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ANALYSIS OF CONVERGENCE OF EUROPEAN REGIONS WITH THE USE OF COMPOSITE INDEX

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ABSTRACT

Convergence study is related to several crucial issues. One of those problems is an individual character of every region in the selected area, as the regions established accordingly to the European classification system NUTS-2 are not homogeneous. Therefore, while analysing convergence in the European Union, regions with extremely dissimilar characteristics (for example GDP per capita) are taken under consideration. Absolute β-convergence means that all of the investigated regions tend to the same level of economic growth. Thus, among the regions with highly differential amounts of the examined variables the convergence hypothesis can be rejected. Due to the heterogeneity in the conducted investigation a classification based on the composite index will be used so that the convergence clubs could be established. Several approaches to convergence will be used according to those regimes. Moreover, there will be an attempt to indicate the determinants that differentiate the selected regions, such as: expenditure on R&D, HRST, quantity of patents, employment, participation of people in tertiary education among all employees. This will allow the analysis of conditional β-convergence to be conducted. In the investigation some methods and models offered by the spatial statistics and econometrics will be used. There are empirical proofs that geographical location has a great impact on the processes of economic growth. Consequently, spatial dependencies will be analysed as well.

Key words: economic convergence/divergence, spatial autocorrelation, spatial econometric model, composite index.

Introduction

Regional growth and convergence are issues that attract a great deal of attention. Research on this topic is developing in different directions, with β-convergence phenomenon being one of them.

The neoclassical growth theory assumes that economies with initially low level of development tend to have faster productivity growth, due to diminishing returns

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on capital. In other words, regions with initial position of a relatively high capital-labour ratio tend to grow relatively slower than economies with low ratio. That induces that low technology regions are able to converge to the steady-state (Fingleton, 2001, p. 117). At its simplest, the convergence phenomenon connected with the neoclassical growth theory implies elimination of dissimilarity between investigated economies. Taking region differences under consideration leads to the expanded convergence model, which accommodates the existence of regionally differentiated steady-state. That leads to conditional convergence, where regions converge to their specific steady-states rather than to one common steady-state level.

Among the absolute convergence studies, the following works can be mentioned: Baumol W. J. (1986), De Long J. B. (1988). Conditional convergence was investigated in Mankiw N. G., Romer D., Weil D. N. (1992), Barro R. J., Sala-i-Martin X. X. (1992).

Apart from the diminishing returns of scale impact on the convergence phenomenon, there are also additional forces that lead regions to their steady-states. Those forces are connected with spatial or regional interactions among investigated economies. Spatial interactions in growth and convergence investigations are conspicuously absent in most empirical convergence investigations. However, the literature on spatial econometrics emphasizes that spatial interactions are crucial in growth and convergence understanding. Those models should acknowledge that changes in one region are able to spill over into other regions. It leads to conclusions that the dynamics of steady-state is affected by interregional interdependencies. Such understanding of convergence can be found, e.g. in: Abreu, M., de Groot, H. L. F., Florax, R. J. G. M. (2005), Rey, S. J., Janikas (2005), Ertur, C., Koch, W. (2007), Fingleton, B., López-Bazo, E. (2006).

The purpose of this investigation is to answer the question whether the phenomenon of convergence of per capita GDP occurs in the area of the European Union countries. Moreover, convergence clubs are established to investigate if convergence has a global or a local character. Convergence clubs are connected with the fact that regions are not strictly homogenous.

The structure of the other part of the paper is as following: in section 1 the subject and the range of investigation is specified. Section 2 briefly characterizes the data used in the investigation and the preliminary analysis. Section 3 presents methodology, including theoretical β-convergence models for cross-section and spatio-temporal regressions, and also points diagnostic statistic tests. In section 4 the results of the investigation are presented. Section 5 presents conclusions and further investigation directions.

1. Subject and range of investigation

According to regional and spatial interactions relevance mentioned above, the main hypothesis of investigation is that spatial dependencies are crucial in investigating the convergence phenomenon. During the investigation several questions will be answered:

1. How to establish convergence clubs, which will include homogenous regions?
2. What is the relation between the type of convergence (absolute or conditional) and the value of speed of convergence and half-life?
3. Does the approach in convergence investigation (global or local) affect the time in which economies reach the same level of development, understood as per capita GDP growth rate?
4. How can the problem of omitted variables in conditional convergence study be solved?

To achieve the aim mentioned in the introduction it will be demonstrated that empirical spatial models of convergence for cross-section data have better statistical characteristics than the ones that ignore the spatial dependencies among regions. It will be also shown that those models allow more precise economic interpretation of parameters. Empirical models are used for the hypothesis verification that the location of the region towards other regions has crucial impact for growth rate in this region.

2. Data

In the investigation the values of per capita GDP were used. The data refer to the period of 2003-2011. The spatial range of the investigation consists of 249 regions of NUTS-2 classification of the European Union countries.

Besides per capita GDP, some other variables were used in the investigation. Conditional convergence estimation was based on the following variables: general expenditures on R&D (GERD), human resources in science & technology (HRST), participation of people with tertiary education among all employees. Figure 1 presents the spatial density of the above mentioned variables. It is visible on the maps that the established area is not a homogenous group of spatial units, therefore it is reasonable to consider clubs of convergence.

(a) (7) (12)

Figure 1. Density of: (a) GERD, (b) HRST, (c) tertiary education level in 2003

3. Methodology

The classical approach to β-convergence analysis assumes that initial values of per capita GDP are negatively correlated with growth rates. The linear models using data in cross-section take the forms:

1. absolute convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha_0 + \beta \ln[GDP_{i1}] + \varepsilon_i,$$

2. conditional convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha_0 + \beta \ln[GDP_{i1}] + \sum_{m=1}^{r} \alpha_m x_{im} + \varepsilon_i,$$

where:

β – convergence parameter; when it is negative and statistically significant, the convergence phenomenon is observed,

x_{im} – value of m^{th} characteristic of region i.

In the conditional convergence model, additional variables inform about special characteristics of regions.

While analysing convergence, spatial approach is advisable. So far, the tools and methods offered by spatial econometrics have been rarely used. Yet in the spatial literature it is strongly pointed that in growth investigations spatial connections cannot be obtained.

The essential element in spatial models is the connectivity matrix, usually marked as **W**. This matrix defines the structure of the spatial connections among spatial units (neighbourhood based on a common border). The matrix has as many rows and columns as there are spatial units. **W** is given as:

$$\boldsymbol{W} = \left[w_{ij}\right]_{N\times N}.$$

Each element of the matrix is non-zero for pairs of regions which are neighbours. Because a region cannot be its own neighbour, element $w_{ij} = 0$ for $i = j$.

Spatial dependencies can be provided by using one of following models: spatial autoregressive model or spatial error model. Those models take the following forms:

1. spatial autoregressive model (SAR):
   1) absolute convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha + \beta \ln[GDP_{i1}] + \rho \sum_{j\neq i} w_{ij} \ln\left[\frac{GDP_{jT}}{GDP_{j1}}\right] + \varepsilon_i,$$

   2) conditional convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha_0 + \beta \ln[GDP_{i1}] + \sum_{m=1}^{r} \alpha_m x_{im} + \rho \sum_{j\neq i} w_{ij} \ln\left[\frac{GDP_{jT}}{GDP_{j1}}\right] + \varepsilon_i,$$

2. spatial error model (SEM):
   1) absolute convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha + \beta \ln[GDP_{i1}] + \eta_i,\ \eta_i = \lambda \sum_{j\neq i} w_{ij}\,\eta_j + \varepsilon_i,$$

   2) conditional convergence:

$$\ln\left[\frac{GDP_{iT}}{GDP_{i1}}\right] = \alpha + \beta \ln[GDP_{i1}] + \sum_{m=1}^{r} \alpha_m x_{im} + \eta_i,\ \eta_i = \lambda \sum_{j\neq i} w_{ij}\,\eta_j + \varepsilon_i.$$

When parameters ρ or λ are significant it indicates that spatial dependencies are crucial in the estimated model.

For the verification of estimated models several diagnostics tests were used:
1. the Moran test (Moran's I) – for the consideration of the 1st order spatial autocorrelation of per capita GDP in the established area and for spatial independence of residuals of the β-convergence models,
2. the Lagrange Multiplier tests (LMlag, LMerr) and their robust versions (RLMlag, RLMerr) as spatial dependence diagnostics,
3. the Likelihood Ratio test (LR) for testing the significance of the spatial dependence.

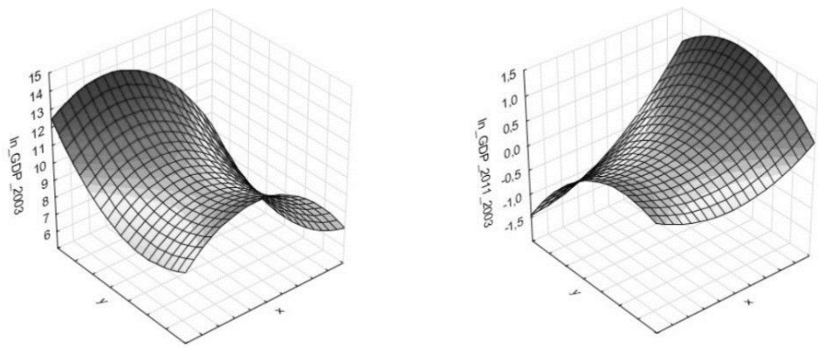
In the conducted investigation the division for convergence clubs was based on the values of the composite index. Stimulants used to calculate the index were the following: general expenditure on R&D, human resources in science & technology, participation of people with tertiary education among all employees and per capita GDP.

4. Results of empirical analysis

The convergence hypothesis was investigated with the use of two approaches. Firstly, the whole selected area was considered. Secondly, spatial regimes were identified and club convergence was considered.

4.1. European Union regions

The first stage in β-convergence investigation was founded on spatial trend surface analysis. Figure 2 compares the spatial distribution of per capita GDP in the initial year to GDP growth rate during the period 2003-2011. The tendencies in Figure 2 part (a) and (b) have inverted surfaces. This leads to the conclusion that the values of per capita GDP in 2003 are negatively correlated to growth rates. This can suggest that the convergence phenomenon occurs in the selected area.



(a) **(b)**

Figure 2. Spatial trends: (a) per capita GDP in 2003, (b) per capita GDP growth rate 2003-2011

Spatial trend analysis was followed by the estimation of econometric models presented in Section 3. Convergence was investigated using the absolute and conditional approach, respectively. Table 1 contains the results of the estimation and verification for the models mentioned above.

Table 1. Results of estimation and verification LM, SAR and SE models

	LM		SAR		SE	
	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.2412 (0.0000)	-0.3245 (0.0000)	-0.1102 (0.0000)	-0.1984 (0.0000)	-0.1660 (0.0000)	-0.2757 (0.0000)
ρ / λ	–	–	0.5954 (0.0000)	0.4518 (0.0000)	0.6640 (0.0000)	0.5294 (0.0000)
α_0	2.5971 (0.0000)	2.9760 (0.0000)	1.1732 (0.0000)	1.7749 (0.0000)	1.8757 (0.0000)	2.5572 (0.0000)
α_1	–	0.00003 (0.2010)	–	0.00002 (0.4200)	–	0.00002 (0.3020)
α_2	–	0.0204 (0.0000)	–	0.0132 (0.0000)	–	0.0170 (0.0000)
α_3	–	-0.0122 (0.0000)	–	-0.0072 (0.0000)	–	-0.0091 (0.0006)
Moran I	0.4430 (0.0000)	0.3044 (0.0000)	-0.0445 (0.8146)	-0.0035 (0.4954)	-0.0555 (0.8725)	-0.0191 (0.6304)
LR ratio	–	–	109.3400 (0.0000)	63.2340 (0.0000)	88.9480 (0.0000)	43.9070 (0.0000)
LM_{err}	92.2574 (0.0000)	43.5694 (0.0000)	–	–	–	–
LM_{lag}	113.6818 (0.0000)	62.3821 (0.0000)	–	–	–	–
RLM_{err}	1.2502 (0.2635)	1.1563 (0.2822)	–	–	–	–
RML_{lag}	22.6746 (0.0000)	19.9690 (0.0000)	–	–	–	–

The convergence parameter (β) is negative and statistically significant in every estimated model. This confirms our preliminary conclusions based on the scatterplots. Diagnostics for the linear models (absolute and conditional) are unsatisfying. In both classical models spatial residuals autocorrelation appears. Also Lagrange Multipliers inform that spatial dependencies must not be omitted. So, linear models cannot be treated as the final tools to verify the convergence phenomenon hypothesis. Therefore, models with spatial dependencies are proposed (SAR and SE). In the models augmented with connectivity, matrix residuals have better characteristics – spatial autocorrelation is eliminated. Robust Lagrange Multipliers inform that SAR model should be applied.

4.2. Regimes based on composite index

Originally, convergence clubs were supposed to be determined by the values of the composite index. So, regimes presented in Figure 3 consist of regions with similar values of the index (classification based on the mean value and standard deviation of the composite index). Group 1 includes economies with the lowest values of the index, whereas group 4 the ones with the highest values.

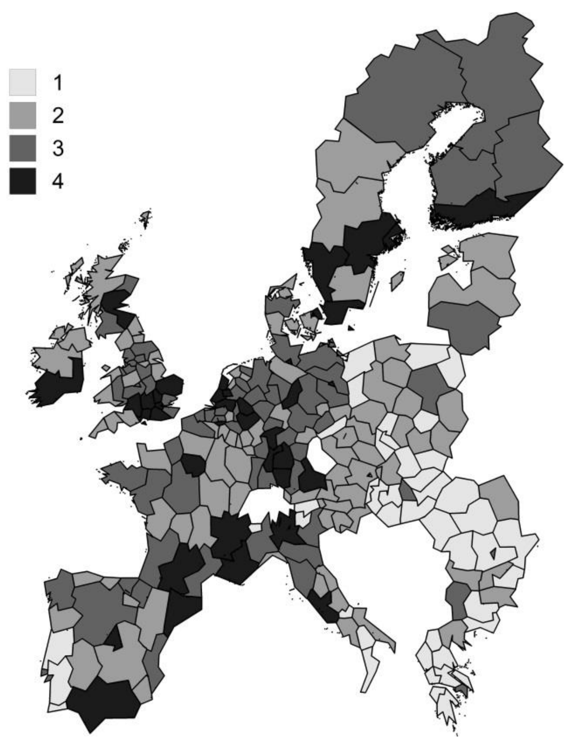


Figure 3. Composite index regimes

One significant issue is strictly connected to the appointed division. For the proposed connectivity matrix (based on a common border) spatial coherence should be maintained. This assumption is not fulfilled as it can be noticed on the map above

(Figure 3). So, for those regimes only the classical models (without spatial dependencies) were estimated.

The results are presented in Table 2. β parameter in every model is negative and statistically significant. Absolute magnitude of convergence parameter in each pair of models is higher for the conditional approach than for the absolute. Although clubs are incoherent, Moran *I* statistics inform that spatial dependencies should be included in estimation, which confirms that none of economies is independent from its neighbours.

Table 2. Estimation and verification of LM models for composite index regimes

	regime I		regime II		regime III		regime IV	
	absolute	conditional	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.3235 (0.0000)	-0.3541 (0.0000)	-0.2465 (0.0000)	-0.3297 (0.0000)	-0.3613 (0.0000)	-0.4080 (0.0000)	-0.0200 (0.7530)	-0.1834 (0.0052)
α_0	3.2615 (0.0000)	3.6430 (0.0000)	2.6413 (0.0000)	3.0098 (0.0000)	3.8196 (0.0000)	3.6780 (0.0000)	0.3495 (0.5930)	1.6050 (0.0086)
α_1	–	0.0003 (0.6131)	–	0.0003 (0.0086)	–	0.00004 (0.4626)	–	0.00005 (0.0641)
α_2	–	0.0114 (0.0326)	–	0.0212 (0.0000)	–	0.0219 (0.0000)	–	0.0167 (0.0001)
α_3	–	-0.0329 (0.0001)	–	-0.0149 (0.0000)	–	-0.0085 (0.0034)	–	-0.0114 (0.0006)
Moran I	0.4086 (0.0051)	0.2327 (0.0579)	0.4409 (0.0002)	0.4017 (0.0008)	0.3587 (0.0019)	0.1811 (0.0621)	0.6617 (0.0004)	0.3264 (0.0428)
LM_{err}	6.8879 (0.0087)	2.2353 (0.1349)	21.5509 (0.0000)	17.8900 (0.0000)	11.8241 (0.0006)	3.0150 (0.0825)	20.1451 (0.0000)	4.9020 (0.0268)
LM_{lag}	2.8715 (0.0902)	0.8292 (0.3625)	11.4128 (0.0007)	3.4171 (0.0645)	7.7959 (0.0052)	2.8343 (0.0923)	11.8122 (0.0000)	6.8703 (0.0088)
RLM_{err}	4.0280 (0.0448)	1.4145 (0.2343)	10.3467 (0.0013)	14.9031 (0.0001)	4.0562 (0.0440)	0.5855 (0.4442)	8.5418 (0.0035)	0.3812 (0.5370)
RML_{lag}	0.0115 (0.9146)	0.0084 (0.9271)	21.7595 (0.0000)	0.4302 (0.5119)	0.0279 (0.8671)	0.4048 (0.5246)	0.2089 (0.6477)	2.3494 (0.1253)

4.3. Spatio-composite regimes

In order to obtain spatial coherence, the modification of the prior division was introduced. As a result three regimes were established, as shown on Figure 4. For those groups of regions the classical models were estimated as well as the spatial models.

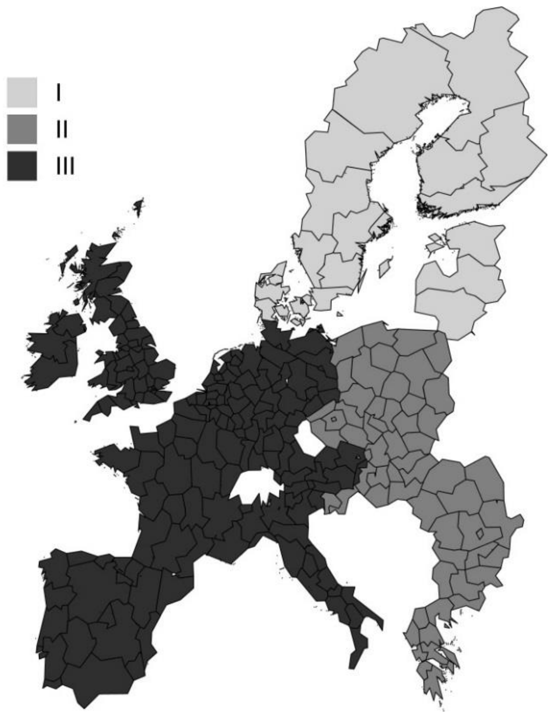
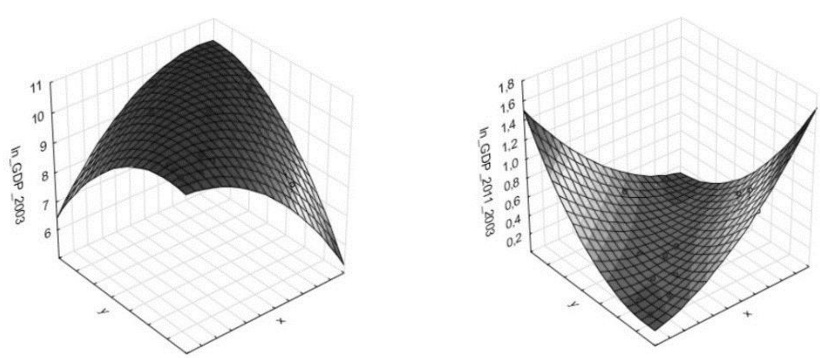


Figure 4. Spatio-composite regimes

For each regime, the analysis of trends and all proposed models was conducted.

The spatial trends of per capita GDP in the initial year and of growth rate in regime 1 are presented in Figure 5. The negative correlation between those two processes is noticeable, therefore it can be preliminary concluded that convergence occurs. The estimated models are included in Table 3.



(a) **(b)**

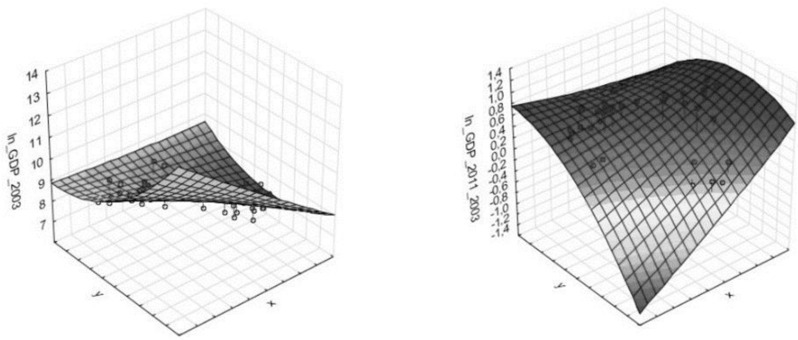
Figure 5. Spatial trends: (a) per capita GDP in 2003, (b) per capita GDP growth rate 2003-2011 for regime 1

In accordance with the initial conclusion β-convergence occurs in this regime. Moran statistics for linear classical models inform about the non-existence of spatial autocorrelation. It is confirmed by Lagrange Multiplier. A lack of spatial dependencies can be a consequence of regions selected to this regimes and the structure of their neighbourhood. As a result spatial parameters are not statistically significant.

Table 3. Estimation and verification of models for regime 1

	LM		SAR		SE	
	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.2685 (0.0000)	-0.3108 (0.0000)	-0.1740 (0.0000)	-0.2335 (0.0000)	-0.2774 (0.0000)	-0.3106 (0.0000)
ρ / λ	–	–	0.3221 (0.0337)	0.2441 (0.1244)	-0.1876 (0.3647)	0.1043 (0.6131)
α_0	3.0028 (0.0000)	3.2760 (0.0000)	1.9541 (0.0000)	2.5231 (0.0000)	3.0915 (0.0000)	3.2770 (0.0000)
α_1	–	0.00004 (0.2721)	–	0.0001 (0.0673)	–	0.00005 (0.1016)
α_2	–	0.0090 (0.0728)	–	0.0063 (0.1479)	–	0.0091 (0.0317)
α_3	–	-0.0084 (0.1068)	–	-0.0086 (0.0351)	–	-0.0088 (0.0482)
Moran I	-0.1427 (0.6557)	0.0330 (0.3430)	-0.3374 (0.8969)	-0.0417 (0.4796)	-0.0104 (0.4249)	0.0049 (0.3939)
LR ratio	–	–	3.0968 (0.0784)	1.5355 (0.2153)	0.5582 (0.4550)	0.0719 (0.7885)
LM_{err}	0.3612 (0.5479)	0.0193 (0.8895)	–	–	–	–
LM_{lag}	1.9357 (0.1642)	0.9867 (0.3205)	–	–	–	–
RLM_{err}	6.1547 (0.0131)	1.0691 (0.3012)	–	–	–	–
RML_{lag}	7.7292 (0.0054)	2.0365 (0.1536)	–	–	–	–

The analogous analysis was conducted for regime 2. Figure 6 presents trend surfaces. In this case, the negative correlation is also noticeable.



(a) **(b)**

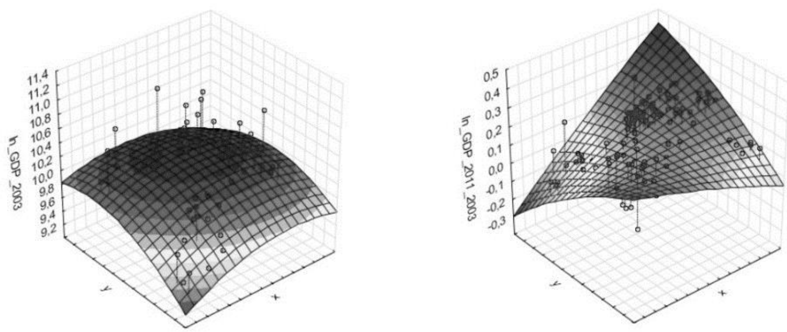
Figure 6. Spatial trends: (a) per capita GDP in 2003, (b) per capita GDP growth rate 2003-2011 for regime 2.

The estimated models confirm the convergence phenomenon. For this regime spatial dependencies are crucial. It is shown by Moran statistics and Lagrange Multiplier for linear models. Parameters ρ / λ are significant in all models. Thanks to the connectivity matrix the spatial autocorrelation is eliminated.

Table 4. Estimation and verification of the models for regime 2

	LM		SAR		SE	
	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.2712 (0.0000)	-0.3331 (0.0000)	-0.1448 (0.0008)	-0.2389 (0.0000)	-0.1824 (0.0014)	-0.3133 (0.0000)
ρ / λ	–	–	0.5166 (0.0000)	0.3408 (0.0080)	0.5383 (0.0000)	0.4399 (0.0014)
α_0	2.8722 (0.0000)	3.0200 (0.0000)	1.5078 (0.0003)	2.0846 (0.0000)	2.1199 (0.0000)	2.8226 (0.0000)
α_1	–	0.00008 (0.8979)	–	0.00002 (0.9686)	–	0.00001 (0.9831)
α_2	–	0.0241 (0.0002)	–	0.0181 (0.0023)	–	0.0232 (0.0010)
α_3	–	-0.0167 (0.0251)	–	-0.0097 (0.1587)	–	-0.0128 (0.1656)
Moran I	0.2481 (0.0017)	0.2156 (0.0051)	-0.0397 (0.5997)	0.0707 (0.1671)	0.0008 (0.4223)	0.0334 (0.2895)
LR ratio	–	–	13.6820 (0.0002)	5.5269 (0.0187)	8.8727 (0.0029)	6.2843 (0.0122)
LM_{err}	6.9655 (0.0083)	5.2605 (0.0218)	–	–	–	–
LM_{lag}	13.4603 (0.0002)	5.0877 (0.0241)	–	–	–	–
RLM_{err}	2.3121 (0.1284)	0.5587 (0.4548)	–	–	–	–
RML_{lag}	8.8070 (0.0030)	0.3859 (0.5345)	–	–	–	–

The results for regime 3 are not unambiguous. However, for the classical models the convergence parameters are negative and significant, the values of Moran *I* and Lagrange Multiplier suggest that spatial dependencies should be introduced to estimation. After the connectivity matrix has been added to the models, β parameters are positive, which can suggest that divergence can be observed in the established area.



(a) **(b)**

Figure 7. Spatial trends: (a) per capita GDP in 2003, (b) per capita GDP growth rate 2003-2011 for regime 3.

Table 5. Estimation and verification of the models for regime 3

	LM		SAR		SE	
	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.0196 (0.4970)	-0.1540 (0.0000)	0.0105 (0.45890)	-0.0199 (0.3211)	0.0227 (0.1991)	0.0157 (0.4981)
ρ / λ			0.8194 (0.0000)	0.7765 (0.0000)	0.8189 (0.0000)	0.8142 (0.0000)
α_0	0.3434 (0.2380)	1.3970 (0.0000)	-0.0792 (0.5770)	0.1596 (0.3943)	-0.0854 (0.6357)	-0.0553 (0.8010)
α_1	–	-0.00001 (0.6230)	–	-0.00001 (0.5428)	–	-0.00001 (0.5079)
α_2	–	0.0154 (0.0000)	–	0.0033 (0.0065)	–	0.0013 (0.5439)
α_3	–	-0.0105 (0.0000)	–	-0.0017 (0.0753)	–	0.00001 (0.9958)
Moran I	0.8155 (0.0000)	0.5967 (0.0000)	-0.0517 (0.8024)	-0.0584 (0.8351)	-0.0501 (0.7938)	-0.0513 (0.7997)
LR ratio	–	–	200.3200 (0.0000)	153.7800 (0.0000)	201.4200 (0.0000)	149.35 (0.0000)
LM_{err}	222.2529 (0.0000)	118.9891 (0.0000)	–	–	–	–
LM_{lag}	224.2186 (0.0000)	155.5310 (0.0000)	–	–	–	–
RLM_{err}	1.7846 (0.1816)	1.9274 (0.1650)	–	–	–	–
RML_{lag}	3.7503 (0.0528)	38.4694 (0.0000)	–	–	–	–

For the purpose of comparing the prior results, the speed of convergence and half-life for the whole area were calculated, and the regimes established by the spatio-composite approach. Those measures are presented in Table 6. Excluding regime 3 some successive conclusions can be deduced. The values of half-life are lower for the conditional models than for the absolute ones – because they include specific region characteristics. In general, the time of reducing the differences of per capita GDP is longer in models containing spatial dependencies.

Table 6. Speed and half-life for whole area and established regimes

	LM		SAR		SEM	
249 regions of the EU						
	absolute	conditional	absolute	conditional	absolute	conditional
β	-0.2412	-0.3245	-0.1102	-0.1984	-0.1660	-0.2757
speed	0.0307	0.0436	0.0130	0.0246	0.0202	0.0358
half-life	22.60	15.90	53.43	28.21	34.37	19.34
Regime I						
β	-0.2685	-0.3108	-0.1740	-0.2335	-0.2774	-0.3106
speed	0.0347	0.0414	0.0212	0.0295	0.0361	0.0413
half-life	19.95	16.76	32.63	23.46	19.20	16.77
Regime II						
β	-0.2712	-0.3331	-0.1448	-0.2389	-0.1824	-0.3133
speed	0.0352	0.0450	0.0174	0.0303	0.0224	0.0418
half-life	19.72	15.40	39.88	22.85	30.98	16.60
Regime III						
β	-0.0196	-0.1540	0.0105	-0.0199	0.0227	0.0157
speed	0.0022	0.0186	–	0.0022	–	–
half-life	315.15	37.30	–	310.35	–	–

5. Conclusions

As it has been shown, the trend surface analysis is helpful for initial conclusions if convergence occurs. The convergence phenomenon is strictly connected to the time and the spatial range of the investigation – for the presented area and regimes the convergence hypothesis was not confirmed in every case. However, it is noticeable that the speed of convergence is higher for clubs of regions than for the whole selected area. Regimes are more homogenous groups (except for club 3), therefore the equalization of the economic development can be of a faster pace. The spatial dependencies were not significant in each of the cases considered, but omitting them could result in spatial autocorrelation of residuals. The time of reducing the differences in the levels of GDP is shorter for the non-spatial models.

The direction for further investigations: dividing regime 3 because of its heterogeneity and diversity of the composite index; analyses with panel data models – changes through investigated period will be exploited; introducing individual fixed effects or Spatial Durbin Model (proposed solutions for omitted variables).

REFERENCES

ABREU, M. H., DE GROOT, L. F., FLORAX, R. J. G. M., (2005). Space and Growth: A Survey of Empirical Evidence and Methods, Région et Développment, Vol. 21, pp. 13−14.

BARRO, R. J., SALA-I-MARTIN, X., (1995). Economic Growth, New York: McGraw-Hill,.

CAURESMA, J. C., FELDKIRCHER, M., (2015).,Spatial Filtering, Model Uncertainty and the Speed of Convergence in Europe, Journal of Applied Econometrics, Vol. 28, Issue 4, pp. 720–741.

ELHORST, P., PIRAS, G., ARBIA, G., (2010). Growth and Convergence in a Multiregional Model with Space-Time Dynamics, Geographical Analysis, Vol. 42, pp. 338–355.

ERTUR, C., KOCH, W., (2007). Growth, Technological Interdependence and Spatial Externalities: Theory and Evidence, Journal of Applied Econometrics, Vol. 22, pp. 1033−1062.

FINGLETON, B., (2001). Equilibrium and economic growth: spatial econometric models and simulations, Journal of Regional Science, Vol. 41, No. 1, pp. 117−147.

FINGELTON, B., (2004). Regional Economic Growth and Convergence: Insight from a Spatial Econometric Perspective, in: L. Anselin, R. J. G. M. Florax, S. J. Rey (eds.), Advanced in Spatial Econometrics. Methodology, Tools and Applications, Springer, pp. 397−432.

FINGLETON, B., LÓPEZ-BAZO, E., (2006). Empirical growth models with spatial effects, Regional Science, Vol. 85, No. 2, pp. 177–198.

GÓRNA, J., GÓRNA, K., SZULC, E., (2014). A β-convergence Analysis of European Regions. Some Re-specification of the Traditional Model, Models and Methods for Analysing and Forecasting Economic Processes. Theory and Practice (edited by Józef Pociecha), Cracow, pp. 83−97.

LE GALLO, J., ERTUR, C., BAUMONT, C., (2003). A spatial econometric analysis of convergence across European Regions, 1980-1995. In B. Fingleton (ed.), European Regional Growth. Advances in Spatial Science. Springer-Verlag, Berlin Heidelberg, pp. 99–129.

MANKIW, N. G., ROMER, D., WEIL, D., (1992). A Contribution to the Empirics of Economic Growth, Quarterly Journal of Economics, Vol. 107, pp. 407−437.

REY, S. J., JANIKAS, (2005). Regional Convergence, Inequality, and Space, Journal of Economic Geography, Vol. 5, pp. 155−176.

REY, S. J., LE GALLO, J., (2009). Spatial analysis of economic convergence, in Mills T. C., Patterson K. (eds.), Palgrave Handbook of Econometrics, Volume II: Applied Econometrics, Palgrave MacMillan, New York, pp. 1251−1290.