure, its enlargement towards other CEE economies leading to an emphasis of divergence inside the monetary union. The Euro area core is quite homogenous, consisting of economies with a quite close development level and being highly economically interdependent, which obtained the highest benefits from using the single currency. The first lesson of our analysis is that the performance of a CEE economy should not be considered with reference to the situation of the Euro Area as a whole, but in relation to the evolution of the monetary union core. Thus, the CEE economies which are the most synchronized with the Euro

Area core would obtain higher benefits as a result of joining the monetary union, while for the economies which are more convergent with the periphery, giving up their own currency would be more costly. The second lesson refers to the complexity of the business cycles synchronization. It is true that the enhancement of the commercial and financial integration of the CEE economies with the Euro area core will increase the economic linkages between them, but, on long term, it does not ensure the convergence of the macroeconomic evolutions. If the structural and income divergences between them are persistent, then monetary integration generates a temporary synchronization of business cycles, which will disappear with the action of the first economic shock. Consequently, the CEE economies will record a different persistence of the business cycles related to the Euro Area core, and the volatility of the business cycles will be higher than that of the monetary union. Applying the complex synchronization analysis to all the seven CEE economies higher costs of euro adoption results in the case of Bulgaria and Romania and lower costs for Hungary, Czech Republic and Poland.

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