Business cycle synchronisation in the EU regions

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Abstract

The present paper provides a comprehensive analysis of the regional business cycle synchronicity. Our study is conducted in three levels. Firstly, we analyse regional business cycle synchronization in the Euro Area, using 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. Our main interest is to study whether the dynamics of business cycles are different across regions with different levels of development. 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. Finally, following Imbs (2004) and Tondl and Traistaru. (2006) we empirically extend the research on identifying factors which might drive regional business cycle synchronization, assessing the importance of sub-national regional variations of business cycles. In particular, we analyse the role of trade integration, the different sectoral patterns of specialisation as determinants of regional growth cycle correlations with the Euro area. We specifically draw attention to yet another possible drive of business cycle synchronisation: regional investments associated with specific special characteristics of economic activities. Panel three-stage least-squares estimation is implemented for the simultaneous equations between determinants and business cycles synchronisation.

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

The degree of synchronization (symmetry) among two countries or regions is defined as the co-movement of growth rates through time by the contemporaneous correlation of their cyclical components of real GDP. The degree of synchronization (symmetry) of macroeconomic fluctuations across economies has been the core issue in the debate of the economic integration literature; whereas, European integration has dominated the scene of the empirical studies. Recently, 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 or regions 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. These implications have brought again in life the question of whether business cycles in the euro area have become more similar over time. The above research question has been addressed in a numerous of studies; yet, it has been approached empirically via two different channels of investigation. The first channel of empirical studies investigates whether business cycles in the euro area have become more similar, while the second one examines the factors, which drive business cycle synchronization.

In the first stance of empirical investigations, 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 countries and a reference country or computed as unconditional bilateral correlations. In the first case, one can examine whether a single country converges to a reference series - the euro area aggregate for instance, while in the second case, one can examine whether there exists dispersion of business cycle similarities over a group of countries. To check for convergence, correlations are typically computed over different time periods using a fixed or rolling sample window. In particular, the first and the second moments help assess whether convergence takes place: a rise in the mean of the correlations computed over consecutive periods coupled with a simultaneous decrease in the variance of the correlations is considered as evidence of increased synchronisation.

In the second 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

1 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)
economic structures, monetary and fiscal policies as well as financial integration\(^2\). 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).

Indeed, there are different methodological approaches of analysing the synchronicity of business cycles that unavoidably reach quasi different conclusions even though all these approaches are parts of a common theoretical corpus with respect to the matters of the spatial analysis. The purpose of our study is to use different methodologies to study in a comprehensive and consolidated way the regional business cycle synchronisation at NUTS II level.

Therefore, our analysis is conducted into three levels. Firstly, we analyse regional business cycle synchronization in the Euro Area, using 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. Our main interest is to study whether the dynamics of business cycles are different across regions with different levels of development. 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. Finally, following Imbs (2004) and Tondl and Traistaru, (2006) we empirically extend the research on both identifying factors which might drive regional business cycle synchronization, assessing the importance of sub-national regional variations of business cycles. In particular, we analyse the role of trade integration, the different regional specialisation patterns in relation to the pattern of EU14, as determinants of regional growth cycle correlations with the Euro area over the period 1980-2009 for the NUTS II regions of EU 14 (except Luxemburg). We specifically draw attention to yet another possible drive of business cycle synchronisation: regional investments associated with specific special characteristics of economic activities. 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.

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\(^2\) 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).
2. Literature Review

As mentioned in the introductory section, the research question of whether business cycles in the euro area have become more similar over time have been addressed in a numerous of studies and while important common conclusions have been reached there are diverse findings about the evolution of business cycle synchronization. This is due to the fact that different datasets and methodologies have been used across studies, making it difficult to compare the results. 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 an overview here. However, it is worth mentioning some major conclusions.

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) 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); synchronisation has lately increased in some ‘peripheral’ countries (Marelli 2006); there are remarkable similarities between the business cycle patterns of countries, despite significant differences in the patterns of fiscal and monetary policies and terms of trade (Christodoulakis et al. 1995) and 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 in the case of the Greek regions (Montoya and de Haan 2007). In general, there are two streams of thought. 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).

Additionally, studies have examined not only to what extent business cycles have become similar but also the driving forces of the co-movement of output. The determinants that affect the synchronization cycles are various. First, the 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). This is why 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 Business Cycles Synchronicity with the EU-14 reference cycle

In this section, we focus on the synchronisation of regional business cycles in the Euro Area, using GDP covering a range of 200 NUTS II regions for a period of 30 years, 1980-2009. The countries under study are: 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). The same datasets are used throughout our paper.

The regional cycle is computed by using the Hodrick–Prescott and the Christiano–Fitzgerald filters. We measure the co-movement of the regional cycles and the Euro Area cycle in terms of their correlation coefficients. Some preliminary stylized facts with respect to the European regions focusing on the spatial differentiation of the EU-14 are presented below. It is worth noting here that there is no homogeneity across our sample of 200 regions, hence for the purpose of our study, we split the regions into two groups initially and then into four groups based on the median of the EU14 average GDP per capita of the 200 regions. Based on the level of development, we group our regions in four groups and we refer to these groups of regions as ‘high-high’, ‘high-low’, low-high’ ‘low-low’.

Map 1 shows the categorization of European regions with criterion the average regional GDP per capita as a percentage of the EU-14 for the period of reference 1980-2009. 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. The second one made up from the less poor European regions (Low-High regions) with GDP per capita between 66-95 of the EU-14 GDP per capita. The third group consists of the less rich European regions (High-Low) with GDP per capita between 96-119 of the EU-14 GDP per capita and the last group consisted of the richest regions (High-High regions) with GDP per capita more than 120 of the EU-14 GDP per capita. As we can observe 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. The division in question raises the matter whether or not the different level of development affects the synchronization dynamics between the regional business cycles and the EU-14 business cycle.
We follow previous studies focusing on deviation business cycles from a specific trend. For the estimation of the regional business cycles as well as the cycle of EU-14 we use annual observations of the GDP in constant prices at the NUTS II European region level covering 30 years from 1980 to 2009. For the identification of the business cycle, we use 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, and 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. Most studies apply non-parametric filters divided into high-pass or low-pass filters, which remove high frequencies.

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 (Montoya and de Haan, 2008). The advantages of this standard practice are first, that it is easy to implement and second, the resulting cyclical residuals are similar to those of the band-pass filter (Belke and Heine 2006, Montoya and de Haan, 2008). 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:

Source: Eurostat (2012)
Observed series \((X_t) = \text{Permanent trend } (T_t) + \text{Cycle } (Z_t)\) \hspace{1cm} (1)

The HP filter has been widely used in business cycle literature. The filter extracts the trend \(T_t\) from a given data \(X_t\) by minimising the following function:

\[
\sum_{t=0}^{T} (X_t - T_t)^2 + \lambda((T_t - T_{t-1})^2 - (T_t - T_{t-2}))^2, \quad (2)
\]

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 \(\lambda \to 0\), the trend approximate the actual series \(X_t\), while as \(\lambda \to \infty\), 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.

In order to investigate the effect of European integration on the business cycle synchronicity we analyze the evolution of the correlation coefficient of the regional business cycles in question with the EU-14 reference business cycle. Following Massmann and Mitchel (2004) we compute an 8-year rolling window average correlation coefficient of regional business cycles with the EU-14 reference business cycle for the time period (1980-2009). Moreover, taking into consideration the income inequalities of the European regions we put forward the dynamics of business cycle synchronicity in the context of each separate group characterized by the different level of per capita income in relation to EU-14.

We present also and the consecutive 8-year rolling window average correlation coefficient of regional business cycle with the national cycle over the same period, so as to investigate the existence of the so-called «border effect» that seems to coexist with the broader process of the European integration. For instance Clark and Van Wincoop (2001) found a stronger border effect in Europe than in the USA despite the intensification of the European integration process. Following De Grauwe and Vanhaverbeke (1993), Fatas (1997) and Montoya and de Haan (2008) we present on the figures 1 to 4, that depict the previous grouping order of the European regions on the basis of the GDP per capita as a percentage of the EU-14, the average correlation of the regional business cycle with the national cycle as well as the average correlation of the regional business cycles with the EU-14 business cycle.
Figure 1. Regions with GDP cap >120 in relation to EU=100, Regional correlation with national and EU-14 business cycles

Figure 2. Regions with GDP cap 96-119 in relation to EU=100, Regional correlation with national and EU-14 business cycles
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 concerned of regional business cycles with the national cycles, it seems that after a slight diminishing trend in the eighties to recuperate 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 poorest European regions (figure 4) for the other three groups of 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 that fosters indeed 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 regions of 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 large extent after the Maastricht treaty (1992). Comparatively, the more developed regions are functionally integrated into the broader European space while the less developed regions are more integrated into their national space relegating to their different economic structures vis-a-vis to the structural characteristics of the more developed European regions.

4. The Dynamic Relationship of Regional Business Cycles

In this section, we employ a VAR type methodology as a measurement devise 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. 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:

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

where $Z_{it}$ is an $(mx1)$ vector of endogenous variables; $A_0$ is an $(mxn)$ 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:

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

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 as follows:

$$Z_{it} = [\text{cyc}_{Eu}, \text{cyc}_{nat}, \text{cyc}_{r}]$$

where $\text{cyc}_{Eu}$ is the cyclical component in the EU countries, $\text{cyc}_{r}$ is the regional cyclical component and $\text{cyc}_{nat}$ is the national cyclical component. For each variable we use a pooled set of $rT$, where $r$ denotes the number of regions and $T$ denotes the number of observations corrected for the number of lags $\rho$. The model is estimated through GMM (Love and Zicchino, 2006) 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

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1 To perform the analysis we used the STATA pvar routine written by Inessa Love (see Love and Zicchino, 2006).
simulation. The analysis of these functions makes it possible to draw conclusions about the responses of regional business cycles to the benchmark business cycles shocks, since they show the response of a specific variable to a one standard error shock in another variable in the system, keeping all other disturbances equal to zero.

4.2. Data

We use annual data over the period 1980-2009 for 200 regions of the EU14 countries. In order to estimate the panel VAR model, we estimate the cyclical component of regional GDP, national GDP and the EU14 GDP. A complete overview of how the cyclical component is estimated is given in the previous section. Our main objective 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. We split the regions into two groups initially and then into four groups based on the median of the EU14 average GDP per capita of the 200 regions. Based on the level of development, we group our regions in four groups and we refer to these groups of regions as ‘high-high’, ‘middle’ (group which consists of the ‘high-low’, low-high’ regions) and ‘low-low’, and we estimate a PVAR for each sample and analyze the difference in 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 VAR models estimated involve variables admitting stationary linear combinations, we estimate the 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

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4 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 vise-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.

5 The panel is balanced

6 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.
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).

4.3. Estimated Results

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 EU14 countries, over the period 1980-2009). Then we split the total sample into four different groups referring to the groups based on the level of development as ‘high-high’ (38 regions), ‘high-low’ (77 regions), ‘low-high’ (52 regions), low-low’ (33 regions). All models for each group is estimated with three variables: $corr$, $corrnat$ and $correu$, for three lags. Corr is the regional cyclical component, $corrnat$ is the national cyclical component, and $correu$ is the EU14 cyclical component. The estimated results of the PVAR of the different groups are reported in Table 1. Further, we estimated the impulse response functions at the 5% error bands generated by the Monte Carlo simulation. Figures 5-9 presents graphs of the impulse response functions at the 5% error bands generated by the Monte Carlo simulation for each group of estimation.

Based on the estimated results, we observe that at period 1, the influence on regional business cycle from the EU, is expressed by the parameter 0.306, while for the high-high regions is 0.303, for the high-low 0.240, for the low- high is 0.205 while for the low- low is 0.000. 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 by the parameter 0.253, while for high-high regions is 0.118, for the high-low 0.162, for the low high is 0.405 while for the low- low is 0.551. The national impact is greater on the less developed regions, whereas they have less effect on the higher developed regions. In terms of the regional own impact, the parameters are for high-high regions is 0.319 for the high-low 0.297, for the low high is 0.151 while for the low- low is 0.013. The impact is greater for the more developed regions rather than the lower ones. Examining the impact across periods, we observe that it 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, which is attributed to their structural characteristics. The maximum shock transmitted from the EU to the region 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 half year, and then decreases reaching a minimum of -0.37% after 3 years. Across the four groups, a cyclical pattern is observed, with however different time of cyclicality. For the higher developed regions, it takes more time to
reach the point of oscillations (minimum in approximately 3 years), whereas for the less developed regions it takes 4 years to reach the minimum point of oscillation.

5. Determinants of the EU14 Regional Business Cycles?

Naturally, the question to address at this point is what factors are behind the business EU 14 regional cycles synchronisation. Taking our study into the next level and following Imbs (2004) and Siedschlag and Tondl (2011), we estimate a system of simultaneous equations in order to unravel the various drives of EU regional business cycle correlations. So 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:

\[
corr_{it} = a_1 + a_2 spec_{it} + a_3 trade_{it} + a_4 inv_{it} + \varepsilon_{1,it} \\
trade_{it} = \beta_1 + \beta_2 spec_{it} + \beta_3 inv_{it} + \beta_4 I_{z, it} + \varepsilon_{2,it} \\
spec_{it} = \gamma_1 + \gamma_2 trade_{it} + \gamma_3 inv_{it} + \gamma_4 I_{z, it} + \varepsilon_{3, it} \\
inv_{it} = \delta_1 + \delta_2 trade_{it} + \delta_3 spec_{it} + \delta_4 I_{z, it} + \varepsilon_{4, it}
\]

where \( i = 1, ..., 200 \) is the index of regions in EU 14 (except Luxemburg), \( t = 1, ..., 23 \). The endogenous variables are the business cycle synchronization (\( corr \)), the trade integration (\( trade \)), the specialization (\( spec \)) and the investments (\( inv \)). The business cycle correlation is estimated by the cyclical component of GDP (in constant prices) between the NUTSII regions of EU-14 (EU-15 except Luxembourg) and the average of EU-14. The time period covers from 1980 to 2009. All data have been obtained from Eurostat (2012). Also all data have been estimated in relation to the EU-14 average. \( corr \) denotes the business cycle correlation between the regional output growth rate and the EU 14 output growth rate. The specialization variable (\( spec \)) is estimated by the Krugman specialization index (Krugman 1991) which measures the extent of which a region’s production pattern differs from that of the average of the EU14: \( SPEC_r = \sum_i s_{i,r} - s \), where \( i \) denotes the sector (\( i = 1 \ldots n \)), \( s_{i,r} \) denotes the share of gross value added in sector \( i \) in the region \( r \) in total value added of region \( r \) and \( s \) denotes the share of gross value added in sector \( i \) in the whole regions of the EU14. The variable takes values 0-2, where 0 denotes absence of specialization as the sectoral structure of the region is identical of that of the benchmark’s and 2 denotes a strongly sectoral
specialization. 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.

The trade integration index \((\text{trade})\) is a proxy index of trade integration in regional level (Petrakos et al 2005) as there are not available any trade data in regional level. First, it is estimated the trade integration of each country at sectoral level and it is calculated as the ratio of the trade \((t)\) of a country \(k\) (region \(r\) under consideration belongs to country \(k\)) with the benchmark economy \(b\) to the trade of the country \(k\) with the world \(w\), in each sector \(i\) \((i=1,2\ldots n)\). Then, the trade integration index is ‘regionalized’ by its weighting with the production location quotient of region \(r\) under consideration. The location quotient term is the ratio of the share of each sector \(i\) to the total production in region \(r\) \((s_{i,r})\) to the share of each sector \(i\) to the total production in country \(k\) \((s_{i,k})\). Thus, the trade integration index \((\text{TII})\) is estimated under the formula:

\[
\text{TII} = \sum_{i=1}^{n} \left[ \frac{t_{i,k,b}}{t_{i,k,w}} \cdot \frac{s_{i,r}}{s_{i,k}} \right].
\]

The index takes values equal or greater than 0. High (low) values are associated with high (low) levels of trade integration of each region with the benchmark economy which is in our case the EU14.

The investments index \((\text{inv})\) is defined as investments in all tangible goods whether bought from third parties or produced for own use.

The exogenous variables that are used are: for the equation of trade the GDP per capita variable (in constant prices), for the equation of specialization the population share, and for the equation of investments the agglomeration index, which is defined as the economic density of a region (ratio of output per area), and the concentration in manufacturing activity. All variable have been obtained from Eurostat (2012).

The concentration variable is estimated by the Krugman concentration index which measures the extent of which a sector is concentrated in a region in relation with the EU14. This index is estimated as follows: \(\text{CONC}_i = \sum_{r} \left| s_{i,r} - s_r \right|\), where \(r\) denotes the region \((r=1\ldots u)\), \(s_{i,r}\) denotes the share of gross value added in sector \(i\) in region \(r\) in the gross value added of the whole regions of EU14 and \(s_r\) denotes the share of total gross value added in region \(r\) in the whole regions of EU14. This index ranges from 0-2 with higher values to imply higher concentration of sector \(i\).

Business cycles correlations, trade integration, specialization and investment are all endogenous variables, where \(I_1, I_2, I_3\) and \(I_4\), contain the vectors of their exogenous determinants, which are different in every equation in order to identify the system.
5.2. Data, Estimation and Results

We estimate the direct and indirect effects of specific determinants on the synchronicity of regional business cycles with the EU-14 business cycle. These endogenous determinants are the trade intensity, the specialization similarities and the investments. The estimation strategy and the simultaneous equations procedures allow for possible endogeneity problems. For this purpose, it is applied a system of simultaneous structural equations controlling for any simultaneity and endogeneity problems. The three-stage least squares (3SLS) panel is a system of four equations, which by using simultaneous estimation and instrumentation isolate the different components of the endogenous variables and achieves consistency and efficiency in the variance-covariance matrix (Imbs 2004). Moreover, the equation system relegates obvious both the direct and the indirect effect of the endogenous variables and specifically these of trade, specialization and investment on the correlation coefficient of the regional cycles with the EU-14 cycle.

Table 2 reports the estimated results of the model consisted of equations (6) to (9). More analytically as far as the results of the first equation are concerned, we observe that the relation between the trade and the business cycles synchronicity is positive and statistically significant. The trade integration has the meaning of the economic openness to other markets and the intensification of linkages and cooperation networks. Its positive correlation with the synchronization coincides with the conventional wisdom which supports that international trade has a significant role in transmitting business cycle fluctuations across areas (Calderon et al 2007). This is explained by 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), their macroeconomic fluctuations have become increasingly affected by external disturbances and so increased trade relations leads to tighter business cycles co-movement (Frankel and Rose 1998, Clark and van Wincoop 2001, Calderon et al 2007).

In contrast, the relation of the specialization (variable which is estimated for all the considered sectors of economic activity) with the business cycles synchronicity is negative indicating that the dissimilarity of the regional economic structures with respect to the EU-14 affects negatively the synchronicity of their cycles. This occurs as the increased specialisation is associated with a quite differentiated market 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). The increased degree of specialisation according to the new economic geography is result of the economic integration process which has a redistributive role of economic activities according to the strength of agglomeration economies. Subsequently, the economic structures tend to diverge in the context of the integration and in that sense their economic cycles become less synchronized.
The third endogenous variable of regional investments, defined as the ratio of the total investments to GDP in relation to the corresponding ratio of the EU-14, affects positively the synchronization of regional and EU-14 cycles. Investment flows reflect a significant capital accumulation which could constitute a mechanism of economic expansion and growth (Swan 1956, Kaldor 1961). According to neoclassical theory, capital accumulation is characterized by diminishing returns and for this reason less developed regions could present common turning points in their economic cycle as they grow faster than the most developed regions. While modern trade theories and the New Economic Geography in their basic theoretical context support for a self-reinforcing nature of agglomeration and capital accumulation, there have been approaches that have taken a step further founding that agglomeration and regional growth is the result of the endogenous capital accumulation (Baldwin 1999). Our analysis confirms the direct positive effect of the endogenous variable of investments in the synchronization of regional and EU-14 cycles.

The equations of (6) (7), (8) and (9) contain the indirect effects of endogenous variables on the correlation coefficient of the regional business cycles with the EU-14 business cycle. As concerns the equation of trade (equation 8), specialization is related positively and statistically significantly with trade implying that regions with a specialized market structure have more intensified trade relations with EU-14. The robustness of this relation is arguably intelligible as it is generally predicted by any theoretical context and by any different conditions and factors that specialization and trade integration are closely related (in the comparative advantage theory is formed by the inter-industry trade or the New Economic Geography-models is formed by centrality and increasing returns, Krugman 1980, Krugman 1991, Venables 1996). Investments are related also positively with trade indicating that the endogenous capital accumulation matter for the trade relations. Hence, a more specialized regional pattern as well as a higher investment ratio in relation to EU-14 increases the trade intensity that in turns fosters the business cycle synchronicity. In that sense the indirect effect of specialization pattern and investments on business cycle synchronicity is positive via their effects on the trade intensity. Moreover, the relation of the exogenous variable of GDP per capita with trade is positive, indicating that the more developed regions tend to trade more comparatively to the less developed regions.

As concerns the equation of specialization (equation 8), the relation of trade and specialization is positive with the coefficient in question to be statistically significant. This indicates that regions with high trade integration are more specialized, an outcome that is consistent with the theoretical perspectives and our previous empirical results. The sign of the investment coefficient is negative and statistically significant implying the inverse relation of investments with specialization. Indeed, a higher regional investment ratio in relation to EU-14 leads to less specialized patterns since higher investment ratios are likely to support a broader range of economic and industrial structures. The relation of a diversified production market with the endogenous capital accumulation inter alia has been attested by other studies as well (Acemoglu and Ventura 2001). As far as the exogenous variable of population size is concerned, its relation with specialisation is negative and statistically significant.
The explanation is the same as in the case of investments. Indeed, a higher population relegates to a more extensive market potential that in turn it can foster a broader economic structure (Amiti 1998). From the equation of investments (equation 9) is inferred that trade integration is related positively with investments as well as the most developed regions with them. The trade theories support that to the extent that investment hinges on income levels and expected returns, the results of changes in trading conditions (by trade liberalization) will include induced shifts in the capital stock (Francois et al 1997). Investments and specialization have in both causality relations negative sign implying thus that as higher level specialization is, as lower level of capital is accumulated. Indeed a very high specialization value in relation to EU-14 average would indicate the existence of a mono-structural production base and a larger degree of vulnerability. These conditions deter any investment activity and capital accumulation. The relation of agglomeration with the investments is positive and is part of the several approaches which integrate economic geography and endogenous growth models. According to them, the agglomeration process operates as a growth pole making people want to invest in a specific region which in turn makes the region grow faster. It is the backward linkage of the interdependent relation among growth and agglomeration (Braunerhjelm and Borgman 2004). The consequence might be called agglomeration-induced investment-led growth (Baldwin and Martin 2004). The concentration in the manufacturing activity is also related positively and statistically significant with the investments. The industrial concentration constitutes a self-reinforced process which is based on increasing returns and externalities under the form of linkages between firms and suppliers as well as between firms and consumers. Thus, the benefits from the industrial concentration are important not only for the foreign but for the domestic firms as well and their investment activity (Cantwell 1991).

6. Conclusions

From the investigation of the business cycle synchronization it becomes evident that the European regions split into sub-groups with criterion of their level of development exhibit differential synchronization dynamics either at national or at European level. The differentiation of the spatial characteristics associated with the unequal effects of European integration affect asymmetrically the distribution of economic activities across European space, the capital accumulation, the type of specialization, the trade density thus the degree of synchronization. It is obvious that the impacts of the determinants, on the basis of the 3SLS, are also depicted into the different behaviour of the cyclical patterns in the context of the dynamic analysis of the PVAR model. In short, there seems to be a quasi division between the more and the less developed European regions of the EU-14. Indeed, the former are more functionally integrated into the broader European space while the latter are less integrated into the broader European space relegating to the fact that their cyclical patterns are mainly determined at the national level.
References


## Appendix: Tables

### Table 1. PVAR estimates

<table>
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<tr>
<th></th>
<th>Total Sample (200 regions)</th>
<th>High-High (38 regions)</th>
<th>High-Low (77 regions)</th>
<th>Low-High (52 regions)</th>
<th>Low-Low (33 regions)</th>
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<td>b</td>
<td>t-stat</td>
<td>b</td>
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**Notes:** *corr* is the regional GDP component, *corrnat* is the national GDP component, *correu* is the European GDP component.
Figure 5. Impulse Responses of Regional Business Cycles for periods 1, estimating the PVAR model for the total regions (200 regions) over the sample period.

Errors are 5% on each side generated by Monte-Carlo with 500 reps.

Figure 6. Impulse Responses of Regional Business Cycles for periods 1, estimating the PVAR model over the High-High Development Regions sample (38 regions) over total sample period.

Errors are 5% on each side generated by Monte-Carlo with 500 reps.
**Figure 7** Impulse Responses of Regional Business Cycles for periods 1, estimating the PVAR model over the High-Low Development Regions sample (77 regions) over total sample period

Errors are 5% on each side generated by Monte-Carlo with 500 reps

**Figure 8** Impulse Responses of Regional Business Cycles for periods 1, estimating the PVAR model over the Low-High Development Regions sample (52 regions) over total sample period

Errors are 5% on each side generated by Monte-Carlo with 500 reps
Figure 9 Impulse Responses of Regional Business Cycles for periods 1, estimating the PVAR model over the Low-Low Development Regions sample (33 regions) over total sample period.

Impulse-responses for 3 lag VAR of corr corrnat correu

Errors are 5% on each side generated by Monte-Carlo with 500 reps.
Table 2. Estimated Estimations of the system of equations (6)-(9) as defined in Section 5.1. using 3SLS of Equations

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