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CONVERGENCE OF CENTRAL AND EASTERN EUROPEAN REGIONS – SPATIAL ASPECT

Summary: The objective of the article is to identify the nature of spatial dependence in terms of economic determinants for the regions of Central and Eastern European countries (according to Eurostat methodology it corresponds with NUTS-2 level). Statistical and spatial econometrics tools were used for the analysis. One of the effects of the study is determining the nature and significance of spatial dependence by means of identifying the existence of clusters formed by regions-neighbours presenting the similar level of development. The second part of the article attempts to assess the impact of spatial dependence on the estimations of beta absolute convergence models. The study covered the period 2000-2010.

Keywords: spatial econometrics, Central and Eastern European countries, distance matrix.

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1. Introduction

The disproportions in socio-economic development represent one of the key problems characteristic for regional and cohesion policy in the European Union. The literature references present numerous studies related to socio-economic development. Various types of tools and techniques, from descriptive statistics methods and indicators to advanced taxonomic methods and econometric models, are applied for the quantitative description of socio-economic development. Most frequently the performed analyses are based on data in the form of time or cross-sectional series (e.g. about households [Dziechciarz-Duda, Król, Przybysz 2012, pp.144-152, regions [Markowska, Jefmański 2012, pp. 74-93; Hlaváček 2009], regional districts "powiaty" [Pietrzak 2010]), panel data (e.g. for countries [Ciołek 2004], regions [Bal-Domańska 2013(b)]). In the process of constructing econometric models describing the determinants of economic growth created based on cross-sectional or panel data referring to countries or regions, the problem appears of how to define certain phenomena occurring across administrative borders. This situation is well illustrated by the example of large urban centres which most often cover an area of one region and its neighbours. They are frequently connected by very strong economic ties resulting from their location and referring to, among others, commuting to work, relations between companies and suppliers, as well as the cooperating partners. In such a situation, the range of impact extends beyond the administrative borders of a single unit. The effect of correlation occurs between the regions.

The objective of the article is to identify spatial dependence in terms of economic development level in the regions (NUTS-2) of the transitional economies – Central and Eastern European countries in the period 2000-2010, and an assessment of their impact on the estimations of absolute convergence models. Therefore it can be stated that the article defines two research goals. The first one, which is of a methodological nature, allows to answer the question of whether the spatial structures have an impact on the convergence models' estimations. The second objective is of an empirical nature and consists in an attempt to both identify and measure the convergence rate.

The selection of Central and Eastern European countries (the Czech Republic, Estonia, Latvia, Lithuania, Poland, Hungary, Slovenia and Slovakia) based on their geographical location and political-economic development – the first group of post--socialist states that acceded to the European Union in 2004.

The literature references present two approaches to convergence: sigma and beta. Sigma convergence refers to the decreasing disproportions between states or regions in time, while beta convergence means the faster rate of poorer regions' development compared to the wealthier regions, having the effect of catching up with the latter. Sigma convergence results from beta convergence.

Sigma convergence is measured using standard deviations of the analyzed variable. Beta convergence is measured by means of econometric models [Sala--i-Martin 1996, pp. 1019-1036], [Bal-Domańska 2010(a); Kościelski, Malaga 2008]. The research on beta convergence covering the countries of Central and Eastern Europe was conducted by, among others [Smętkowski, Wójcik 2009], who indicated a relatively weak beta convergence among the sub-regions (NUTS-3) of ten Central and Eastern European countries in the period 1998-2005.

In general terms, the model of beta absolute convergence describes the influence of the initial value of the economic development level on the economic growth rate which can be presented by means of the following formula:

$$\frac{1}{T}\ln\frac{y_{i0+T}}{y_{i0}} = \alpha - [\frac{(1-e^{-\beta^k T})}{T}]\ln(y_{i0}) + \varepsilon_{it},$$

$\theta = \frac{(1-e^{-\beta^k T})}{T}$ – the parameter defining the convergence rate against the long-term equilibrium (the distance covered in a year), T – the number of years.

If a negative, significant θ parameter estimate, at the initial level of revenue is achieved the occurrence of convergence is confirmed. The value of this estimate informs us about the direction of dependence between the initial level of development and the economic growth rate. β^k parameter informs us about the convergence rate, i.e. what percentage of the distance towards the long-term equilibrium can be covered by a particular economy within one period. While calculating a model, the half-life value is often defined which informs us about the number of years a given economy requires, following certain assumptions, to cover half the distance to the long-term equilibrium.

2. The procedure of analyzing spatial dependence in regional development and convergence

In the course of analyzing spatial interactions specific problems have to be dealt with, e.g.: identifying networks, distance (proximity), spatial dependence specification (spatial lag and spatial error models) and the adjustment of a unit (region) size to the analyzed problem nature.

Spatial autocorrelation represents one of the basic terms in the analysis of spatial dependence, understood as the occurrence of relations between objects located within some proximity. It is manifested by the creation of clusters characterized by similar values (positive autocorrelation) or radically different values (negative correlation). The basic reasons underlying spatial correlation are represented by the power of the interaction between units and the incompatibility between the boundaries of the analysed processes and the borders of administrative units [Suchecki 2010].

The occurrence of spatial autocorrelation can exert a negative impact on the estimations of model structural parameters since it undermines one of the fundamental assumptions of the least square dummy variable method (LSDV) regarding the random component sphericity, including its value being independent from the random component value of other objects. Failure to meet this assumption results in obtaining poor quality parameter estimations referring to structural models.

The key term for spatial correlation is the concept of proximity and the definition of the matrix which can be used to describe it. Its correct construction requires not only to identify the network and the direction of relations, but also the range of impact. The most popular matrix (applied in this study) is the proximity matrix of n-th order, where n refers to the number of borders which have to be crossed from one object to the second one.

The value of I Moran's statistics [Moran 1947], [Cliff, Ord 1981] is applied in measuring spatial dependence. This statistic functions in two variants – global for defining the general regional similarities, and a local one which defines whether the i-th object (region) is surrounded by objects presenting similar or different values. If spatial correlation is missing I Moran's statistics show a tendency to take the following values: $I \approx -\frac{1}{n-1}$. While verifying the statistical hypotheses referring to Moran's statistics the absence of clusters presenting either high or low values (zero hypothesis) is assumed. The joint-count test [Kopaczewska 2006] can also be applied for the assessment of spatial dependence, which allows verifying whether the spatial dependence refers to positive or negative residuals. The idea of the test is to verify the tangency probability of objects characterised by similar values. A zero hypothesis in this test assumes that the distribution of events in space is a random one and that autocorrelation does not occur.

It is important to specify the method for presenting spatial dependence in a model. The article discusses two approaches:

- spatial autocorrelation of the random component (SEM *Spatial Error Model*) – when the model disregards autocorrelated spatial variables and the spatial component constitutes a part of a random component,
- spatial autoregression (SAR/SLM *Spatial Autoregressive Model / Spatial Lag Model*) – when the values of *Y* endogenous variable from *s* unit influence the variable in *I* unit and other locations.

The question arises as to which model construction is the correct one [Anselin 1998, pp. 237-289] indicates that in a situation when the model of spatial or social processes equilibrium is analysed, where the explained variable is also under the influence of processes occurring in the ambient units, the spatial autoregressive model is the correct one. If, however, autocorrelation does not result from either spatial or social interactions and only represents the effect of the random component non-sphericity, then the spatial error model is the proper one. It is also possible to apply, for the purposes of the model correct construction selection, the statistical values based on the reliability function. This study takes advantage of the Akaike information criterion (AIC) [Akaike 1974].

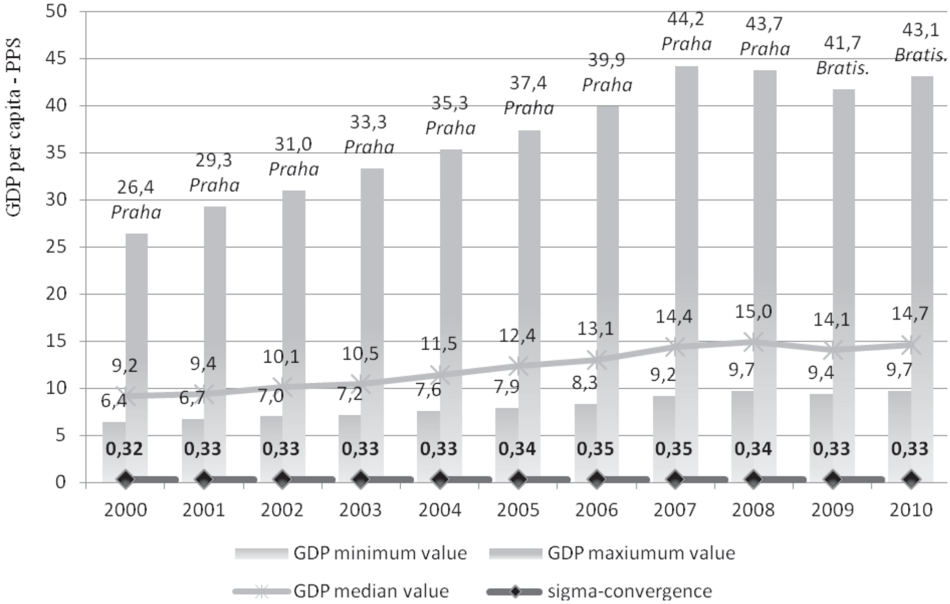
Spatial lag models (SAR/SLM) are estimated following the highest reliability method. Spatial error models (SEM) were estimated using the GLS method and δ by means of optimisation. All the calculations were performed in *R* programme.

3. The scope and basic statistics of GDP spatial diversification in NUTS-2 regions of Central and Eastern European countries

The study covered 40 regions at NUTS-2 level from selected Central and Eastern European countries: the Czech Republic (8 regions), Estonia (1), Latvia (1), Lithuania (1), Poland (16), Hungary (7), Slovenia (2) and Slovakia (4). The study referred to the period 2000-2010.

The value of gross domestic product variable, according to the purchasing standard calculated per 1 inhabitant (GDP), was used to measure the economic growth and convergence. As the data presented in Chart 1 show, the minimum value recorded in the space of the studied regions was increasing year after year except for a slight fall in 2009. In 2010 its value was higher by 52% than the GDP value in 2000. The Polish Podkarpackie and Lubelskie regions were the ones showing the lowest revenue until 2008, in 2010 – as the result of favourable growth dynamics –

they improved their GDP and moved to higher positions. The lowest revenues, on the other hand, in the final year of the study were characteristic for the following Hungarian regions: *Észak-Magyarország* and *Észak-Alföld*.



Bratis. – Bratislavský kraj

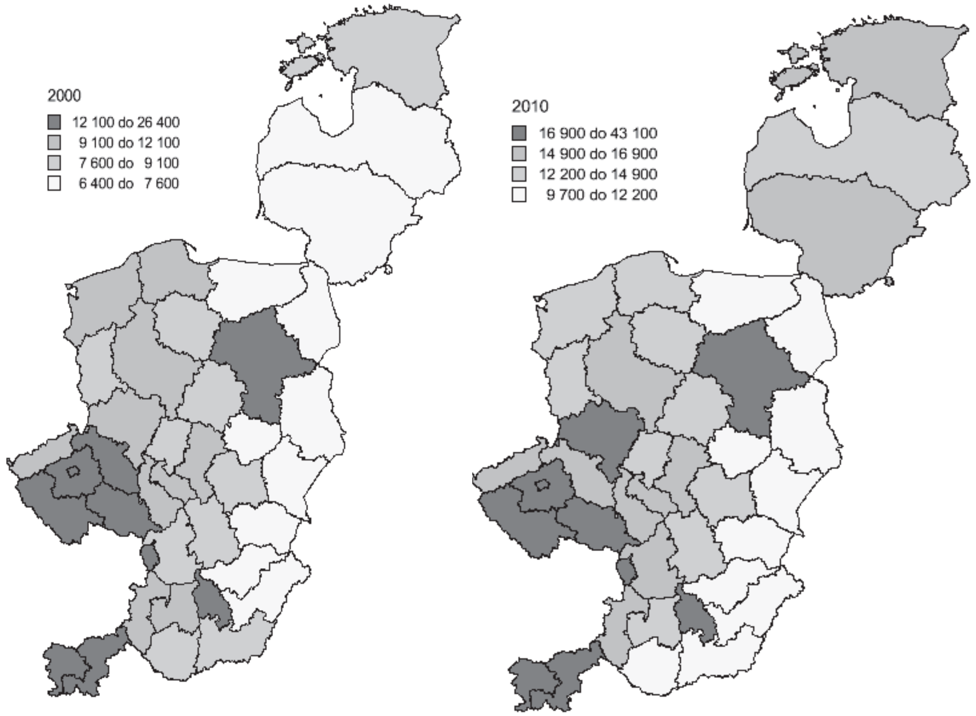
Chart 1. The minimum and maximum value of GDP variable and the value of sigma convergence measure in the regional space of Central and Eastern Europe in the period 2000-2010

Source: author's compilation.

Similar tendencies can be observed in relation to the highest (maximum) values, which until 2007 were growing dynamically. However, in the subsequent two years 2008 and 2009, GDP value dropped slightly, only to increase again in 2010. It is worth noticing that until 2008, the highest revenue was characteristic for the Praha region, however, in the last two years of the study it was overtaken by the *Bratislavský kraj* region which recorded, during the entire period, an increase of GDP variable at the average annual rate of 7,6% (and which was the fastest growth rate).

As far as sigma convergence is concerned, until 2007 a gradual advancement of developmental disproportions was observed, which was caused by the much faster development of those regions already featuring high level of it, and a relatively low growth rate recorded for poor regions. It was not until 2008 that sigma convergence processes were observed as the result of which the convergence level in 2010 reached a slightly lower value than the one observed at the beginning of the studied period (the sigma convergence measure in 2000 was 0,333 and in 2010 – 0,325).

Picture 1 presents the spatial distribution of the GDP variable value among the regions of Central and Eastern Europe in the initial and final year of the study, i.e. in 2000 and in 2010. For the illustration of GDP distribution the regions were divided into four groups. The values of the 1st, 2nd, 3rd and 4th quartiles were used for the division of regions.



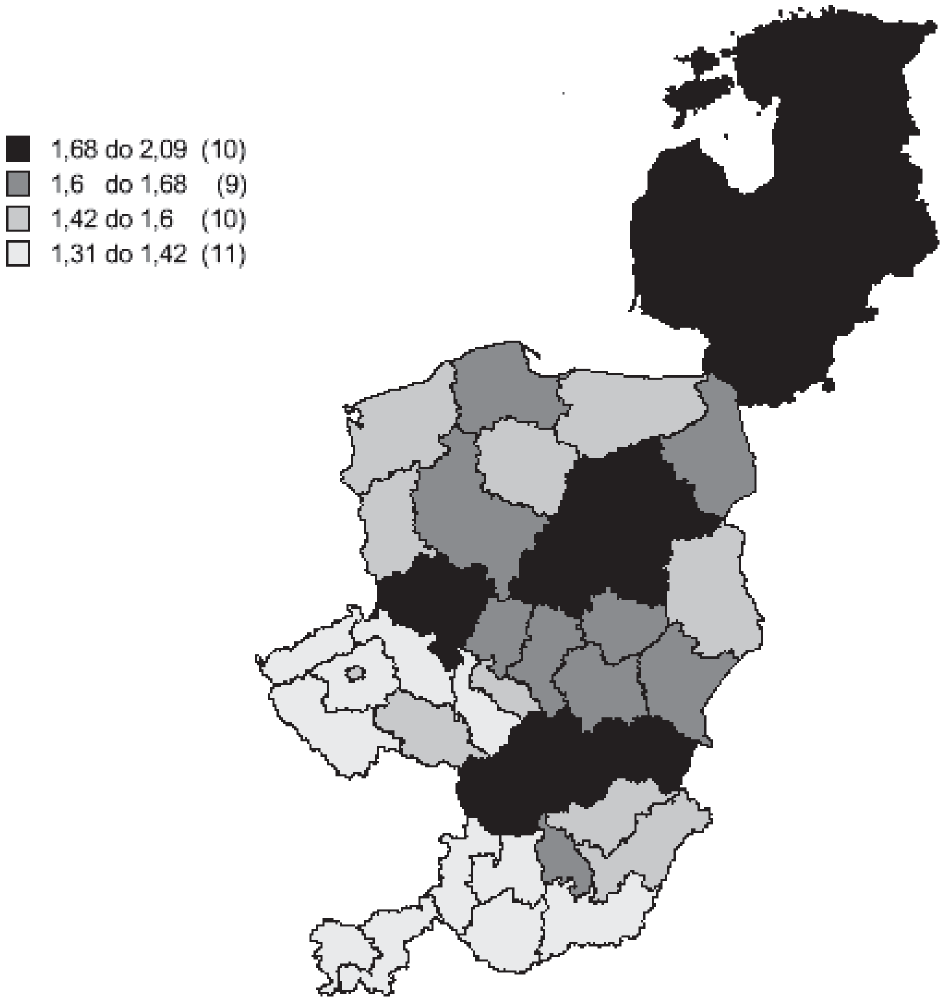
Picture 1. Spatial diversification of the GDP variable value in the regions of Central and Eastern Europe in the period 2000 and 2010

Source: author's compilation.

As the presented data indicate, in 2010 compared to 2000, certain changes in the positions of regions regarding GDP are visible. The selected regions moved to classes characterized by a lower revenue level (their ranking position dropped). Among them the following regions were listed: Czech (*Severovýchod*), Hungarian (*Közép-Dunántúl, Dél-Dunántúl, Dél-Alföld*) and Polish (Zachodniopomorskie and Pomorskie). Some of the Polish regions (Dolnośląskie and Pomorskie), Slovak (*Západné Slovensko*) and regions-states such as Lithuania, Latvia and Estonia moved to a higher class.

The assessment of spatial correlation level in terms of GDP variable value indicates the absence of a statistically significant value of *I* Moran's statistics, which in 2000 showed the level of 0,0004 and -0,01 in 2010. Therefore one can state that the distribution of GDP variable value in both years was a random one and that there were no visible clusters of either rich or poor regions.

Picture 2 illustrates the values of the gross domestic product dynamics index, according to the purchasing power standard calculated per 1 inhabitant, in 2010 compared to 2000. The most extensive changes were recorded in the regions-states such as Lithuania, Latvia and Estonia, in three Polish regions (Mazowieckie, Łódzkie and Dolnośląskie) and also in four Slovak regions.



Picture 2. Spatial diversification of the GDP variable dynamics index in the regions of Central and Eastern Europe in 2010 compared to 2000

Source: author's compilation.

The slowest development was observed in Czech, Slovenian and Hungarian regions (except *Közép-Magyarország* which was included in the second class in term of the economic growth rate of the studied period). The following regions were the outstanding ones: Mazowieckie in Poland and *Bratislavský kraj* in Slovakia, which presented one of the highest economic growth levels in the studied years, maintaining at the same time one of the highest economic growth dynamics.

4. The results of convergence analysis – spatial aspect

The analysis of convergence was initiated by estimating the model, which presented the impact of initial GDP level on economic growth rate in the cross-section of Central and Eastern European NUTS-2 regions, having applied the least square dummy variable method. The estimations are presented in Table 2. The spatial correlation of LSDV model residuals was assessed (Table 1), followed by the estimation of spatial lag and spatial error models (Table 2). The analysed spatial models took the form of:

- spatial lag model (SAR/SLM):

$$\frac{1}{T}(\ln y_{i0+T} - \ln y_{i0}) = \alpha - \pi \ln(y_{i0}) + \delta W(\frac{1}{T}(\ln y_{i0+T} - \ln y_{i0})) + \varepsilon \quad \varepsilon \sim IID,$$

- spatial error model (SEM):

$$\frac{1}{T}(\ln y_{i0+T} - \ln y_{i0}) = \alpha - \pi \ln(y_{i0}) + \varepsilon \quad \varepsilon = \lambda W \varepsilon + \zeta .$$

I Moran's statistics for the classical regression model residuals amounted to 0,159 with the probability of 0,05, and therefore was within the margin of null hypothesis rejection featuring the absence of spatial autocorrelation. Low values were also obtained for the values of positive and negative residual clusters in the *joint count* test which presented the respective values: 5,715 (*p*-value = 0,095) and 5,858 (*p*-value = 0,063), indicating weak spatial dependence for negative residuals and slightly stronger for positive residuals.

Table 1. The values of spatial autoregression

Specification	Measure value	*p*-value
Total *I* Moran's measure	0,159	0,050
Joint count test:		
positive residuals	5,715	0,095
negative residuals	5,858	0,063

Source: author's estimations.

As expected, negative estimates of model structural parameters for beta absolute convergence were obtained (Table 2) regarding all the analyzed structures.

Table 2. The estimations of beta absolute convergence for NUTS-2 regions of Central and Eastern European countries in the period 2000-2010

Specification	Basic (LSDV)	Spatial lag (SLM)	Spatial error (SEM)
Intercept	00.884 (0.541)	00,736 (0.433)	00,840 (0.508)
*ln*GDP2000	−00.047 (0.059)	−00,044 (0.056)	−00,042 (0.055)
AIC	−51.015	−50,848	−50,805

Source: author's estimations.

All the estimations of structural parameters turned out to be statistically insignificant, which indicates the absence of beta absolute convergence processes in the regional space of Central and Eastern European countries and the absence of the catch-up effect regarding the regions showing low development level in 2000 in relation to wealthy regions. These results were obtained for all the model structures, i.e. with and without spatial structure.

It has to be pointed out that all estimations of structural parameters at *ln*GDP2000 take similar values from −0,042 for the spatial error model to −0,047 for the classical regression one. This indicates the stability of the obtained results, regardless of the model structure. In our case the model extension by the spatial structure did not have any significant impact on the estimate values of the structural parameters' assessments.

5. Final remarks

The research objective defined in this article focused on the assessment of spatial dependence and its impact on regional convergence model estimations. In conclusion we should point out the following:

- in the Central and Eastern European space, in the period 2000-2010, no statistically significant clusters of regions presenting small or high GDP variable values were observed,
- the total growth of *GDP* variable value was recorded in all regions and the fastest growth rate occurred in 2008,
- no regional convergence processes were observed either in terms of sigma or beta approach,
- the obtained estimation results of convergence models allow for putting forward the thesis that these estimations are resistant to the possible impacts of spatial dependence. The other analyses conducted by the author regarding all the European Union regions seem to confirm this thesis [Bal-Domańska 2010(a)].

The size of the regions is of considerable significance for drawing conclusions about the importance of spatial dependence for the performed estimations. The analysed NUTS-2 level regions cover relatively large areas characterized by an internally diversified economic structure. This may result in the spatial dependence being blurred, since in the case of such large territorial units the socio-economic interdependencies between regions can turn out to be quite weak, whereas the fact that they present a limited internal consistence suggests that the largest spatial impacts occur within their economies. In the course of the subsequent stage of the study it is worth verifying the significance of spatial dependence at the level of NUTS-3 sub-regions which represent smaller and internally more consistent units. [Bal-Domańska 2010 (a)].

References

Akaike H., *A new look at the statistical model identification*, IEEE Transactions on Automatic Control, 19(6) 1974, pp. 716-723.

Anselin L., Le Gallo J., Jayet H., *Spatial Panel Econometrics*, [in:] *The Econometrics of Panel Data, Fundamentals and Recent Developments in Theory and Practice*, L. Matyas, P. Sevestre (eds.), 3rd ed. Kluwer, Dordrecht 2008.

Bal-Domańska B., *Analiza zależności między innowacyjnością a dynamiką rozwoju europejskiej przestrzeni regionalnej*, [in:] D. Strahl, *Innowacyjność europejskiej przestrzeni regionalnej a dynamika rozwoju gospodarczego*, Wrocław University of Economics, Wrocław 2010(a), pp. 114-154.

Bal-Domańska B., *Procesy konwergencji wydajności pracy w regionach Unii Europejskiej*, Wiadomości Statystyczne 2/2013(b), Central Statistical Office, pp. 1-14.

Bal-Domańska B., *Przestrzenne zróżnicowanie i uwarunkowania gospodarcze regionów Unii Europejskiej*, 22nd Scientific Conference of The Section of Classification and Data Analysis of Polish Statistical Association 27th Taxonomic Conference entitled "Data classification and analysis – theory and applications", Karpacz 11-13 September 2013 (c).

Ciołek D., *Szacowanie regresji wzrostu i konwergencji dla danych panelowych. Metody ilościowe w naukach ekonomicznych, tom 4*, edit. A. Welfe, Warsaw School of Economics – Publishing House, Warsaw 2004.

Cliff A.D., Ord J.K., *Spatial Processes*, Models and Applications, Pion, London 1981.

Dziechciarz-Duda M., Król A., Przybysz K., *Minimum egzystencji a czynniki warunkujące skłonność do korzystania z pomocy społecznej. Klasyfikacja gospodarstw domowych*, [in:] *Taksonomia 19. Klasyfikacja i analiza danych – teoria i zastosowania*, eds. K. Jajuga, M. Walesiak, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław 2012, pp.144-152.

Hlaváček P., *The Foreign Direct Investments in the Usti Region: Theory, Actors and Space Differentiation*, E & M Ekonomie a Management, 2009, 12(4), pp. 27-39.

Kopczewska K., *Ekonometria i statystyka przestrzenna z wykorzystaniem programu R CRAN*, CeDeWu. PL, Warszawa 2006.

Kościelski T., Malaga K., *Nierówności regionalne* w *Polsce* w *świetle neoklasycznych modeli wzrostu z saldem środków Unii Europejskiej*, Studia Regionalne i Lokalne, 2008, 4(34), pp. 7-25.

Markowska M., Jefmański B., *Fuzzy classification of European regions in the evaluation of smart growth,* Przegląd Statystyczny 2012, Vol. 59, 1, Warsaw, pp. 74-93.

Moran P.A.P., *The Interpretation of Statistical Maps*, Journal of the Royal Statistical Society, B10, 1947, pp. 243-51.

Pietrzak M., *Application of economic distance for the purposes of a spatial analysis of the unemployment rate for Poland*, Oeconomia Copernicana, 2010, vol. 1, pp. 79-98.

Sala-i-Martin X.X., *The Classical Approach to Convergence Analysis*, The Economic Journal, 1996, 106(437), pp. 1019-1036.
Smętkowski M., Wójcik P., *Rozwój regionalny w Europie Środkowo-Wschodniej,* Studia Regionalne i Lokalne, nr 4(38)/2009, pp. 39-66.
Suchecki B. (ed.), *Ekonometria przestrzenna*, C.H. Beck, Warszawa 2010.

KONWERGENCJA REGIONÓW (NUTS-2) EUROPY ŚRODKOWO-WSCHODNIEJ – ASPEKT PRZESTRZENNY

Streszczenie: Celem artykułu jest identyfikacja charakteru zależności przestrzennych w zakresie uwarunkowań gospodarczych dla regionów państw Europy Środkowo-Wschodniej (według metodologii Eurostatu odpowiada to poziomowi NUTS-2). Do analizy wykorzystano narzędzia statystyki i ekonometrii przestrzennej. Jednym z efektów badania jest określenie charakteru i istotności zależności przestrzennych poprzez identyfikację istnienia skupisk regionów-sąsiadów o podobnym poziomie rozwoju. W drugiej części artykułu podjęto próbę oceny wpływu zależności przestrzennych na oszacowania modeli beta konwergencji absolutnej. Badaniem objęto lata 2000-2010.

Słowa kluczowe: ekonometria przestrzenna, regiony Europy Środkowo-Wschodniej, macierz odległości.