

Anagnostou, Ageliki; Panteladis, Ioannis; Tsiapa, Maria

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## Disentangling Different Patterns of Business Cycle Synchronicity in The EU Regions

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## Disentangling Different Patterns of Business Cycle Synchronicity in The EU Regions

Ageliki Anagnostou\* Ioannis Panteladis\*\* and Maria Tsiapa\*\*\*

\*Department of Economics, University of Thessaly, Greece  
Tel. +3024210 74596, Email: aganag@uth.gr

\*\*National Centre for Social Research, Greece  
Tel. +30210 7491600, Email: panteladis@yahoo.com

\*\*\*Department of Planning and Regional Development, University of Thessaly, Greece  
Tel. +3024210 74467, Email: mtsiapa@uth.gr

### Abstract

The present paper provides a comprehensive and consolidated analysis of the business cycle synchronicity between European regions and EU-14. Our study is conducted in three levels. First, we analyse regional business cycle synchronization with the EU-14 benchmark cycle, using real GDP in 200 NUTS II regions for a period of 30 years (1980-2009), detrended by Hodrick–Prescott filter. Secondly, we employ a VAR type methodology as a measurement device to examine the dynamic relationship of the regional business cycles. Our main interest is to study the dynamics of business cycles as well as the pattern of the transmission mechanism to regions with different level of development. Finally, following Imbs (2004) and Tondl and Traistaru (2006), we empirically extend the research on identifying factors which might drive regional business cycle synchronization. In particular, we analyse the role of trade integration-cum- the sectoral patterns of specialisation as determinants of regional growth cycle correlations with the EU-14. Moreover, we draw attention to regional productivity as another possible determinant of business cycle synchronisation associated with the pattern of the spatial distribution of economic activities across regions. Panel three-stage least-squares estimation is implemented for the simultaneous equations between determinants and regional business cycles synchronisation.

**JEL Classification:** R11, R12, E32

**Key Words:** Business Cycles, Synchronization, 3SLS, Panel VAR, Impulse response function, EU 14 Regions

## 1. Introduction

The degree of synchronization of macroeconomic fluctuations across economies has been the core issue in the debate of the economic integration literature. European integration has dominated the scene of the empirical studies due to the venture of a common currency in the context of the EU that unavoidably raises questions with respect to the pattern of integration per se and consequently to the ideal operation of an optimum currency area. In that sense, there has been a growing concern on whether there exist divergences of economic trends in the euro zone. In terms of policy implications, if divergences exist, a common policy, i.e. monetary policy, may not be equally effective for all countries in the union; therefore, the problem “*one size does not fit all*” cannot be dismissed. According to De Haan *et al.* (2008), if business cycles in countries forming a monetary union diverge considerably, the common monetary policy will not be optimal for all countries concerned.

Moreover and taking into consideration that any national economy is composed of diverse interlinked regions with different economic characteristics and activities, the integration process is likely to have a stronger effect at the regional level than at the national one. This stronger effect can be expected because regions trade relatively more than countries and specialisation at regional level is higher at the regional level than at the national one (Krugman 1993, Fatás 1997). Barrios and de Lucio (2003) argue that the dynamics of regional business cycles may condition the adjustment of national economies to economic integration. Consequently, assessing the regional business cycle synchronisation has now become more operational and reliable, and research has been directed to the study of possible asymmetric effects at a spatially disaggregated scale.

The different theoretical approaches of analysing the synchronicity of business cycles focusing on both at national and regional level, unavoidably reach quasi different conclusions. Moreover, different datasets vary considerably across studies, making it difficult to compare the results and finally have a comprehensive and consolidated picture of the regional business cycle synchronicity.

The purpose of this paper is to study in a comprehensive and consolidated way the regional business cycle synchronisation at NUTS II level. For this purpose, our investigation explicitly addresses two interrelated questions: a) Is the pattern of business cycle synchronization different across regions with different level of development? if so, b) what are the drives of the regional business cycle synchronization? In order to answer the above questions, our analysis is conducted into three levels. Firstly, we analyse regional business cycle synchronization with EU-14 benchmark cycle, using real GDP in 200 NUTS II regions for a period of 30 years (1980-2009), detrended by Hodrick–Prescott filters. Secondly, we employ a VAR type methodology as a measurement devise to examine the dynamic relationship of the regional business cycles. More specifically, we employ a panel VAR model in order to study the transmission mechanism of the stochastic shocks on the regional business cycles. Finally, following Imbs (2004) and Tondl and Traistaru (2006), we empirically extend the research in identifying

factors which might drive regional business cycle synchronization. In particular, we analyse the role of trade integration and the different regional specialisation patterns, as determinants of regional growth cycle correlations. Last but not least, we draw attention to regional productivity as an additional possible determinant of business cycle synchronisation associated with specific characteristics of the distribution of economic activities across European space. Panel three-stage least-squares estimation is implemented for the simultaneous equations between determinants and business cycles synchronisation.

The paper is organized as follows. Section 2 provides a brief literature review, while Section 3 presents some stylised facts of the EU regional cycles synchronisation. Section 4 employs a panel VAR model to examine the dynamic relationship of the regional business cycles; methodology, data and estimated results are reported in the same section. In Section 5, we determine the drives of regional business cycle synchronisation at the NUTS II level, employing a system of simultaneous equations. The model, the data and the results are presented in the same section. Section 6 concludes and discusses policy implications of our results.

## **2. Short Literature Review**

Business cycle synchronisation has been addressed in a numerous studies; yet, it has been approached empirically via three different channels of investigation. In the first stance of empirical investigations, and giving emphasis on the time series properties of the business cycle synchronisation, studies predominantly apply non-parametric filters such as the Hodrick-Prescott (Hodrick and Prescott 1997) filter, the Baxter-King (Baxter and King 1999), the Christiano-Fitzgerald (Christiano and Fitzgerald 2003), band pass filters, and the phase average trend-PAT (Boschan and Ebanks 1978) to measure business cycle, decomposing output into trend and cycle components from observed real output. After have measured business cycles, synchronicity is measured by computing contemporaneous unconditional Pearson correlations either between the business cycles of individual regions and a reference country/EU benchmark cycle or computed as unconditional bilateral correlations. To check for convergence (synchronisation), business cycle correlations are typically computed over different time periods using a fixed or rolling sample window. Some significant contributions in this type of literature are among others, by Fatás (1997); Harding and Pagan (2002); Doyle and Faust (2002); Gayer (2007); Massmann and Mitchell (2004); Koopman and Azevedo (2003); Artis and Zhang, (1997, 1999).

In the second stance of empirical investigations, studies examine the dynamic relationship of the business cycles by mainly employing VAR type models. Explaining shocks through economic interdependence, this type of analysis explains how shocks are transmitted from one economy to another. In this framework, Jagrič (2002) identifies a high degree of synchronization of the Slovenian cycle with the German cycle. In a similar line of research, Benčík (2011) examines the business cycle synchronisation between the V4

countries (Czech Republic, Hungary, Poland and Slovakia) and the euro area, by directly calculating cross correlations and output gap component correlations from common and country-specific shocks. He concludes that the business cycles of the V4 countries were gradually more synchronised with the euro area as an outcome of integration process. Filis *et al* (2010) examines the degree of business cycles synchronisation between Bulgaria and the European Union (EU) using quarterly data. They conclude that the Bulgarian and the European business cycles are not coordinated and the costs of participating in the EU should be taken into account. Likewise, Leon (2007) is employing similar techniques to evaluate the transmission mechanism of stochastic shocks between Greece and the Eurozone for the period 1980-2005 with quarterly data. The results verify that both areas exhibit lower volatility over time. However, synchronization of the cycles in terms of correlation and their transmission mechanism seems to become weaker over time.

In the third stance of empirical investigations, several factors which might drive business cycle synchronization have been put forward; the most prominent ones being trade intensity, similarities in economic structures, monetary and fiscal policies as well as financial integration. Focusing on the national level of business cycle synchronisation, the majority of the above mentioned studies employ variations of a system of equations estimated by TSLS and examine whether correlations depend on variables such as trade intensity, specialisation, capital account restrictions, foreign asset positions and policy variables (fiscal and monetary variables). Some indicative studies are by Frankel and Rose (1998); Otto *et al* (2001); Clark and van Incoop (2001); Bordo and Hebling (2003); Gruben *et al.* (2002); Imbs (2004a, 2004b), Inklaar *et al.* (2005); Baxter and Kouparitsas (2004); Artis *et al.* (2003, 2004); Barrios *et al.* (2003), Traistaru, (2004); Bergman (2005). A thorough survey on the studies which have reported results on the drives of the business cycle synchronization have been provided by De Haan *et al* 2008, so we will abstain from giving a detailed overview here. The conclusions are summarised as follows: trade intensity has strong and positive effect on business cycle synchronization; more specialized production structure is related to less symmetric fluctuations; exchange rate volatility have positive impact on synchronization; standard deviation of money market rates are positively related to synchronization.

Concerning whether European business cycles have become more synchronised, various studies have concluded that European business cycles have become more synchronised (Artis and Zhang 1997, Barrios *et al.* 2003) especially amongst the more developed EMU members (Beine *et al.* 2003). There is more synchronisation amongst EMU members compared to the European periphery (Beine *et al.* 2003). Furthermore, synchronisation has lately increased in some 'peripheral' countries (Marelli 2006), while there are remarkable similarities between the business cycle patterns of countries, despite the significant differences in the patterns of fiscal and monetary policies or trade (Christodoulakis *et al.* 1995). The cross-correlation of regions across national borders has increased over time (during the period 1979-1992 associated with the ERM implementation), while, simultaneously, cross-regional correlation within

countries has decreased (Fatas, 1997). On the contrary, other studies allege for a less apparent evidence in the correlation of the cyclical movements (Harding and Pagan 2001) considering that the correlation of synchronised cycles remains low or even decreases (i.e. in the case of the Greek regions) (Montoya and de Haan 2007). In general, there are two streams of thoughts. The first supports the idea that economic integration leads to more symmetric fluctuations which, in turn, lead to more synchronised business cycles. The second agrees with Krugman (1991) and the notion that increasing integration will lead to regional concentration of industrial activities which, in turn, will lead to sector- or even region- specific shocks, increasing the likelihood of asymmetric shocks and diverging business cycles (Camacho et al. 2006). However, the bulk of the literature suggests increasing synchronicity (Marelli 2006).

In terms of regional business cycle synchronisation, it is worth mentioning that relative size (in terms of population) significantly affects economic co-fluctuations (Barrios and de Lucio 2003). Differences in industrial structure patterns and specialisation among regions are also important factors in business cycle synchronisation, as industry-specific shocks will generate a higher degree of business cycle synchronisation among regions with similar production structures rather than among regions with asymmetric structures (Imbs 2001). Hence, industry-specific shocks usually play a more important role at the regional than the cross-national level (Belke and Heine 2006). Moreover, the integration process is believed to have a stronger effect on the synchronisation cycles in regions rather in countries due to intensified trade relations and specialisation levels (Tondl and Traistaru 2006). Some studies suggest the correlation of regional business cycles with the national cycle remains high over time in spite of European economic integration, inferring the existence of a border effect (Montoya and de Haan, 2007), while others show that this effect has notably decreased (Barrios and de Lucio 2003).

### **3. Some Stylized Facts of the Regional Cycles**

In this section, we put forward some preliminary stylised facts of the European regions' business cycles using real GDP data for 200 NUTS II regions for 30 years, over the period of 1980-2009. The countries under study include: Austria (AT), Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), the Netherlands (NL), Portugal (PT), Spain (ES), Sweden (SE) and the United Kingdom (UK)<sup>1</sup>. The same dataset is used throughout our paper. It is worth noting here that there is no homogeneity across the 200 regions; hence, we split the regions into four groups based on their level of development, referring to them as 'high-high', 'high-low', 'low-high' and 'low-low' regions. The sample of the 200 regions was split into the above mentioned four groups based on the EU-14 GDP per capita average. Figure 1 depicts the four groups of the 200 European regions. The first group consists of the poorest peripheral regions (Low-Low regions) with GDP per capita lower than 65 of the EU-14 GDP per capita average. The second group, which is referred as 'Low-High' regions, falls within the range of 66

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<sup>1</sup> Luxembourg was discarded from the sample because of lack of data

to 95 of the EU-14 GDP per capita. The third group is referred as ‘High-Low’ European regions with GDP per capita ranging from 96-119 of the EU-14; and the last group is consisted of the richest regions (‘High-High’ regions) with GDP per capita more than 120 of the EU-14 average GDP per capita. As we can observe from Figure 1, there is a quasi north-south division in the sense that the northern European regions are more developed, in terms of GDP per capita in relation to EU-14, than the southern ones. This raises the question of whether or not the different level of development affects the synchronization dynamics between the regional business cycles and the EU-14 business cycle. Henceforth in our study, we will examine the synchronization of the business cycles with respect to the development differentiation of the 200 European regions.

*Insert Figure 1 about here*

For our analysis, we focus on the correlations of the regional cycles with the EU-14 reference cycle. We determine the business cycle using the ‘deviation cycle’ proposed by Lucas (1977), which is defined as a cyclical fluctuation in the cyclical component of a variable around its trend. The ‘deviation cycle’ is identified by isolating the cyclical component from the trend component; for this purpose, it is necessary to apply a specific de-trending technique, which transforms the non-stationary variable of regional output into a stationary one. There are a variety of filtering techniques to extract the cyclical components of the macroeconomic series, the most common one are the Hodrick–Prescott and the Christiano–Fitzgerald filters. In our study we use the Hodrick-Prescott filter (1997), which estimates the trend component by minimising deviations from trend, subject to a predetermined smoothness of the resulting trend. It is a high-pass filter that removes fluctuations with a frequency of more than eight years and puts those fluctuations in the trend. The advantages of this standard practice are first, that it is easy to implement and secondly, the resulting cyclical residuals are similar to those of the band-pass filter.

We decompose the economic series of interest (the regional real GDP of EU-14 in log terms) into the sum of a slowly evolving secular trend, and a transitory deviation from it, which is classified as the following cycle:

$$\text{Observed series } (X_t) = \text{Permanent trend } (T_t) + \text{Cycle } (Z_t) \quad (1)$$

The filter extracts the trend  $T_t$  from a given data  $X_t$  by minimising the following function:

$$\sum_{t=1}^N (X_t - T_t)^2 + \lambda((T_t - T_{t-1})^2 - (T_{t-1} - T_{t-2}))^2, \quad (2)$$

where  $X_t$  is the actual series,  $T_t$  is the trend series and  $\lambda$  is the smoothing parameter, which penalises the acceleration in the trend component relative to the business cycle component ( $X_t - \hat{T}_t$ ). In other words, the  $\lambda$  parameter controls the smoothness of the adjusted trend series  $T_t$ , i.e., as  $\lambda \rightarrow 0$ , the trend

approximate the actual series  $X_t$ , while as  $\lambda \rightarrow \infty$ , the trend becomes linear and thus deterministic. According to Marcet and Ravn (2001), the parameter  $\lambda$ , which is determined endogenously in annual data, should be between 6 and 7, while according to Ravn and Uhlig (1997), it should be equal to 6.25.

Following Massmann and Mitchel (2004), we calculate an 8-year rolling window of the correlation coefficient of regional business cycles with the EU-14 reference cycle for the four different groups of regions. In addition, we present the consecutive 8-year rolling window of the regional correlation coefficient with the national cycle over the same period, so as to investigate the existence of the so-called «border effect». The results are shown in Figures 2 to 5.

*Insert Figures 2-5 about here*

At first, it appears that for all groups of regions, the average correlation of the regional cycles with the national cycles is always higher than the average correlation of the regional cycles with the EU-14 cycles. Secondly, as far as the average correlation coefficient of regional business cycles with the national cycles is concerned, it seems that after a slight diminishing trend in the eighties the average correlation coefficient recuperates in the nineties in a parallel way with the increasing trend of regional business cycles synchronicity with the EU-14. Thirdly, apart from the case of the poorer European regions, the discrepancy of the degree of synchronization of the regional cycles with the national and EU-14 cycles respectively decreases over time and basically during the post-Maastricht period 1992-2009, for the other three groups of regions (Figure 5), which coincided with the further intensification of the European integration process. Last but not least the degree of synchronization with the European cycle is higher (with the slope of the curve to be steeper) for the more developed regions than for the less developed ones (Low-Low and Low-High regions).

All in all, the national border effect seems to coexist with the broader tendency of European integration that is fostered in a large extent after the Maastricht treaty (1992). Nevertheless, this tendency is not symmetric in the sense that the more developed regions seem to be more functionally integrated into the broader European space than the less developed regions. In other words, the integration process for the latter is mostly national oriented, which means that the less developed regions and especially the least developed ones (Low-Low) of EU-14, constitute a kind of quasi 'sheltered economies' that are detached from the broader European space remaining less capable to compete in a more integrated European markets (Rodríguez-Pose and Fratesi, 2006).



#### 4. The Dynamic Relationship of Regional Business Cycles

In this section, we employ a VAR type methodology as a measurement device to examine the dynamic relationship of the regional business cycles. Our main interest is to study whether the dynamics of business cycles are different across regions with different levels of development. Hence, this section is focusing on measuring the magnitude and timing of business cycle transmission from the EU-14 and the country to the regions, attempting to detect any differences between the transmission in the four groups of regions. For this purpose, we employ a panel VAR model in order to study the transmission mechanism of the stochastic shocks on the regional business cycles. Using Panel VAR techniques gives us the benefits from both taking advantages of a VAR approach and panel data techniques. This technique combines the traditional VAR approach, which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity.

##### 4.1. Panel VAR Methodology

The structural form of a PVAR model is given by:

$$A_0 Z_{it} = A(L) Z_{it-1} + e_{it}, \quad (3)$$

where  $Z_{it}$  is an  $(m \times 1)$  vector of endogenous variables;  $A_0$  is an  $(m \times m)$  with 1's on the diagonal and contains the parameters that capture the contemporaneous relations;  $A(L)$  is a matrix polynomial in the lag operator  $L$ ; finally,  $e_{it}$  is the structural disturbance vector. Pre-multiplying equation (1) by  $A_0^{-1}$ , we obtain the reduced form that we can actually estimate:

$$Z_{it} = B(L) Z_{it-1} + u_{it}, \quad (4)$$

where  $B(L) = A_0^{-1} A(L)$  and  $u_{it} = A_0^{-1} e_{it}$  is the reduced form residual vector.

In the baseline specification, the vector  $Z$  is specified as follows:

$$Z_{it} = [cyc_{EUt}, cyc_{nat}, cyc_{rt}]' \quad (5)$$

where  $cyc_{EUt}$  is the cyclical component in the EU countries,  $cyc_r$  is the regional cyclical component and  $cyc_{nat}$  is the national cyclical component. For each variable we use a pooled set of  $r \cdot T$ , where  $r$  denotes the number of regions and  $T$  denotes the number of observations corrected for the number of lags  $p$ . The model is estimated through GMM (Love and Zicchino 2006)<sup>2</sup> and calculated after the fixed effects have been removed by the use of the forward mean-differencing, or so called 'Helmert' transformation (Helmert procedure, see Arellano and Bover 1995). Once the VAR variables are obtained, impulse response functions are engendered with their respective confidence intervals at a significance level of 5% being estimated by applying Monte Carlo simulation. The analysis of these functions makes it

<sup>2</sup> To perform the analysis we used the STATA pvar routine written by Inessa Love (see Love and Zicchino 2006).

possible to draw conclusions about the responses of regional business cycles to the benchmark business cycles shocks.<sup>3</sup>

## 4.2. Data

We use annual data over the period 1980-2009<sup>4</sup> for 200 regions of the EU-14 countries. In order to estimate the panel VAR model, we estimate the cyclical component of regional GDP, national GDP and the EU-14 GDP. A complete overview of how the cyclical component is estimated is given in the previous section. Our main objective in this section is to examine the dynamics of regional business cycles across regions with different levels of development. The disadvantage of using PVAR techniques is the homogeneous slope parameters which must be assumed despite the fact that we can allow region specific heterogeneity using region fixed effects (Marattin and Salotti 2010). In order to overcome this difficulty in one degree, and achieve homogeneity across regions, we estimated four different panels. As mentioned in the previous section, the regions were split into four groups referring to these groups as 'high-high' (38 regions), 'high-low' (67 regions), 'low-high' (62 regions), low-low' (33 regions); hence, we estimated a PVAR for each sample and analyzed the regional differences of the estimated results and of the impulse responses for the four samples.

Before getting into the analysis of impulse response functions we have to mention that unit root tests on all variables of our models provide evidence for  $I(1)$  processes. The test employed is the panel unit root test of Im, Pesaran and Shin (2003) (IPS). The results from the unit root test show that all variables are not stationary in levels, but they are all stationary in first-difference. Following the fact that all of our panel VAR models estimated involve variables admitting stationary linear combinations<sup>5</sup>, we estimated the panel VAR in levels rather than cointegrated VARs (arguments on this can be found in Sims *et al* 1990; Favero 2001). Additionally, VAR in first differences provides no information on the relationship between the levels of the variables in the VAR, and it is this aspect on which economic theory is most informative. We focus on the impulse-response functions, which describe the reaction of one variable in the system to the innovations of another variable while holding all other shocks at zero (that is, we use orthogonalized shocks). The analysis of the impulse response functions allows to assess differences and commonalities across the different groups of regions in the transmission mechanisms of various disturbances.

## 4.3. Estimated Results

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<sup>3</sup> Our identification scheme is based on a lower triangular Cholesky decomposition with the above indicated ordering. Hence, a variable coming earlier in the ordering affects the next ones both contemporaneously and with a lag, while a variable coming later has merely lagged effects on the preceding ones. This implies that structural shocks of national and EU14 affect regional cycles but not vice-versa. Reversing the order was also tested but results were approximately the same (not shown in our paper). To complete the interpretation of our findings, we also expose the matrix with variance decompositions, which describe the percent of one variable explained by innovations accumulated over time in another variable.

<sup>4</sup> The panel is balanced

<sup>5</sup> Pedroni Residual Cointegration Test, Johansen Fisher Panel Cointegration Test, and Kao Residual Cointegration Test were employed to test for cointegration in our panel sample, the existence of the cointegration relationship was not supported, the results are not presented here for economy of space.

This section presents the main results of the empirical model outlined in section 4.2. We have estimated the PVAR model over the whole sample (200 regions of EU-14 countries, over the period 1980-2009) and for the four different groups of regions: 'high-high' (38 regions), 'high-low' (67 regions), 'low-high' (62 regions), 'low-low' (33 regions). All models are estimated with three variables: *cyc*, *cycnat* and *cyceu*, for three lags. The estimated results of the PVAR of the different groups are reported in Table 1. Based on the estimated results, we observe that at period 1, the influence on regional business cycle from the EU-14, is expressed by the parameter 0.3058 for the total sample, while for the high-high regions is 0.3031, for the high-low 0.2844, for the low-high is 0.2047 while for the low-low is -0.0003. The EU has greater impact on the more developed regions, whereas, it has less or no effect on the less developed regions. At the national level, the influence on regional business cycle from the national component is expressed at period 1 for the total sample by the parameter 0.2531, while for high-high regions the parameter is 0.1176, for the high-low 0.0916, for the low-high is 0.4054 while for the low-low is 0.5506. The national impact – “the border effect” is greater on the less developed regions, whereas the effect is lower on the higher developed regions. In terms of the regional own impact, the parameters are: for high-high regions is 0.3191 for the high-low 0.3035, for the low-high is 0.1511 while for the low-low is 0.0125. Interestingly, we also observe that the regional own impact is greater for the more developed regions rather than the lower ones. Examining the impact across periods, we observe that the impact diminishes over time and across all groups in absolute terms. Also, it is observed that there is an alteration of the sign across periods; this is translated as a kind of instability of the relationship between the cycles in question.

Further, to investigate explicitly the dynamic properties of EU-14 and national business cycles impact on the regional business cycles, we estimated the impulse response functions at the 5% error bands generated by the Monte Carlo simulation for the four groups of regions. Figures 6 to 10 depict the impulse response functions of the regional business cycle shocks of one standard deviation of the EU-14 and national benchmark cycle shocks for 3 period, as obtained from the estimation of PVAR for the total sample of 200 regions and for the four different groups of regions. In particular, each figure shows the relative impact of euro area shock (one-standard error shocks) on the country's and on the regions' cyclical component. High (small) values of shocks indicate greater (lesser) transmittal of euro area shock to the cycle of the country or to the regions' cycle. A value of zero indicates no transmittal at all. The results of our particular interest is the response of the regional cyclical component to the EU-14 cyclical component and to the national one for the different groups of regions. The panels representing the impulse response of regional cyclical component to a one standard deviation shock in national cyclical component shock clearly show a positive impact across all four groups of regions. We also notice that this response has a larger impact on the value of cyclical component in the 'high-high' groups of regions, while the impact is less to the lower developed groups of regions. More particularly, the respective maximum transmitted shock from the nation to the regions in the 'high-high' regions is 1.11%, for the

'high-low' is 1%, for the 'low-high' is 0.76% and for the 'low-low' is 0.94% respectively. These results suggest that the national effects is greater on the higher developed regions rather than regions with lower level of development. We also observe that for the lower developed regions it takes more time for the effect to diminish to the value of zero than the higher developed ones. In addition and across the four groups of regions, a cyclical pattern is observed, with however different time of cyclicity. For the higher developed regions, it takes less time to reach the point of oscillation (minimum in approximately 3 years), whereas for the less developed regions it takes a little bit more than 3 years to reach the minimum point of oscillation.

Observing the EU-14 cyclical cycle impact on the regional cycle, we observe that the initial shock does not have an immediate impact on the regional cycle. The maximum shock transmitted from the EU to the regions in the 'high-high' regions is initially close to zero, which then increases reaching the maximum of 1.7% after one year, and then decreases reaching a minimum of -0.24% after 4 years. The maximum shock transmitted from the EU to the region in the 'low-low' regions is initially close to zero, which then increases reaching the maximum of 0.20% after a half of a year, and then decreases reaching a minimum of -0.37% after 3 years. Across the four groups of regions, a cyclical pattern is also observed, with however different time of cyclicity. For the higher developed regions, it takes more time to reach the point of oscillation (minimum in approximately 4 years), whereas for the less developed regions it takes 3 years to reach the minimum point of oscillation.

## 5. Determinants of the EU14 Regional Business Cycles?

Having analysed the dynamics of the regional business cycles in the preceding section, the question to address next is what factors are behind the regional cycles synchronisation with the EU-14 business cycles. Taking our study into the next level and following Imbs (2004), Siedschlag and Tondl (2011), we estimate a system of simultaneous equations in order to unravel the various drives of business cycle correlations. Hence in this section, we specify the model relating each individual specification with the existing literature; we briefly describe the relevant variables involved and we present the data. We close our section presenting and discussing the estimated results and comparing the findings against the other regional literature.

### 5. 1. Econometrics Methodology and Data

For the purpose of our study, we estimate the following system of equations simultaneously:

$$corn_{it} = \alpha_1 + \alpha_2 trade_{it} + \alpha_3 spec_{it} + \alpha_4 prod_{it} + \alpha_5 d_i + e_{it} \quad (6)$$

$$trade_{it} = \beta_1 + \beta_2 spec_{it} + \beta_3 prod_{it} + \beta_4 I_{it} + \beta_5 d_i + e_{it} \quad (7)$$

$$spec_{it} = \gamma_1 + \gamma_2 trade_{it} + \gamma_3 prod_{it} + \gamma_4 I_{it} + \gamma_5 d_i + \varepsilon_{it} \quad (8)$$

$$prod_{it} = \delta_1 + \delta_2 trade_{it} + \delta_3 spec_{it} + \delta_4 I_{it} + \delta_5 d_i + \varepsilon_{it} \quad (9)$$

where  $i = 1, \dots, 200$  is the index of regions in the EU-14 (except Luxembourg),  $t = 1, \dots, 23$  is the time period.  $corr$  denotes the business cycles correlations,  $trade$  is the trade intensity/integration,  $spec$  is the specialization index and  $prod$  is the total productivity. Business cycles correlations, trade, specialization and productivity are all endogenous variables, while  $I_1, I_2, I_3$  and  $I_4$  contain vectors of the exogenous determinants for each equation and  $d_i$  is a dummy variable for the less developed regions. Identification of the system requires differences between at least  $I_2, I_3$  and  $I_4$ . An eight-year rolling windows was applied to our annual data over the given period, 1980-2009. The business cycle synchronization is being measured by taking the correlations of NUTSII regions' GDP (in constant prices) with the average of EU-14 over the time period 1980 to 2009. The Hodrick-Prescott filter was applied to get the cyclical component over the time period with  $\lambda=6.25$ .

$trade$  is an index of integration. Due to the fact that there is no trade data at the regional level, we estimate the trade integration index for each region using a proxy. Following Petrakos et al, 2005, we first estimate the index of integration at the national level using the following formula:

$$trade_{it} = \frac{(EXP_{i,EU-14} + IMP_{i,EU-14})}{(EXP_{i,world} + IMP_{i,world})} \quad (10)$$

and then we regionalize the national index by multiplying the index with the corresponding production location quotient,  $\left(\frac{s_{i,r}}{s_{i,k}}\right)$ , and the result was summed over the sectors for each region.

Hence, the trade index is calculated as follows:

$$trade_r = \sum_{i=1}^n \left[ \left( \frac{EXP_{i,EU-14} + IMP_{i,EU-14}}{EXP_{i,world} + IMP_{i,world}} \right) \times \left( \frac{s_{i,r}}{s_{i,k}} \right) \right] \quad (11)$$

High (low) values are associated with high (low) levels of trade integration of each region to the broader EU area. The sectors under study are six: a) agriculture, b) manufacturing and energy, c) construction, d) accommodation, food services activities, transportation, storage, information and communication, e) financial activities and real estate, and f) non-market services.

We define specialization as the similarity of economic structures in regions using Krugman's (1991) index:

$$spec_r = \sum_i^n |s_{i,r}^s - s_i| \quad (12)$$

where  $i$  denotes the sector ( $i=1\dots n$ ),  $s_{i,r}^s$  denotes the share of sector  $i$  in gross value added in region  $r$  and  $s_i$  denotes the share of sector  $i$  in the total gross value added of the EU-14. The specialization variable measures the extent to which a region's production pattern differs from that of the EU-14 average, and it takes values between 0 (perfect similarity or absence of specialization) and 2 (maximum dissimilarity or

total specialization). The higher the index the less similar the economic structures of the two areas are. Absence of specialization means that the sectoral structure of the region is identical to the benchmark's one. The sectors used here are the same ones mentioned before.

Total productivity is the ratio of production output to what is required to produce it (inputs). We measure productivity as the total output per unit of input, i.e. Gross Domestic Product (GDP) per hour worked for each region in relation to EU-14.

In terms of exogenous variables, in the equation of trade, we use the gravity index and the region's population size. The gravity index is the economic geographic position of each region with the relation to the rest. It is proxied by an index (Evenett and Keller, 2002), which is calculated by:

$$grav_r = \sum_{j=1}^n \frac{gdp_r \cdot gdp_j}{D_{rj}} \quad (13)$$

where,  $gdp_r$  is the GDP in region  $r$ ,  $gdp_j$  is GDP of the region  $j$ ;  $d_{rj}$  is the distance between the centroids of regions  $r$  and  $j$ . The gravity index takes values greater than 0, from a less to a more central place in the EU market.

In the equation of specialization, we use GDP per capita (in constant prices) as an exogenous variable. Finally, in the equation of productivity, we use two exogenous variables capturing the spatial density in industrial concentration as well as the spatial density of the overall economic activities. In our study we use the industrial concentration index in order to examine the regional variations in productivity, as well as the agglomeration index in its simple version covering the overall economic activity as an alternative variable affecting productivity. The concentration variable measures the extent to which the industrial sector is concentrated in a region in relation to the EU-14. This index is estimated as follows:

$$mconc_r = \left| s_{i,r}^c - s_r \right| \quad (14)$$

where  $r$  denotes the region,  $s_{i,r}^c$  denotes the share of gross value added in sector  $i$  (industrial) in region  $r$  in the total gross value added of the total number of EU-14 regions and  $s_r$  denotes the share of total gross value added in region  $r$  to the total of EU-14 regions. The index takes values equal or greater than 0 with higher values to imply higher concentration in a given sector. The agglomeration index is estimated as GDP over the area of each region. We also include a dummy variable in all equations representing the 'low-low' and 'low-high' regions having GDP per capita below the EU-14 average.

## 5.2. Data, Estimation and Results

In this section, we report the results from the Three-Stage Least Squares estimation of equations (6) to (9), and we discuss the magnitude and significance of the estimates, comparing the results with the existing evidence. The benefit of using three-stage least squares (3SLS) estimation according to Imbs (2004), is that it combines simultaneous equations procedures and account for possible endogeneity of

the four variables of our model. It further gives consistency of the estimators via the instrumentation and appropriate weighting in the variance-covariance matrix. The estimated models are presented in Table 2. We begin by examining individually the four different estimated equations.

The estimates in the primary equation of the simultaneous system of equations indicate that, *ceretis paribus*, trade integration increases business cycle synchronization between regions and EU-14, as it is positive and statistically significant. Trade integration reflects the economic openness to other markets and the intensification of linkages and cooperation networks. Its positive value reveals the fact that as regions are becoming more integrated into the broader economic milieu, either by intra-trade relations or by increasing backward and forward trade linkages (Perocco *et al*, 2007), business cycles co-movements become tighter (Frankel and Rose 1998, Clark and van Wincoop 2001, Calderon *et al* 2007). This is in agreement with the general finding in the empirical studies that international trade has a significant role in transmitting business cycle fluctuations across areas (i.e. Calderon *et al* 2007).

On the contrary, the relationship between the regional cycle correlations and specialization is negative and statistically significant, indicating that the dissimilarity of the regional economic structures with respect to the EU-14 affects negatively the synchronicity of their cycles. Increased specialization is associated with a quite differentiated production structure in relation to EU, which responds differently to sectoral-shocks as they are in essence asymmetric (Imbs 2001, Long and Plosser 1983, Krugman 1999, Barrios and Lucio 2003).

Finally, the sign of productivity is positive and statistically significant relegating the fact that production structure similarities foster the convergence of aggregate productivity, thus the business cycle correlations (Cardarelli and Kose 2004). Finally, the coefficient of the dummy variable is negative, indicating that the business cycles of the less developed regions are less synchronized with the EU-14 business cycles, confirming both the results of the descriptive analysis and the PVAR analysis results in the preceding sections of this paper.

The estimates in the second equation of the simultaneous system, indicate that specialization is positively related to trade as the relevant coefficient is statistically significant, implying that regions with a specialized sectoral structure have more intensified trade relations with EU-14. In that sense, and despite the negative effect of specialization observed in the primary equation, there is also an indirect positive impact on cyclical synchronization via its positive impact on trade. Needless to say that the specialization pattern is different among the different groups of regions.

Taking a look at the next variable, productivity is also positively related with trade indicating that the intensification of productivity bolsters indeed the competitiveness of a region and subsequently the trade integration dynamics. Last but not least, the coefficient of the exogenous variable of the gravity index is positive and statistical significant indicating that the differentiation of the geographic economic

position of the European regions does matter for the trade intensity as higher values of gravity index are associated with higher trade relations with the EU-14. The location of a region largely determines the conditions of integration into the broader economic space, so the positive sign of the gravity index reflects the integration dynamics via the positive impact on trade.

At last, the coefficient of the dummy is negative and statistically significant relegating to the fact that the trade performance of the less developed regions seem to be lower than that of the more developed ones. In the third and fourth equations of the simultaneous equation system, the relation between productivity and specialization seems to be negative with the coefficient in question to be statistically significant. This means that a broader range of production structures in contrast to highly specialized mono-sectoral production structures seems to strengthen the overall productivity via the sectoral linkages and the capital accumulation (Acemoglu and Ventura 2001).

The relation between specialization and GDP per capita ratio that stands for the income gap is also negative as the coefficient is parri passu statistically significant. Indeed a higher level of development expressed in terms of GDP per capita, is negatively associated with the specialization in the sense that the more developed regions tend to proliferate a broader range of capital and high tech intensive production systems with the less developed regions instead, to be characterized by more traditional patterns of economic activities (Imbs and Wacziarg 2003, Tondl and Traistaru 2006). In the same sense, the coefficient of the population variable that is also negative and statistically significant, indicates that a more extensive market potential can sustain a broader economic structure (Amiti 1998). Finally, the coefficient of the dummy variable in the third equation, is positive and statistically significant implying that the poorer regions tend to specialize more than the richer ones with an orientation of the specialization pattern towards a restrictive scope of traditional activities.

Observing the relationship of the spatial density variables (agglomeration and industrial concentration) with productivity, we see that it is positive and statistically significant in both cases (Table 2. 3sIs Model 1). Agglomeration and industrial concentration constitute a self-reinforced process (Myrdal, 1957) which is based on increasing returns and static externalities under the form of backward/forward linkages (Hirschman, 1958) between firms and suppliers as well as between firms and consumers; thus, the benefits are important for the investment activity -cum-productivity (Cantwell 1991). Even in the case of dynamic external economies of scale associated with technological spillovers, the existence of a systemic entity either concerning the entire industrial structure (localization economies) or the entire city or region (urbanization economies) affects the investments, including human capital, and consequently productivity. This type of dynamic externalities could be either MAR type (Marshall, 1920, Arrow, 1962 and Romer, 1986) at industrial level, or Jacob type (Jacob, 1969, 1984) at city or regional level (urbanisation economies). Finally, a very interesting finding with respect to density variables is the estimated results of the nonlinear relationships with productivity. Indeed, we detect an inverted U-turn



relationship between the spatial density variables and productivity. This means that there is an inversion in the relationship with productivity, as the agglomeration and industrial concentration becomes more intensive. This inversion could be attributed to agglomeration diseconomies and to the mechanism of dispersion of activities due to the intensification process of European integration (further reduction of the trade cost), which makes investment decisions increasingly sensitive to wage differentials leading to partial dispersion of economic activities across regions. (Puga, 1997; Venables, 1996) More specifically, a decrease in the investment dynamics (due to higher competition, wages and land rents) in the core regions leads to decreased productivity of the spatially agglomerated activities, causing partial reallocation of these activities to the less developed regions. In that sense and in contrast with the model 1, we observe a reverse effect for the less developed regions (Table 2. Model 2.). In the second model in Table 2, the density variables in the productivity equation, are multiplied by the dummy variable of less developed regions, both in levels and in the second order. What is observed is that the nonlinear relationship has now a U-shape, which is exactly opposite of that observed in model 1. The level of spatial density of the less developed regions is definitely lower than the one of the more developed regions; therefore, the intensification of their own scale of economic activities leads to a positive instead relation of productivity with the density variables. This can indicate a type of spillovers to the less developed regions, especially to those which have geographical proximity to the core ones.

## **6. Conclusions**

This study has focused on investigating the regional business cycles at NUTS II level, providing a comprehensive and consolidated analysis of the business cycle synchronicity between European regions and EU-14 area. Our results reveal that the more developed regions of Europe are more functionally integrated into the broader European space than the less developed ones. Examining the magnitude and the timing of business cycle transmission from the EU-14 benchmark cycle and the national benchmark to the regional cycles, attempting to detect any differences between the transmission within the four groups of regions, we find that a) the EU has greater impact on the more developed regions, whereas, it has less or no effect on the less developed regions; b) the national impact – “the border effect” is greater on the less developed regions rather than the higher developed ones; and finally, c) even though the transmitted values of the euro area shocks are very small, the values of shocks are greater for the higher developed regions rather than those to the lower developed regions. Shock propagations in the four groups of regions differ due to the differentiated pattern of integration into the broader European space.

This diverse pattern of integration is attributed to the different spatial pattern of economic activities. From the 3SLS estimation we observe indeed that differences in trade intensity, specialization patterns and regional productivity do explain the differences in regional business cycle correlations with the EU-14. If the above drives constitute mechanisms of economic integration, then it is obvious that the more

developed regions are more integrated than the less developed ones. At the same time, the uneven spatial pattern of economic activities reflected into the differential density pattern of them seems to activate antithetical trends as the integration process is intensified. That is, the agglomeration diseconomies in combination with the negative effects of the spatially agglomerated activities in the more developed regions are translated into a partial dispersion of these activities to the less developed ones mainly to those that are geographically adjacent to the existing European centers. To conclude, *“one size does not fit all”* cannot be dismissed.

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**Table 1.** PVAR estimates for the total sample of the 200 regions and the four groups of the regions differentiated by the level of development

		Total Sample		High-High		High-Low		Low-High		Low-Low	
		(200 regions)		(38 regions)		(67 regions)		(62 regions)		(33 regions)	
		b	t-stat	b	t-stat	b	t-stat	b	t-stat	b	t-stat
<b>EQ1:</b>	<b>dep.var : cyc</b>										
	cyc (t-1)	0.1626	3.48	0.3191	4.34	0.3035	8.32	0.1511	3.07	0.0125	0.13
	cycnat(t-1)	0.2531	5.70	0.1176	1.79	0.0916	2.17	0.4054	5.25	0.5506	4.14
	cyceu14(t-1)	0.3058	7.54	0.3031	3.50	0.2844	4.66	0.2047	2.76	-0.0003	0.00
	cyc(t-2)	-0.2171	-7.08	-0.2422	-3.06	-0.1455	-4.58	-0.2655	-5.74	-0.2306	-4.16
	cycnat (t-2)	-0.0860	-2.47	-0.1143	-1.88	-0.1817	-5.58	-0.0583	-0.61	0.2498	1.80
	cyceu14 (t-2)	-0.3045	-6.17	-0.2093	-1.85	-0.2211	-3.13	-0.2970	-3.48	-0.5871	-3.81
	cyc (t-3)	-0.2320	-8.97	-0.2640	-5.76	-0.2054	-6.25	-0.2415	-5.45	-0.2200	-4.27
	cycnat (t-3)	0.0268	0.82	0.0433	0.74	0.0210	0.56	-0.0235	-0.27	0.3159	1.96
	cyceu (t-3)	0.0059	0.12	-0.0587	-0.55	0.0021	0.03	0.1169	1.26	-0.3115	-1.50
<b>EQ2:</b>	<b>dep.var : cycnat</b>										
	cyc (t-1)	0.0727	4.81	0.1018	2.28	0.2467	5.56	-0.0034	-0.16	0.0215	1.40
	cycnat(t-1)	0.5049	14.94	0.5151	6.91	0.3804	6.01	0.6418	12.60	0.5155	9.38
	cyceu14(t-1)	0.1424	4.22	0.0791	1.08	0.0487	0.99	0.1204	2.44	0.1829	2.62
	cyc(t-2)	0.0067	0.69	-0.0262	-1.20	0.0212	0.95	-0.0154	-0.72	0.0162	1.08
	cycnat (t-2)	-0.3630	-14.71	-0.3690	-7.57	-0.4621	-12.03	-0.2757	-5.37	-0.1736	-2.84
	cyceu14 (t-2)	-0.2036	-6.85	-0.1704	-2.21	-0.0278	-0.53	-0.2607	-5.91	-0.4533	-6.15
	cyc (t-3)	0.0125	1.24	-0.0019	-0.07	0.0736	2.39	-0.0048	-0.28	0.0120	0.86
	cycnat (t-3)	-0.0930	-4.08	-0.0896	-1.84	-0.0596	-1.46	-0.1952	-4.69	-0.0538	-1.07
	cyceu (t-3)	-0.0518	-1.95	-0.0875	-1.37	-0.1027	-2.47	0.0201	0.42	-0.0407	-0.54
<b>EQ3:</b>	<b>dep.var : cyceu</b>										
	cyc (t-1)	0.0263	4.01	0.0253	1.39	0.0566	3.38	-0.0089	-0.60	0.0193	2.68
	cycnat(t-1)	0.0237	1.79	0.0161	0.62	-0.0275	-1.47	0.1538	4.82	0.0441	1.52
	cyceu14(t-1)	0.6622	37.73	0.6723	17.80	0.6882	25.41	0.5732	18.27	0.5842	12.72
	cyc(t-2)	0.0132	2.44	0.0115	0.80	0.0081	0.57	0.0125	1.17	0.0152	2.25
	cycnat (t-2)	0.0146	0.97	-0.0368	-1.49	-0.0694	-4.42	0.0746	1.91	0.3361	8.55
	cyceu14 (t-2)	-0.5692	-29.36	-0.5170	-11.62	-0.4785	-13.07	-0.5777	-17.51	-0.8026	-15.91
	cyc (t-3)	-0.0083	-1.30	-0.0415	-2.20	-0.0328	-2.11	-0.0131	-0.96	0.0278	3.41
	cycnat (t-3)	-0.0042	-0.29	0.0292	1.08	0.0615	2.98	-0.0727	-2.28	-0.0940	-2.95
	cyceu (t-3)	-0.0847	-4.33	-0.0871	-1.97	-0.1282	-3.85	-0.0248	-0.69	-0.0540	-1.28

**Notes:** *cyc* is the regional GDP cyclical component, *cycnat* is the national GDP cyclical component, *cyceu14* is the European GDP cyclical component estimated using the HP filter.

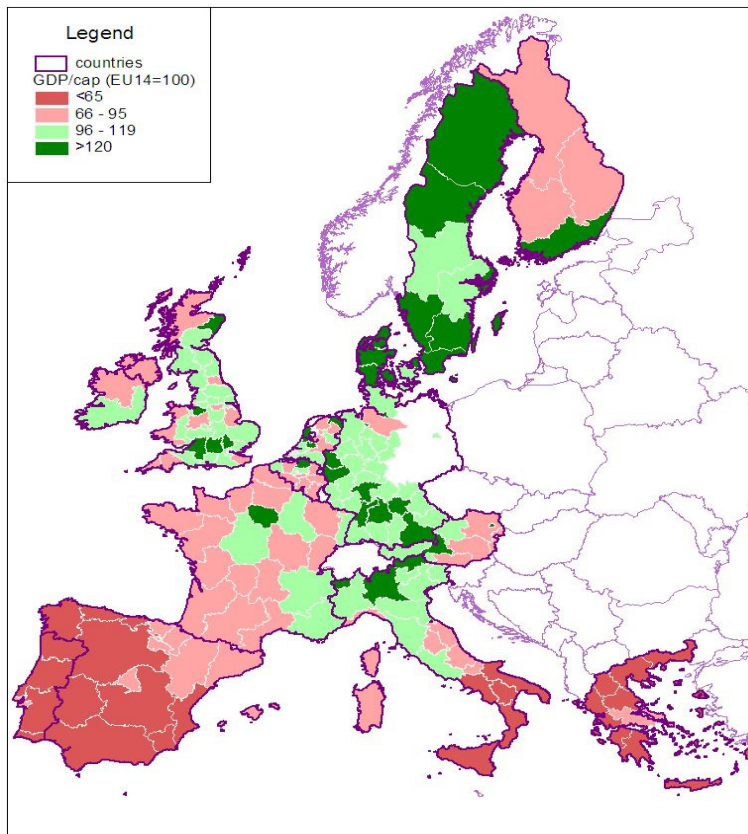


**Table 2.** Estimated Estimations of the system of equations (6)-(9) as defined in Section 5.1. using 3SLS of Equations for the total sample of the regions (200 regions-4596 observations)

3sls Model 1				3sls Model 1			
Equation	R-sq	F-Stat	P-value	Equation	R-sq	F-Stat	P-value
corr	0.182	243.34	0.000	corr	0.182	247.51	0.000
trade	0.915	14024.42	0.000	trade	0.913	14049.39	0.000
spec	0.933	21666.88	0.000	spec	0.929	21908.41	0.000
prod	0.632	1244.49	0.000	prod	0.420	887.85	0.000
	<b>Coef.</b>	<b>t-stat</b>	<b>p-value</b>		<b>Coef.</b>	<b>t-stat</b>	<b>p-value</b>
<b>corr</b>				<b>corr</b>			
trade	0.031	11.85	0.000	trade	0.030	11.76	0.000
spec	-0.024	-13.36	0.000	spec	-0.024	-13.28	0.000
prod	0.004	10.52	0.000	prod	0.004	10.89	0.000
dumlow	-0.041	-2.35	0.019	dumlow	-0.039	-2.24	0.025
c	0.248	6.23	0.000	c	0.234	5.89	0.000
<b>trade</b>				<b>trade</b>			
spec	0.692	238.16	0.000	spec	0.693	238.67	0.000
prod	0.052	28.14	0.000	prod	0.059	32.37	0.000
grav	7.08e-06	6.04	0.000	grav	5.80e-06	4.84	0.000
pop	-.000176	-10.4	0.000	pop	-.000116	-6.79	0.000
dumlow	-0.850	-8.97	0.000	dumlow	-0.780	-8.33	0.000
c	-6.808	-31.29	0.000	c	-7.606	-35.6	0.000
<b>spec</b>				<b>spec</b>			
trade	1.454	239.78	0.000	trade	1.457	240.04	0.000
prod	-0.027	-9.88	0.000	prod	-0.054	-19.99	0.000
gdpc	-0.020	-18.3	0.000	gdpc	-0.017	-15.63	0.000
dumlow	1.521	11.94	0.000	dumlow	0.985	7.84	0.000
c	7.207	25.67	0.000	c	9.710	35.55	0.000
<b>prod</b>				<b>prod</b>			
trade	3.419	32.87	0.000	trade	3.962	27.33	0.000
spec	-2.356	-31.00	0.000	spec	-2.518	-22.79	0.000
mconc	24.064	15.67	0.000	mconc*dumlow	-60.695	-18.83	0.000
mconcsq	-3.452	-6.65	0.000	mconcsq*dumlow	40.454	10.71	0.000
aggl	0.095	22.85	0.000	aggl*dumlow	-0.096	-16.32	0.000
agglsq	-.000109	-19.00	0.000	agglsq*dumlow	.0000976	12.12	0.000
dumlow	-21.983	-34.28	0.000				
c	98.444	102.03	0.000	c	110.968	131.00	0.000

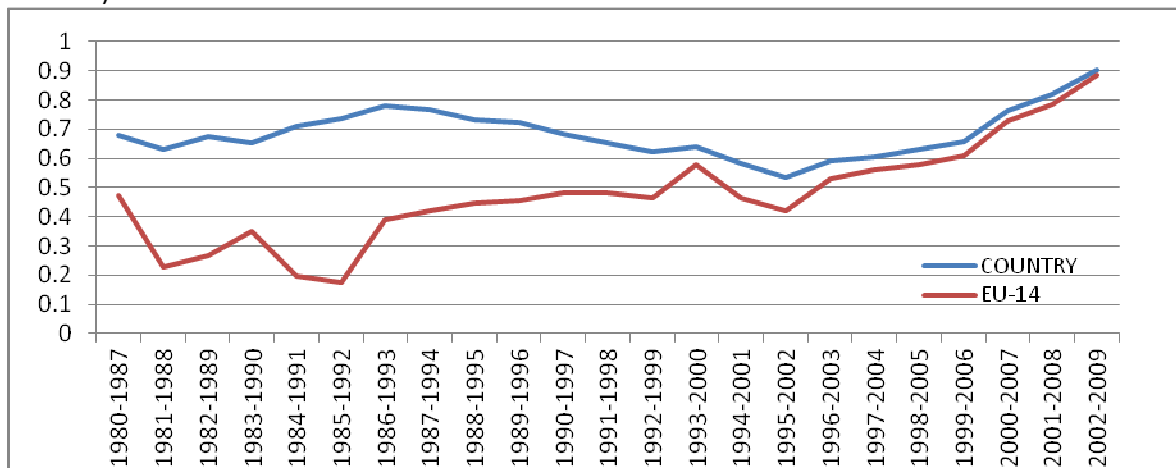
**Notes:** *d* in Model 2 represents the dummy for the low developed regions

**Figure 1.** GDP per capita in NUTSII regions of EU14 (average period 1980-2009)

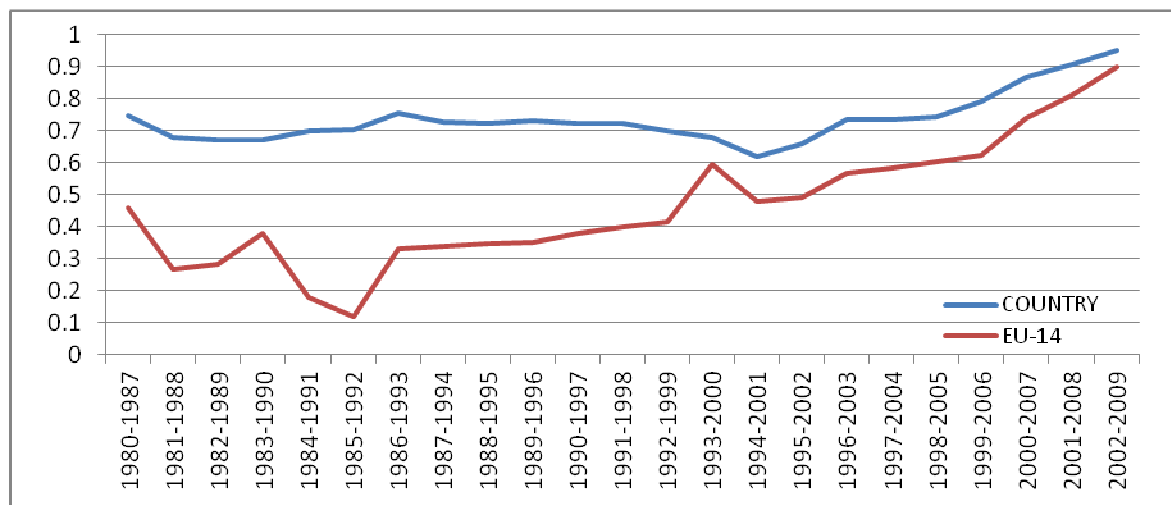


Source: Eurostat (2012), author's elaboration

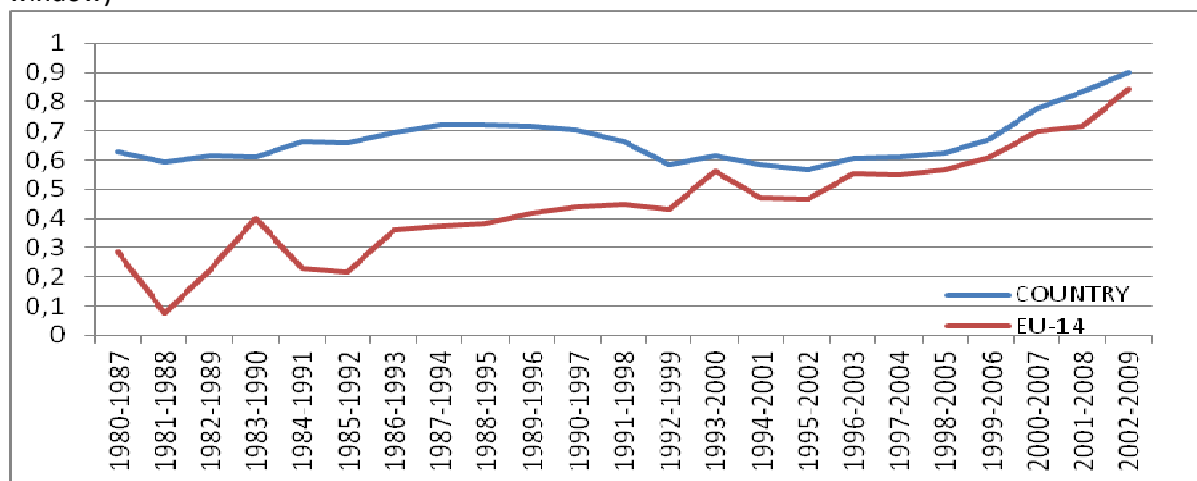
**Figure 2.** Regional correlation of high-high regions with national and EU-14 business cycles (8-year rolling window)



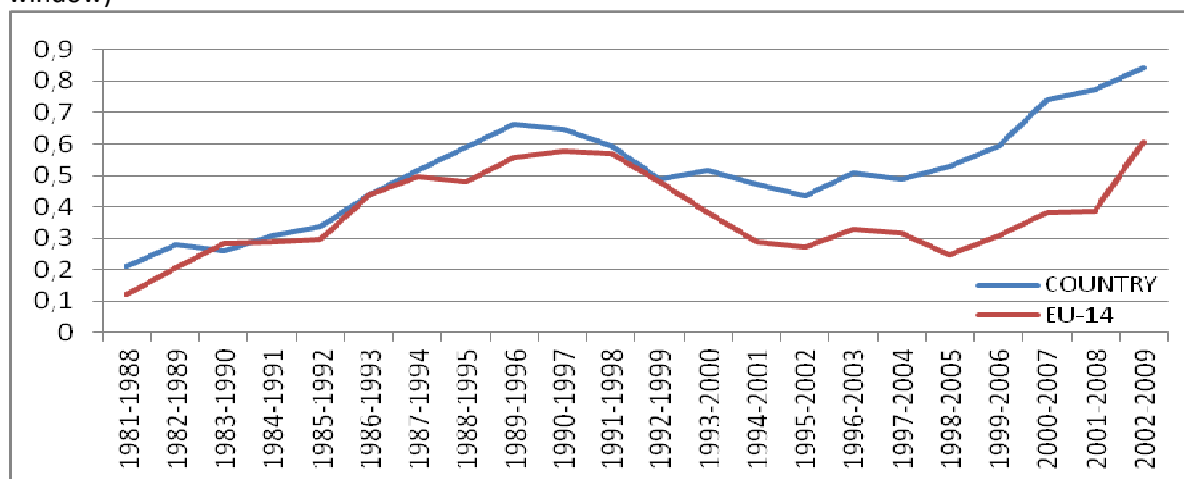
**Figure 3.** Regional correlation of high-low with national and EU-14 business cycles (8-year rolling window)



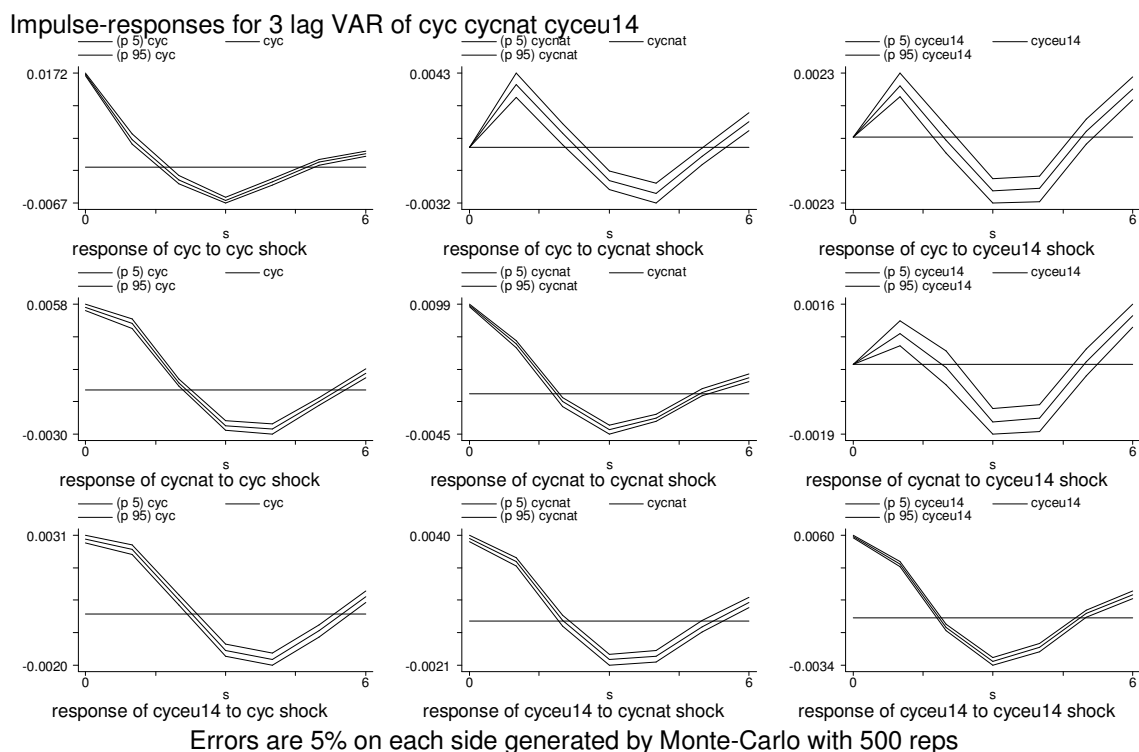
**Figure 4.** Regional correlation of low-high regions with national and EU-14 business cycles (8-year rolling window)



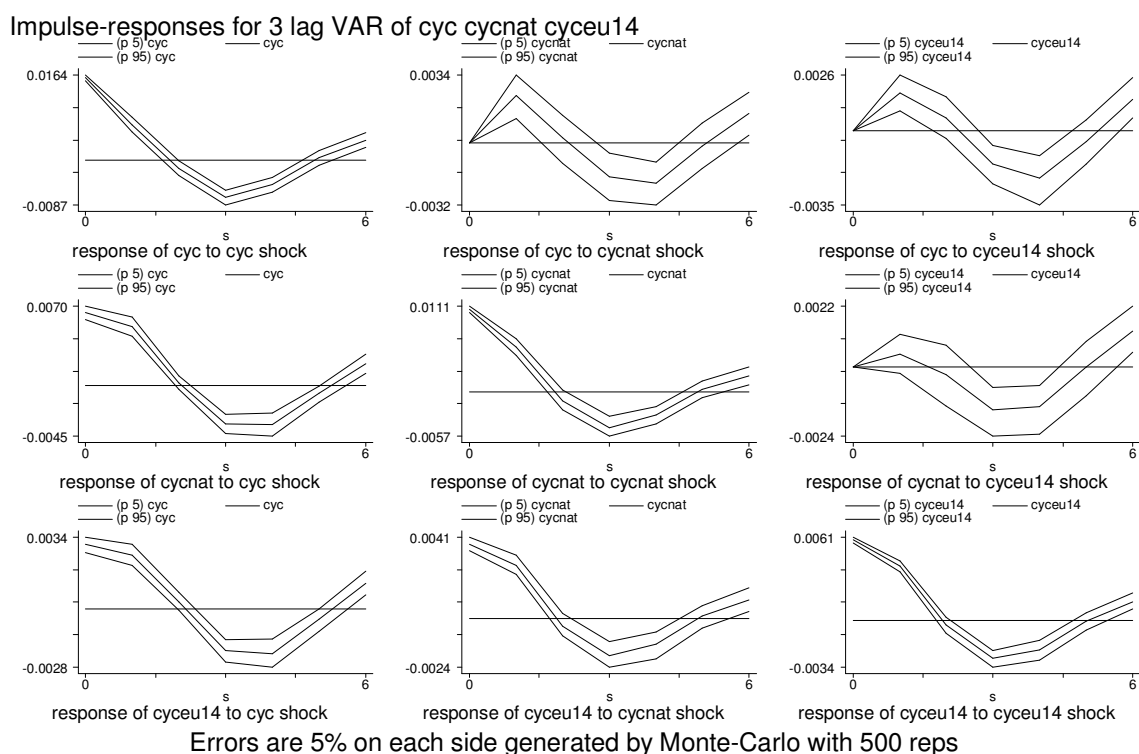
**Figure 5.** Regional correlation of low-low regions with national and EU-14 business cycles (8-year rolling window)



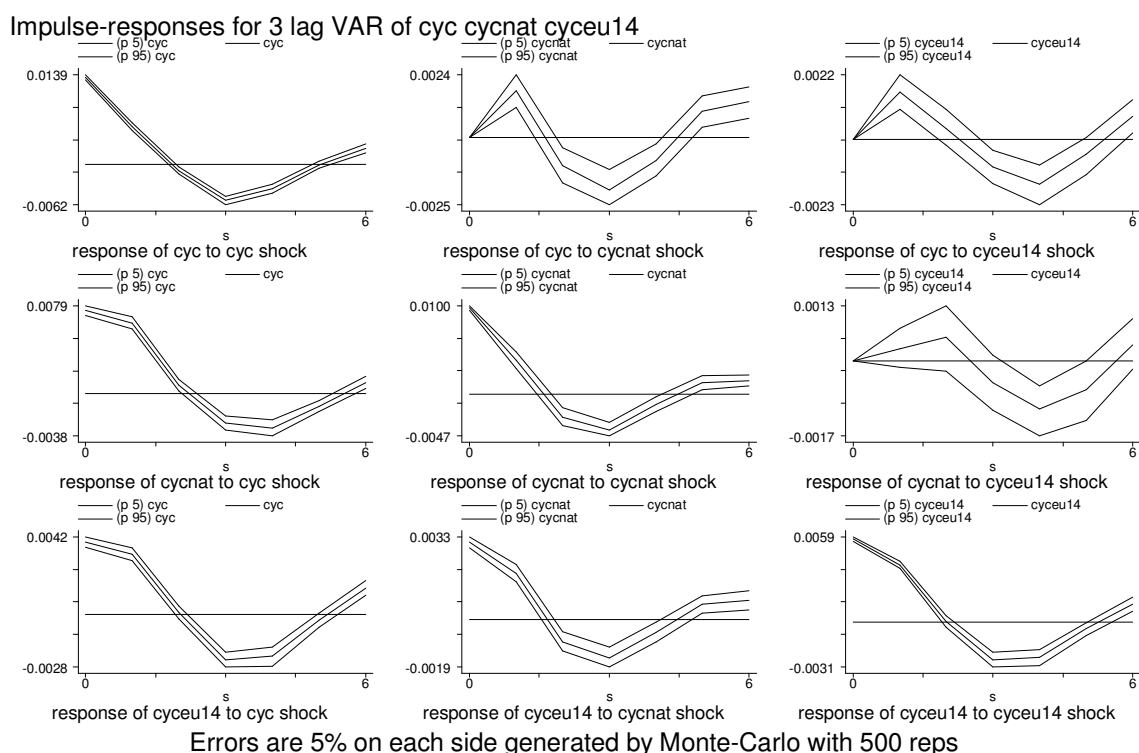
**Figure 6.** Impulse Responses of Regional Business Cycles to the EU-14 and national benchmark cycle shocks for 3 period obtained from the estimated PVAR for the total number of regions (200 regions)



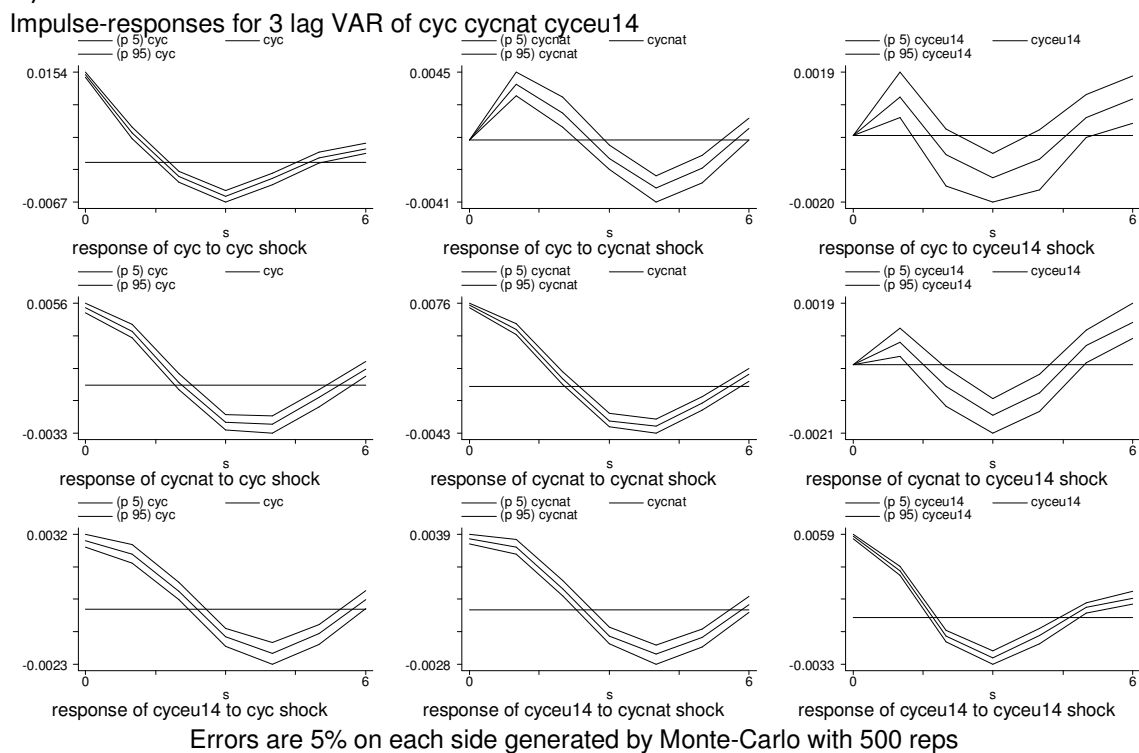
**Figure 7** Impulse Responses of Regional Business Cycles to the EU-14 and national benchmark cycle shocks for 3 period obtained from the estimated PVAR for the High-High Development regions (38 regions)



**Figure 8** Impulse Responses of Regional Business Cycles to the EU-14 and national benchmark cycle shocks for 3 period obtained from the estimated PVAR for the High-Low Development regions (77 regions)



**Figure 9** Impulse Responses of Regional Business Cycles to the EU-14 and national benchmark cycle shocks for 3 period obtained from the estimated PVAR for the Low-High Development regions (52 regions)



**Figure 10** Impulse Responses of Regional Business Cycles to the EU-14 and national benchmark cycle shocks for 3 period obtained from the estimated PVAR for the Low-Low Development regions (33 regions)

