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TERRITORIAL COHESION OF MUNICIPALITIES IN POLAND IN 2005-2017 IN TERMS OF SYNTHETIC MEASURE, IN THE CONTEXT OF CONVERGENCE AND SPATIAL CLUSTERING

Key words: territorial cohesion, synthetic measure, convergence, municipality, spatial clusters

ABSTRACT. The concept of territorial cohesion has gained importance in the context of the development of the European Union's regional policy, but definitions of the concept vary enormously. The article uses the concept of spatial development supporting economic and social aspects of cohesion and, on this basis, constructs a multidimensional index of territorial cohesion based on five dimensions (economic, demographic, infrastructural in two approaches and environmental) of the phenomenon. The measure was applied to the total population of municipalities (2,175) in rural areas in Poland in the years 2005-2017. The aim of the study was to assess the territorial cohesion of municipalities in Poland in static and dynamic terms and use econometric tools to identify the potential convergence of cohesion and determine the effect of "catching up", according to Jeffrey G. Williamson [1965], where municipalities with a higher level of cohesion are followed by municipalities with a lower level. The results of previous studies conducted at different regional levels indicate an increase in income polarization in rural areas and the creation of islands of convergence, where the regions with the highest and lowest wealth become similar intra-group but not inter-group. The results indicate a decrease in relative territorial cohesion in rural areas in Poland in 2005-2017 at a municipality level and a tendency to the formation of spatial clusters of entities with similar levels of the characteristic. They do not allow to confirm the view of convergence of cohesion between entities with different levels of the characteristic.

INTRODUCTION

The perception of rural development at an EU and a national level is characterized by an integrated approach to the management of rural space, providing better opportunities to improve the quality of life of the inhabitants of these areas [Gagliardi, Percoco 2017]. The emergence of the concept of integrated, coherent rural development, replacing the concept of multi-functional development, is a reaction to the persistence of clear spatial disparities in the socio-economic development of rural areas [Kołodziejczyk et. al 2017].

The provision of the Treaty of Lisbon, which supplements economic and social cohesion with territorial cohesion and stresses that territorial cohesion should be achieved at all levels: European, national, regional and local, while respecting the principle of subsidiarity and pursuing the main objective of the cohesion policy, is important for European regional and cohesion policy. The main objective of the cohesion policy is not to eliminate geographical disparities, but to provide mechanisms through which the quality of, *inter alia,* the economic and social infrastructure base can change [Fratesi, Wishlade 2017]. It is a policy aimed at the use of endogenous potential, territorial resources and knowledge and enabling the implementation of interventions aimed at development challenges, while adapted to local conditions. The territorialization of the development policy is highlighted by Jacek Szlachta [2018], indicating that a feature of the territorial approach is conscious emphasis on spatial determinants, i.e. natural and institutional resources, and individual preferences and experiences, thus adapting the policy to the specificities of the place where the intervention is directed. The success of the cohesion policy, thus, depends on basing territorial development on endogenous potential and reinforcing it with the Community dimension (support for locally relevant pro-development projects, which lead to the integration of territories) [Faludi 2013, Gorzelak 2019]. However, achieving the cohesion of rural areas requires the accurate and realistic identification of endogenous potential and development opportunities, as well as the identification of investment priorities and instruments supporting these areas. It is also important to coordinate the instruments of intervention of the rural development policy and cohesion policy [González et al. 2015].

The concept of cohesion in the context of rural development is presented in multifaceted terms (economic, demographic, social and territorial) and there are different methods for measuring it [Van Well 2012]. Economic cohesion is linked to the level of the socio-economic development of a given area, which results from the state and structure of the economy and the financial situation of local authorities, while demographic cohesion results from the demographic situation and is quite often the outcome of economic development. Territorial cohesion is, therefore, related to the state of spatial management resulting from both natural resources and human activity [Kołodziejczyk 2014]. Investment activities that improve spatial development should be interpreted as supporting socio-economic cohesion. The territorial dimension, thus, relates, on the one hand, to harmonizing the functioning of

rural space and demonstrating the possibility of exploiting the socio-economic potential in these areas and, on the other, to creating conditions for the functioning of socio-economic activities.

In Poland, the diversification of rural areas became particularly visible at the beginning of the 21st century, with its accession to European structures and the launch of various programs related to financing structural transformations in rural areas. Areas with a higher level of development and a more diversified economic structure found it easier to adapt to the new conditions. There was a concentration of economic and social activity in certain areas and its outflow from others [Kołodziejczyk, Gospodarowicz 2014]. This can be demonstrated by tracking the dynamics of individual socio-economic indicators, e.g. own income of municipalities per capita. This measure is not only a good measure of economic processes, but also indicates the investment capacity of local government units, thus influencing their level of development and shaping the living conditions of their inhabitants [Jakubowski 2018]. Therefore, it can be used to assess the diversity of rural development. According to Statistics Poland (GUS), in 2000, the level of municipality revenue per capita, measured by the value of the first and the tenth decile of the population, amounted to PLN 206.5 and PLN 1,161.4 for rural municipalities (R) and PLN 278.1 and PLN 1,031.9 for urban-rural municipalities (UR). In 2005, these relations were: PLN 292.8 and 1,783.7 (R) and PLN 386.3 and 1,746.9 (UR), in 2010 – PLN 442.0 and 2,741.9 (R) and PLN 569.2 and 2,675.7 (UR), while in 2017 – PLN 650.9 and 3,195.3 (R) and PLN 822.2 and 2,970.4 (UR). The income of rural municipalities was, thus, much more unevenly distributed than that of urban-rural municipalities. This relation is permanent. These inequalities cannot only be explained by the unfavorable socio-economic situation in the local government unit, as the spatial rent and managemental capabilities in the municipality, determining its development, are, to a large extent, responsible for them [Kluza 2019]. This may lead to the conclusion that the task of the rural development policy is to ensure the integrated development of rural areas and not to further concentrate investments (and thus jobs) in the most developed areas. Therefore, it is important that rural development processes take the specific endogenous resources of a given area into account and use them more effectively. In this approach to rural development, endogenous and exogenous factors are seen as complementary and mutually reinforcing and enabling the use of local resources [Adamski, Gorlach 2007]. Tomasz Marszał and Iwona Pielesiak [2008] indicate that the condition for the cohesion of the area is the management of space, which determines integrated development (economic, social and territorial). Tomasz Markowski [2009] defines territorial cohesion as a state of spatial development that ensures the improvement of social and economic cohesion. This interpretation of territorial cohesion was adopted in this study.

The aim of the study is to present, in a multifaceted way, the cohesion of rural areas in Poland (rural and urban-rural municipalities), in the years 2005-2017, in static and dynamic

fashion and in the relationship between individual aspects. The multidimensional index of territorial cohesion (CI) was estimated and, in its analysis, also the spatial element was taken into account. An attempt was made to assess whether the obtained values indicate the convergence or rather divergence of cohesion at the level of individual units of local government. On the basis of literature sources and the analysis of unit economic indicators (own income *per capita*), the hypothesis was accepted about the deepening differences in the level of cohesion between the analyzed territorial self-government units in the assumed period, both in the spatial aspect and with respect to type.

RESEARCH MATERIAL AND METHODS

The measurement of phenomena related to cohesion and the construction of a synthetic cohesion indicator required the use of quantitative data and appropriate quantitative approaches. The verification and quantification of research assumptions were based on the materials of Statistics Poland (GUS) for the years 2005-2017. This period was adopted due to the possibility of fully capturing the changes stimulated by the implementation of the cohesion policy, i.e. the program of social and economic transformation in Poland, implemented in the programming period 2007-2013. It was assumed that the analysis would be carried out at a level of municipalities (LAU 2), which, in accordance with national legislation, are local government units with decision-making and financial autonomy, allowing them to carry out tasks in the field of socio-economic development and conduct a relatively independent policy in the disposal of material, capital and human resources. The study covered the whole population of municipalities in rural areas in Poland (i.e. rural and urban-rural municipalities) – 2,175 units divided into rural (1,566) and urban-rural (609) ones. Rural areas are diversified in terms of both population and area (Table 1).

Some analyses were also conducted for voivodeships (16 NUTS 2 regions). Achieving the research objective and verifying the research hypothesis required empirical research, which was carried out in a series of stages. As indicated by Eduardo Medeiros [2016], territorial cohesion in a holistic approach should consider the widest possible range of characteristics of the studied local government units in terms of, among others, socio-economic characteristics, the level of demographic and environmental development and the level of infrastructural development in relation to technical and social infrastructure. The particular partial aspects of the development of local government units can be described by means of a number of variables. Based on previous studies, both domestic and foreign, which included, inter alia, Leszek Jańczuk [2013], Jerzy Parysek [2018], Marcin Spychała [2017], Monika Stanny [2012] and Mieczysław Adamowicz and Agnieszka Smarzewska [2009], it was assumed that the level of socio-economic development can be described by a set of features describing economic activity in the area under study, measured by the

Table 1. Characteristics of municipalities in rural areas in Poland in 2017

Municipalities by type and size [thousand inhabitants]		Number of gminas	Population	Surface area of gminas [ha]	Number of villages
Rural		1,566	10,984,469	195,899	30,273
< 2.5	very small	37	79,618	3,948	509
2.5-5.0	small	535	2,119,587	60,080	9,507
5.0-10.0	average	729	5,076,127	95,188	14,905
10.0-15.0	large	191	2,282,205	25,847	3,807
> 15.0	very large	74	1,426,932	10,836	1,545
Urban-rural		609	8,843,239	102,781	12,798
< 5	very small	26	100,542	3,118	294
5.0-7.5	small	116	739,008	18,036	2,097
7.5-15.0	average	253	2,762,404	40,907	5,235
15.0-30.0	large	167	3,425,983	32,700	4,070
> 30.0	very large	47	1,815,302	8,020	1,102

Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

number of business entities in operation, the situation on the labor market, particularly the share of employed people in the population and the economic characteristics of local government units, particularly the income situation and propensity to invest. In the case of demographic processes, measures of population density and birthrate were used, as well as measures describing population migrations and indicators of the population structure expressed by means of demographic and social dependency in static and dynamic dimensions.

The level of development of technical infrastructure was described by assessing the intensity of water, sewage and gas transmission networks, both with respect to network density and the share of the population with access to these facilities in the total population of the local government unit. Pre-school and school education facilities (at various levels of organized education, particularly broken down into primary and secondary schools), cultural facilities (community centers and libraries) and health centers were treated as elements of social infrastructure, while accessibility measures were expressed both in the form of standardized quantitative indicators (per surface area) and share indicators, defining the proportion of the population using the above mentioned elements of social infrastructure.

The level of environmental development was described on the basis of relative indicators defining the share of areas of increased importance from the perspective of

environmental protection (protected areas, Natura 2000 sites or forested areas) in the total area of the territorial self-government unit, the intensity of financial expenditures related to environmental protection per unit of time and elements related to waste management (municipal waste and treated wastewater).

The final set of measures and partial indicators used to construct synthetic measures describing the partial elements of the territorial cohesion index was selected from a wide range of related statistics with the use of statistical tools, such as correlation calculus, which aimed to eliminate collinearity and redundancy of the used characteristics and ensure their unambiguous ability to describe the analyzed phenomenon. The Hellwig taxonomic method [Hellwig 1968], belonging to multiple-criteria decision analysis (MCDA), which also includes, for example, the TOPSIS method [Bąk 2016, Dmitruk, Gawinecki 2017], was used to create five partial measures that form the basis for assessing the overall level of development in spatial terms. It is based on the construction of an abstract object called development pattern.

In Hellwig›s approach, the studied objects are ordered according to their distance from the development pattern, which makes it possible to determine their relative level of development. To estimate a synthetic measure of development, according to Hellwig›s algorithm, it is necessary to identify a set of partial variables, determine their nature in relation to the dynamics of a complex phenomenon, reduce the data to comparable values, define a pattern and calculate the distance of individual entities (municipalities) from it and finally aggregate the partial variables and estimate a relative taxonomic measure of development.

The calculated synthetic measure of development (Hellwig's measure), takes positive values with a population average equal to 100, and the higher its value, the closer a given object is to the pattern and it is characterized by a higher level of partial development. The differences between the values of the measure for individual regions (or in relation to the population average) illustrate the scale of value differentiation within the examined sample.

The measures of development in five dimensions estimated with Hellwig›s method were used to construct an aggregate index of cohesion (CI) using the Data Envelopment Analysis (DEA) approach, according to the scheme described by Pedro Sánchez-Zamora et al. [2017] and Pedro Sánchez-Zamora and Rosa Gallardo-Cobos [2020] and Ernest Reig-Martínez et al. [2011]. DEA is a tool developed in the 1970s to calculate various types of performance measures in production units, or so-called decision making units (DMUs), using linear programming techniques [Charnes et al. 1978]. The DEA method involves constructing relative measures for a set of DMUs, taking the efficiency of transformation of inputs into outputs into account, using the production frontier occupied by the best units in the group as a reference. The main elements differentiating DEA models are the orientation (input-oriented or output-oriented) and the treatment of scale effects, which can be fixed (CRS), variable (VRS) or non-increasing (NIRS). The basic

model is input-oriented (i.e., minimizing their use) with fixed scale effects (the so-called CCR model). DEA creates a production function using a set of $k = 1,..., K$ DMU's whose task is to transform a vector of inputs $x = (x_1,..., x_M)$ into a vector of outputs $y = (y_1,..., y_R)$. The maximization problem is represented in linear form so that the relative position of a given DMU against the values in the peer group can be determined. Taking into account the aim of the study, which was to create a synthetic measure based on a set of variables or factors describing the position of a particular local government unit in relation to each of the partial dimensions of territorial cohesion and to facilitate the comparison of the value of the measure achieved by a particular unit with the values in the peer group the CCR model with fixed scale effects, output oriented model was used, assuming a single (virtual) input with a normalized value of 1 for each local government unit and five outputs described by the values of partial synthetic measures estimated with Hellwig's approach. The formula of the DEA model used was:

$$max_{\mu_{r0}}\ h_0 = \sum_{r=1}^{R} \mu_{r0}\, I_{r0}$$

under budget constraints:

$$\sum_{r=1}^{R} \mu_{r0}\, I_{rk}\ \leq 1$$

where h_0 describes the level of the estimated territorial cohesion index for a single decision-making unit DMU (municipality).

The philosophy of measuring the territorial cohesion of the decision-making unit in this version of the optimization task departs from the use of the input-output transformation scheme in favor of determining the maximum value of an index containing a set of indicators or measures describing different aspects of territorial cohesion. In order to determine whether, in the case of estimated measures of territorial cohesion (partial and aggregated index), there is spatial clustering, tools of spatial statistics, measures of spatial autocorrelation, were used. Spatial autocorrelation is a tool for assessing the homogeneity of spatial structures, assuming that the occurrence of one phenomenon in a spatial unit (e.g. administrative unit) increases or decreases the probability of that phenomenon occurring in neighboring units. It can, therefore, be simplified as the degree to which a spatial object is similar to other objects in the vicinity or surrounding it. There are a number of univariate and multivariate measures that describe the phenomenon of spatial autocorrelation.

The most popular univariate measure is Moran's I Index [Moran 1950], which has the character of a correlation coefficient for the relationship between a variable (e.g.

a development indicator) and surrounding values, thus resembling Pearson's correlation coefficient in its assumptions. The definitions of object proximity used refer to the width of the distance band (units within a given homogeneous distance) or the number of *k* nearest, i.e. direct neighbors (e.g. 2 nearest neighbors). The values of index I are in the range from -1 to +1. The statistic can be classified as positive, negative and zero, i.e. without spatial autocorrelation. Positive spatial autocorrelation occurs when Moran's I is close to +1. This means that the values cluster together, i.e., neighboring regions have similar levels of the phenomenon. Negative spatial autocorrelation occurs when Moran's I is close to -1. i.e. neighboring regions are characterized by different levels of the phenomenon. A value close to 0 usually means no autocorrelation. Moran's I index is described by a formula similar to the classical correlation formula, comparing the covariance in the numerator and the variance in the denominator, supplemented by a spatial element w_{ij} – a matrix of spatial weights:

$$I = \frac{N}{W} \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \overline{x})}$$

Moran's univariate I Index is a global statistic that indicates the clustering or dispersion of data.

An absolute value of β convergence in terms of cohesion was calculated for the aggregate cohesion index and five sub-measures. β convergence originally refers to the process by which economic growth dynamics of relatively lower wealth regions significantly exceed the growth dynamics of higher wealth areas, enabling catching-up i.e. a gradual reduction of developmental inequalities and a move towards a steady-state. The concept of convergence derives from the neoclassical growth theory of Robert Solow [1956], whose key assumption is that as a consequence of reduced profitability in rich economies, a higher growth rate in less wealthy economies should lead to the ‹catching up› of the value of the examined characteristic (e.g. income or GDP *per capita*) and the level of development in both groups [Jakubowski 2018]. To verify the convergence, econometric models are used, in which the dynamics of the dependent variable (the examined characteristic, e.g. income, but also other statistics describing the selected element of regional development) is described using its lagged values from past periods. Assuming that the dynamics of the analyzed characteristic is the only factor generating growth, absolute β convergence was estimated on the basis of the model:

$$g_i = a + b \log(y_{i,0}) + \varepsilon$$

containing the value of the analyzed statistic in the *i*-th municipality in the base year 2005 ($y_{i,0}$), the structural parameters of the model (a, b), the random component (ε) and the rate of change of the characteristic in the years 2005-2017 $g_i = \frac{1}{T} \log(\frac{y_i,\tau}{y_{i,0}})$. Statistical significance and the sign of the parameter $b = -(1 - e^{-\beta T})$ confirm the occurrence of the phenomenon of convergence ($b > 0$) or divergence ($b < 0$) while insignificance negates it. b is used to calculate the coefficient of convergence $\beta = -\ln(1 + b) / T$, where $\beta < 0$ indicates the process of divergence between regions and $\beta > 0$ the process of convergence, which allows to additionally determine the speed with which the regions move in the direction of a steady-state and the value of half-life, i.e. $hl = \frac{\ln 2}{\beta}$ the time to reduce the existing developmental differences by half. The regression equation can be estimated using pooled or panel data, indexed by time [Kluth 2016].

RESEARCH RESULTS

The results of the estimation of partial measures of development (demographic, economic, infrastructural and environmental) indicate that their level is conditioned by the spatial location in the regional (voivodeship) system (Table 2). In the period 2005-2017, the differences in geographical space on the east-west and north-south axes are marked and consolidated. The amplitude of regional rating changes is significant (with maximum shifts of seven positions downwards or four upwards), but extreme rating positions remain unchanged. The level of economic development is characterized by relative stability by region in the adopted time unit, as indicated by the high (0.95) Spearman rank correlation between data in 2005 and 2017. The level of environmental development is characterized by relatively higher volatility, but the set of regions in the highest and lowest positions remains constant. The development of technical and social infrastructure was relatively stable by region with a Pearson correlation level exceeding 0.95 for data in both compared time units.

Demographic, economic, environmental and infrastructural development show a dependence on the type of municipality and the number of inhabitants (Table 3). Municipalities with fewer inhabitants have lower development indicators than more populous municipalities, regardless of the municipality type. The observation of development processes in communes in the years 2005-2017 allows to conclude that they are consolidating. The development level of the surveyed phenomena in particular size groups of communes does not change much in relation to the average for that group of communes. This has a significant impact on the fluctuations in the level of development of the studied aspects between municipalities in terms of population. When analyzing

Table 2. Hellwig's measures of development in 2005-2017, average values for NUTS 2 regions (voivodeships)

Region	Development level									
	demographic		economic		environ-mental		infrastructure			
							technical		social	
	2005	2017	2005	2017	2005	2017	2005	2017	2005	2017
Dolnośląskie	106.9	107.7	124.3	131.1	126.0	128.6	97.8	92.8	85.5	77.6
Kujawsko-pomorskie	119.0	114.3	97.1	95.2	93.3	104.5	109.4	104.1	82.5	80.0
Lublin	67.8	68.2	65.7	61.6	70.7	53.3	77.7	74.9	82.9	83.4
Lubuskie	114.0	101.6	117.7	120.1	150.6	152.9	79.4	77.5	111.3	110.3
Łódzkie	81.0	86.1	96.5	97.5	75.8	74.9	92.1	89.3	126.4	121.5
Małopolskie	116.2	123.4	91.4	99.2	97.3	98.0	119.2	131.7	85.1	92.1
Mazowieckie	93.5	99.8	97.6	101.6	80.3	80.6	87.5	97.0	94.4	88.8
Opolskie	84.4	75.4	121.3	110.6	123.1	123.3	100.5	98.8	124.5	117.5
Podkarpackie	101.5	106.2	90.1	77.2	98.0	81.9	142.5	130.7	121.2	118.2
Podlaskie	44.9	51.5	85.4	73.1	87.0	75.3	73.1	65.6	69.5	72.1
Pomerania	143.3	146.2	97.6	110.3	121.1	132.3	104.2	102.5	76.8	83.7
Śląskie	103.4	105.1	143.7	127.6	95.3	98.0	129.9	144.5	98.2	102.7
Świętokrzyskie	74.6	68.7	83.5	79.5	91.1	76.2	98.6	103.4	136.7	135.6
Warminsko-mazurskie	109.4	102.0	84.2	76.3	122.0	126.2	83.2	78.4	134.6	140.7
Wielkopolskie	127.6	124.4	122.8	125.9	112.6	132.8	107.9	105.6	108.2	109.4
Zachodnio-pomorskie	116.3	99.6	101.8	125.1	134.1	138.7	93.3	86.4	88.3	99.7

Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

differences between groups of rural municipalities with the highest and lowest level of development in particular years, one may observe that they increased in the economic, demographic, environmental and technical infrastructure spheres and decreased in the social infrastructure sphere. In the latter case, this may be related to the creation of favorable conditions for the improvement of social infrastructure (which has a direct impact on the quality of life) and vice versa. As regards the development dynamics of the surveyed characteristics in the size groups of rural municipalities, one may observe that it is the highest for the largest municipalities.

Table 3. Hellwig's measures of development in 2005-2017, average values for types and population types of municipalities

Municipalities by type and size [thousand population]		Development level									
		demographic		economic		environ-mental		infrastructure			
								technical		social	
		2005	2017	2005	2017	2005	2017	2005	2017	2005	2017
Rural		107.4	111.4	98.3	103.6	93.5	94.8	102.6	106.3	98.3	98.7
< 2.5	very small	45.7	44.9	72.1	70.1	89.9	79.4	64.5	58.9	95.7	92.6
2.5-5	small	76.2	76.7	65.9	69.9	77.7	79.5	80.8	77.5	98.8	100.3
5-10	average	103.0	106.2	91.9	90.3	88.1	90.1	92.8	94.7	101.3	100.8
10-15	large	138.1	146.5	125.0	128.7	94.4	101.8	123.1	134.1	101.5	102.7
> 15	very large	174.0	182.8	136.8	158.7	117.3	123.1	151.7	166.5	94.1	96.9
Urban-rural		98.7	90.3	128.8	127.4	137.2	132.3	120.1	116.0	98.2	97.5
< 5	very small	82.0	68.7	97.0	111.7	131.9	136.7	104.0	89.6	91.7	93.8
5-7.5	small	83.7	75.7	95.5	96.5	111.4	109.8	88.2	83.7	99.1	95.2
7.5-15	average	98.1	90.8	123.1	112.5	122.5	118.8	104.7	99.3	102.7	100.8
15-30	large	109.8	102.8	150.3	144.9	154.0	140.7	129.0	126.1	98.6	99.5
> 30	very large	119.9	113.3	178.0	171.5	166.2	155.2	174.5	181.3	99.1	98.1

Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

In urban-rural municipalities, the level of demographic development decreased in comparison with the average for this municipality type in the surveyed years, the discrepancies between the group of municipalities with the highest and lowest level of demographic development and technical infrastructure also increased, while they decreased for the level of economic development, social infrastructure and environmental development. As in the case of rural municipalities, the number of inhabitants in the municipality was the factor driving development dynamics. The development level of the surveyed characteristics did not decrease in municipalities with the highest number of inhabitants, as compared to the average for this type of municipality.

In the case of the overall cohesion index (CI) estimated using the DEA approach, their values fall in the range 0-1. with an increasing level of the metric indicating an increase in cohesion. In the period 2005-2017, there was a decrease in the average value of the index from 0.536 to 0.408 (Table 4). The estimated value of the total trend regression in the time frame of analysis ($y = -0.0076x + 0.5382$ with $R^2 = 0.68$) confirms the hypothesis of

Table 4. Average Cohesion Index values and Moran's I index for the Cohesion Index and five development measures (2005-2017)

Year	Cohesion Index	Moran's I Index for CI and development measures:					
		CI	demo-graphic	economic	technical infra-structure	social infra-structure	environ-mental
2005	0.536	0.428	0.4954	0.3658	0.44	0.2769	0.3247
2006	0.523	0.429	0.514	0.3717	0.4527	0.2705	0.3353
2007	0.515	0.395	0.487	0.3289	0.4568	0.2656	0.3525
2008	0.531	0.419	0.5721	0.333	0.4581	0.2524	0.3697
2009	0.481	0.455	0.5936	0.5304	0.4624	0.2469	0.3869
2010	0.453	0.438	0.5954	0.5043	0.4705	0.2417	0.3898
2011	0.476	0.461	0.6051	0.509	0.4782	0.236	0.4213
2012	0.481	0.446	0.5946	0.4991	0.4915	0.2351	0.4385
2013	0.484	0.445	0.5751	0.4972	0.5042	0.2294	0.4557
2014	0.488	0.463	0.5825	0.4871	0.5148	0.2241	0.4729
2015	0.478	0.491	0.5626	0.4853	0.5356	0.2223	0.4996
2016	0.447	0.523	0.5338	0.5187	0.5403	0.22	0.5073
2017	0.408	0.547	0.5581	0.5279	0.5434	0.2128	0.5218

Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

a decrease in cohesion in the time frame studied, with a progression of polarization. The limit of maximum coherence, set at a level above 90%, corresponding to the efficiency limit in the classical DEA model was achieved in 2005 by 207 municipalities, but only by 145 in 2017. At the same time, with regard to the dynamics of annual changes in the index, it can be indicated that periods of its growth were interspersed with periods of sharp declines (2009-2010 and then from 2015).

In the case of values of the single-factor global I Moran Index for individual variables (the overall Cohesion Index and partial development measures), they are statistically significant at the 1% level in the analyzed period, and their dynamics show an increasing trend. This allows the rejection of the null hypothesis H_0 of the statistic that the attribute is randomly distributed in the analyzed space in favor of the alternative hypothesis that spatial distribution in the data set is less dispersed than if spatial processes were random. At the same time, it can be concluded that the analyzed attributes will tend to form spatial clusters

grouping high and low values. The dispersed spatial pattern may reflect the functioning of an aggregation process, where a high value trait attracts other high value traits, similarly, a low value trait attracts other low value traits. For all six statistics analyzed, there was an increase in the value of the spatial autocorrelation index in the time frame studied. The tendency to build clusters grouping entities with similar values is most visible for the overall Cohesion Index and the measure of demographic development, a relatively lower level was recorded for the measure of social infrastructure development. In the latter case, the reason may be the locally and spatially limited to a single municipality character of investments in selected elements of infrastructure in this sphere.

Figure 1 presents disaggregated average values of the Cohesion Index in provinces (NUTS 2 regions). Index values are characterized by a downward trend in the time frame 2005-2017 for all analyzed territorial units, however not uniform and spatially homogeneous. The region with the highest average value of the index for most of the studied period was Śląskie, while the two regions with the lowest cohesion indices, on average, in subsequent years of analysis, were the Podlaskie and Lubelskie regions. The extreme values of the index in 2005 amounted to 0.66 for Śląskie and 0.39 for Lubelskie (0.51 for the Mazowieckie voivodeship marking the lower edge of the group of voivodeships with average/high values of the index), while in 2017 they dropped to 0.49 for Śląskie, 0.29 for Lubelskie, and 0.39 for Łódzkie (closing the group of entities with average/high values of the index).

Figure 2 presents changes in the ranking of voivodeships in relation to the cohesion index value. Lines showing the dynamics and volatility of ranking values have a relatively stable shape and course. In particular, the position of territorial units on the top (first) and bottom (15th, 16th) positions of the ranking, indicating the highest and lowest level of cohesion, remains stable. The set of regions on these positions remains unchanged. Average values of the cohesion ranking in 2005-2017 show that the highest average position in the ranking was held by the Śląskie Voivodeship. Leading positions were also held by the Wielkopolskie, Opolskie and Podkarpackie voivodeships. All these regions are located in the western or southern part of Poland.

The lowest positions in the ranking were invariably held by regions located in the eastern belt of the country, i.e. the Podlaskie and Lubelskie voivodeships, Mazowsze also held a low position, which is a result of the influence of the low cohesion of communes located in the eastern part of the region. Comparing the values of the rankings in the extreme years, 2005 and 2017, it can be indicated that a positive change in the ranking value concerned 5 regions – Małopolska (by 9 positions), Zachodniopomorskie (by 6 positions), Mazowieckie and Pomorskie (by 3 positions) and Podkarpackie (by 1 position). The Kujawsko-Pomorskie, Lubelskie, Podlaskie and Śląskie voivodships maintained their places in the ranking. The worsening of the position in the ranking was recorded

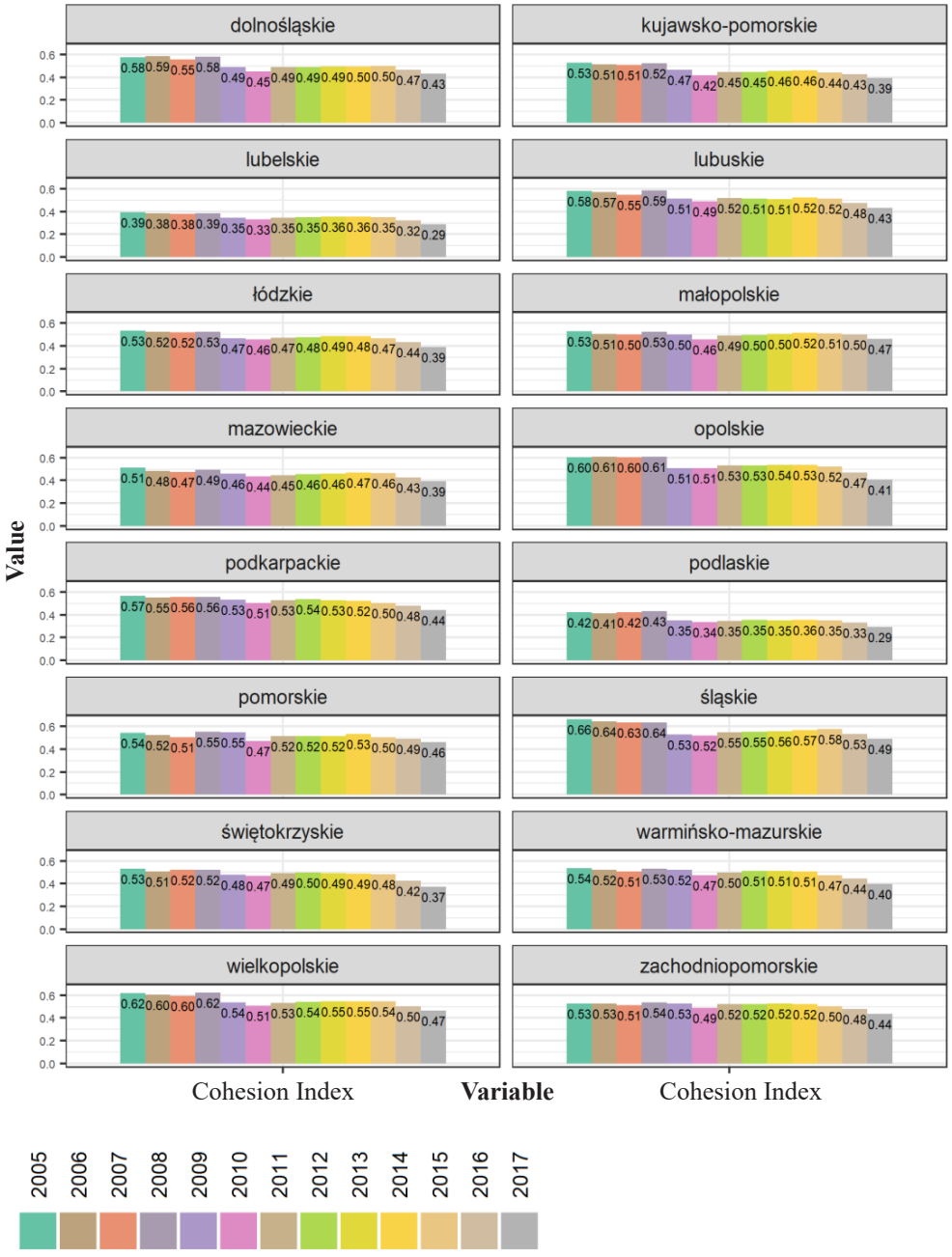


Figure 1. Cohesion Index values for rural areas in Poland in the years 2005-2017 by regions (NUTS 2 voivodeships)
Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

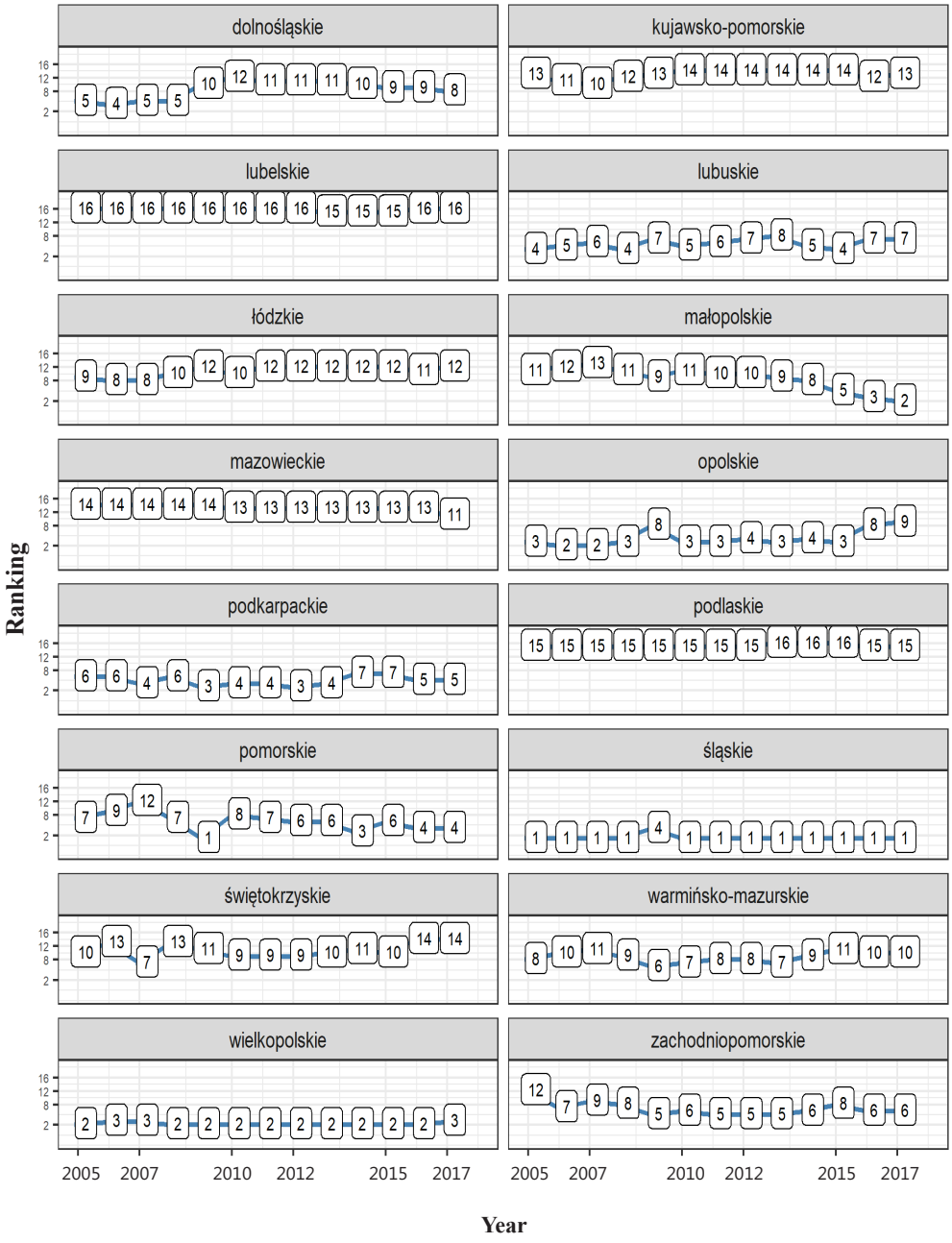
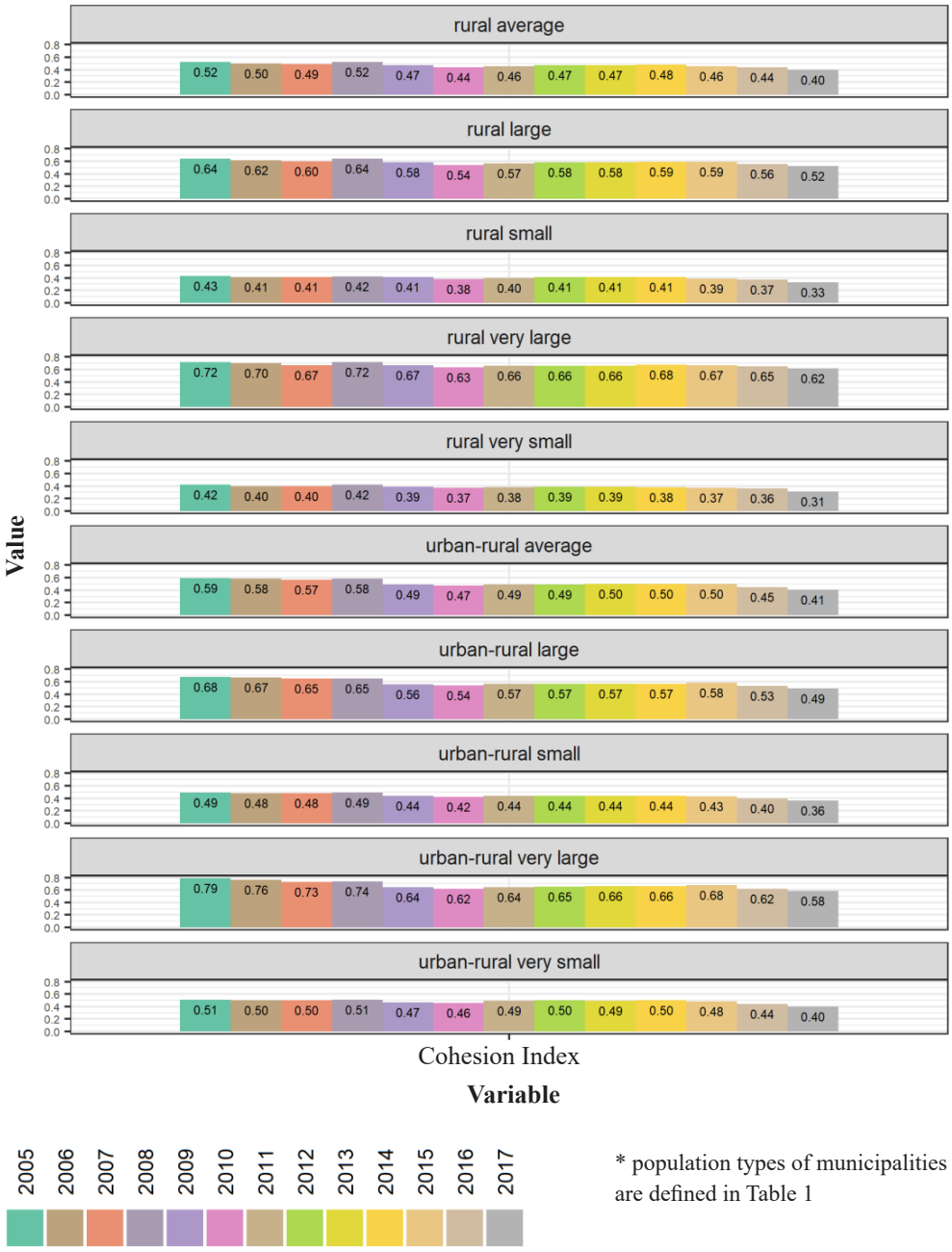


Figure 2. Cohesion Index ranking in the years 2005-2017 by regions (NUTS 2 regions)

Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)



* population types of municipalities are defined in Table 1

Figure 3. Cohesion Index values for rural areas in Poland in 2005-2017 for population types of municipalities
Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

for the following voivodships: Wielkopolskie (by 1 position), Warmińsko-mazurskie (by 2 positions), Dolnośląskie, Lubuskie and Łódzkie (by 3 positions) and Świętokrzyskie (by 4 positions) and Opolskie (by 6 positions). What is particularly characteristic is a rapid improvement (Małopolska) and deterioration (Opolskie) of the relative position in the cohesion of the two southern regions of Poland, which is a result of the impact of demographic factors.

Figure 3 presents the change dynamics of the Cohesion Index by type of municipality (urban-rural and rural) and for five population types (small, very small, medium, large and very large). The highest CI values were recorded for very large municipalities – both for rural and urban-rural municipalities. Rural municipalities (small and very small) were characterized by the lowest coherence in the period of analyzed years. It is possible to note a slight decrease in the spread of the range of extreme values in comparison between 2005 and 2017. The highest Cohesion Index level in 2017 was found in the group of the largest rural municipalities, surpassing the previously leading largest urban-rural municipalities in 2005.

A total of five OLS absolute β convergence regression models were estimated for the Cohesion Index and partial measures of development at a municipal level. The dependent variable in each case was the rate of change of the trait between 2005 and 2017 (g_i), defined as the logarithmic quotient of the trait level in the extreme years of analysis (2017 and 2005), while the explanatory variable was the initial trait level (in 2005). The statistical parameters of the models were satisfactory. As indicated by the results in Table 5 for the studied municipalities of the estimation of directional coefficients of models in the case of both the aggregate measure Cohesion Index and the five partial measures of development, a positive relationship between the level of the trait and the dynamics of its growth can be identified. The regression coefficients of the equations were statistically significant at the 1% level, while the β coefficients were positive, although not high, indicating a relatively low rate of convergence. This is confirmed by the observation of the half-life value, which determines the period required to reduce, by half, the currently existing inequality. At a level of municipalities, the time required to reduce inequality is very long. This applies, in particular, to both infrastructure measures, but also to the level of economic development, demographics and the overall Cohesion Index. On the other hand, the level of coefficients for the measure of environmental development was relatively high, indicating a much higher rate of convergence. However, the results of measuring environmental convergence should be treated with some caution, due to the specificity and objective difficulties associated with the proper measurement of environmental development, as some of the adopted characteristics, especially those related to environmentally valuable areas are endogenous in nature. The regression equations β convergence were also estimated at a NUTS 2 regions level, but here the directional coefficients of the equations were statistically insignificant, indicating a lack of a significant relationship. Thus, based on the estimated

Table 5. Results of pooled model estimation of univariate absolute β convergence for the Cohesion Index and partial measures of development at a municipality level. Dependent variable – rate of change of a characteristic in 2005-2017 (g_i)

Variable		Parameters of the equation				Half-life (years)	Effect
		α	b	β	R^2		
Cohesion Index		-0.033*** (0.000)	-0.017*** (0.000)	0.001	0.113	485	negligible convergence
Measure of development	demographic	0.06*** (0.004)	0.014*** (0.001)	0.001	0.08	596.7	negligible convergence
	economic	0.157*** (0.004)	-0.035*** (0.000)	0.003	0.38	235.5	negligible convergence
	technical infrastructure	0.019*** (0.004)	-0.005*** (0.001)	0.000	0.009	1,842.6	negligible convergence
	social infrastructure	0.04*** (0.01)	-0.01*** (0.00)	0.000	0.02	802.8	negligible convergence
	environmental	0.477*** (0.20)	-0.108*** (0.004)	0.038	0.206	19.2	convergence

Statistical significance: *** 1%, ** 5%, * 10%; standard errors in parentheses; number of observations – 2,175
Source: own elaboration based on data from the Regional Data Bank of Statistics Poland (GUS)

values, we can conclude that, in the case of the full population of municipalities in rural areas, in the period 2005-2017, we can identify a trace convergence in terms of cohesion, demographic, economic, and infrastructural development, and moderate in terms of the environment. At the same time, the results of convergence regression cannot be interpreted in isolation from the results of the estimation of spatial autoregression, indicating a high intensity of the process of building spatial clusters of local government units with similar values of development characteristics. The results of studies on the level of demographic, economic and infrastructural development, in terms of rural and urban-rural gminas in the voivodships, prove that disproportions persist and that the polarization effect has strengthened in the years in question. The relative position of some regions in the examined development elements is becoming stronger.

CONCLUSIONS

Research on the level and dynamics of territorial cohesion in 2005-2017 for municipalities in rural areas in Poland, determined by the degree of demographic, economic, infrastructural and environmental development has shown that, in the development of rural space, there are parallel opposite processes of spurious convergence and relatively strong polarization. This finding is confirmed by the correlation relationships between the studied elements of rural space development in 2005 and 2017. The relatively low level of correlation of demographic and economic development with the element of social infrastructure indicates that social infrastructure may be a barrier to the convergence process, especially in rural municipalities. Despite the fact that the correlation between the examined aspects occurs at different levels of interdependence, it is concentrated in certain areas, which is evidence of progressing polarization. The poles of demographic, economic, infrastructural and environmental development are the communes with a larger number of inhabitants. The above considerations lead to general conclusions that there are clear differences in the level of territorial cohesion in particular regions of Poland. From the perspective of the adopted characteristics, between 2005 and 2017, there was an increase in differentiation between municipalities in the regions, i.e. a decrease in the degree of internal cohesion in NUTS 2 regions. The intensity of the process of the catching up of municipalities with a higher level of development and level of cohesion by municipalities with a lower level is low, which may indicate that, on a local scale, territorial cohesion is reached too slowly at a regional level. This is a particularly worrying symptom in a country that is a beneficiary of the cohesion policy, since its funds are aimed at reducing disparities between regions and within regions, i.e. among municipalities. The observation of socio-economic phenomena in the years 2005-2017 confirm that separate groups of municipalities require a separate cohesion policy, which would create conditions for the better use of existing and potential local resources in accordance with the strategic objectives of the region, while the implementation of the polarization-diffusion model in Poland carries the risk of deepening differences in terms of economic and social cohesion.

BIBLIOGRAPHY

Adamowicz Mieczysław, Agnieszka Smarzewska. 2009. Model and indicators of sustainable development in rural areas from the local perspective. *European Policies. Finance and Marketing* 1 (50): 251-268.

Adamski Tomasz, Kazimierz Gorlach. 2007. Koncepcja rozwoju neo-endogennego, czyli renesans znaczenia wiedzy lokalnej. [W] *Socjologia jako służba społeczna* (The concept of neo-endogenous development, or the renaissance of the importance of local knowledge. [In] Sociology as social service), ed Kazmierz Gorlach, Marek Niezgoda, Zdzisław Seręga. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.

Bąk Andrzej. 2016. Porządkowanie liniowe obiektów metodą Hellwiga i TOPSIS – analiza porównawcza (Linear ordering of objects using the Hellwig and TOPSIS methods –comparative analysis). *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu* 426: 22-31.

Charnes Abraham, William W. Cooper, Edwardo Rhodes. 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research* 2 (6): 429-444.

Dmitruk Joanna, Jerzy Gawinecki. 2017. Metody wielowymiarowej analizy porównawczej – budowa i zastosowanie (Methods of multivariate comparative analysis – construction and application). *Biuletyn WAT* 66 (4): 103-119.

Faludi Andreas. 2013. Territorial cohesion and subsidiarity under the European Union treaties: A critique of the 'territorialism' underlying. *Regional Studies* 47 (9): 1594-1606. DOI: 10.1080/00343404.2012.657170.

Fratesi Ugo, Fiona G. Wishlade. 2017. The impact of European Cohesion Policy in different contexts. *Regional Studies* 51 (6): 817-821. DOI: 10.1080/00343404.2017.1326673.

Gagliardi Luisa, Marco Percoco. 2017. The impact of European Cohesion Policy in urban and rural regions. *Regional Studies* 51 (6): 857-868. DOI: 10.1080/00343404.2016.1179384.

González Ainhoa, Gavin Daly, Philip Pinch, Neil Adams, Visvaldis Valtenbergs, Malcolm C. Burns, Hjalti Johannesson. 2015. Indicators for spatial planning and territorial cohesion: Stakeholder-driven selection approach for improving usability at regional and local levels. *Regional Studies* 49 (9): 1588-1602. DOI: 10.1080/00343404.2015.1018883.

Gorzelak Grzegorz. 2019. Polityka regionalna i spójności terytorialnej. [W] *Nasza Europa: 15 lat Polski w Unii Europejskiej* (Regional policy and territorial cohesion. [In] Our Europe: 15 Years of Poland in the European Union), 102-110. Warszawa: CASE.

Hellwig Zdzisław. 1968. Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr (Application of the taxonomic method to the typological division of countries by their level of development and the stock and structure of skilled human resources). *Przegląd Statystyczny* 4 (15): 307-327.

Jakubowski Andrzej. 2018. Convergence or divergence? Multidimensional analysis of regional development in the New European Union member states. *Barometr Regionalny* 16 (1): 31-40.

Jańczuk Leszek. 2013. Determinanty rozwoju społeczno-gospodarczego regionów w Polsce (Determinants of the socio-economic development of regions in Poland). *Roczniki Nauk Społecznych* 5 (41): 121-132.

Kluth Katarzyna. 2016. *Statystyczna i ekonometryczna analiza konwergencji gospodarczej i społecznej państw Unii Europejskiej* (Statistical and econometric analysis of economic and social convergence of the European Union countries). Toruń: Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika.

Kluza Krzysztof. 2019. Socio-economic disparities between rural boroughs as a function of their peripheral location. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu* 63 (2): 37-48.

Kołodziejczyk Danuta. 2014. A territorial perspective on the economic and social cohesion of communes in Poland. [In] *Rural development and EU cohesion policy,* ed. Władysław Kamiński, Krystian Heffner, 85-101. Warszawa: Studia Regionalne.

Kołodziejczyk Danuta, Marcin Gospodarowicz. 2014. *Instytucjonalne uwarunkowania rozwoju infrastruktury jako głównego czynnika zrównoważonego rozwoju obszarów wiejskich, cz. 2* (Institutional determinants of infrastructure development as the main factor of sustainable rural development, part 2). Warszawa: Wydawnictwo Instytutu Ekonomiki Rolnictwa i Gospodarki Żywnościowej – Państwowego Instytutu Badawczego.

Kołodziejczyk Danuta, Marcin Gospodarowicz, Danuta Lidke, Marcin Mazur. 2017. *Ocena poziomu spójności demograficznej i społeczno-gospodarczej obszarów wiejskich w porównaniu z miastami* (Assessment of the level of demographic and socio-economic cohesion of rural areas compared to cities). Warszawa: Wydawnictwo Instytutu Ekonomiki Rolnictwa i Gospodarki Żywnościowej – Państwowego Instytutu Badawczego.

Markowski Tomasz. 2009. *Gospodarka regionalna i lokalna* (Regional and local economy). Warszawa: PWN.

Marszał Tomasz, Iwona Pielesiak. 2008. Spójność obszaru metropolitalnego w świetle powiązań infrastruktury – przykład Łódzkiego Obszaru Metropolitalnego (Cohesion of the metropolitan area in the light of infrastructure links – the example of Łódź Metropolitan Area). *Studia Komitetu Przestrzennego Zagospodarowania PAN* 120: 180-196.

Medeiros Eduardo. 2016. Territorial cohesion: An EU concept. *European Journal of Spatial Development* 60: 1-30.

Moran Patrick Alfred Pierce. 1950. Notes on Continuous Stochastic Phenomena. *Biometrika* 37 (1): 17-23. DOI:10.2307/2332142.

Parysek Jerzy J. 2018. Rozwój społeczno-gospodarczy oraz czynniki i uwarunkowania rozwoju. [W] *Teoretyczne i aplikacyjne wyzwania współczesnej geografii społeczno-ekonomicznej* (Socio-economic development and the factors and determinants of development. [In] Theoretical and applied challenges of contemporary socio-economic geography), ed Paweł Churski, 37-55. Warszawa: Studia KPZK.

Reig-Martínez Ernest, José A. Gómez-Limón, Andrés J. Picazo-Tadeo. 2011. Ranking farms with a composite indicator of sustainability. *Agricultural Economics* 42 (5): 561-575. DOI: 10.1111/j.1574-0862.2011.00536.x.

Solow Robert M. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics* 70 (1): 65-94. DOI: 10.2307/1884513.

Spychała Marcin. 2017. Zróżnicowanie przestrzenne absorpcji funduszy unijnych perspektywy finansowej 2007-2013 a zmiany poziomu wzrostu gospodarczego województw w Polsce (Spatial diversity of the EU funds absorption from the financial perspective 2007-2013 and changes in the level of economic growth of voivodeships in Poland). *Nierówności Społeczne a Wzrost Gospodarczy* 49 (1): 348-358. DOI: 10.15584/nsawg.2017.1.26.

Stanny Monika. 2012. *Poziom rozwoju społeczno-gospodarczego obszarów wiejskich w Polsce – pomiar zjawiska złożonego* (Level of socio-economic development of rural areas in Poland – measurement of a complex phenomenon), http://admin.www.irwirpan.waw.pl/dir_upload/site/files/Monika/PomiarZjawiskaZlozonego_IRWIR2012, access: 12.11.2021.

Szlachta Jacek. 2018. Terytorializacja jako wyzwanie polityki rozwoju – perspektywa europejska (Territorialization as a challenge for development policy – the European perspective). *Studia Komitetu Przestrzennego Zagospodarowania Kraju PAN* 184: 10-19.

Sánchez-Zamora Pedro, Rosa Gallardo-Cobos, Carlos Arturo Romero-Huertas. 2017. Assessing the determinants of territorial cohesion. Evidence from Colombian departments. *Geoforum* 87: 48-61.

Sánchez-Zamora Pedro, Rosa Gallardo-Cobos. 2020. Territorial cohesion in rural areas: An analysis of determinants in the post-economic crisis context. *Sustainability* 12 (9): 3816. DOI: 10.3390/su12093816.

Van Well Lisa. 2012. Conceptualizing the logics of territorial cohesion. *European Planning Studies* 20 (9): 1549-1567. DOI: 10.1080/09654313.2012.708021.

Williamson Jeffrey G. 1965. Regional inequality and the process of national development: A description of patterns. *Economic Development and Cultural Change* 13: 3-47.

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SPÓJNOŚĆ TERYTORIALNA GMIN W POLSCE W LATACH 2005-2017 W UJĘCIU MIERNIKA SYNTETYCZNEGO, W KONTEKŚCIE KONWERGENCJI I KLASTERYZACJI PRZESTRZENNEJ

Słowa kluczowe: spójność terytorialna, miara syntetyczna, konwergencja, gmina, skupienia przestrzenne

ABSTRAKT

Pojęcie spójności terytorialnej zyskało na znaczeniu w kontekście rozwoju polityki regionalnej Unii Europejskiej, jednak definicje tego pojęcia są bardzo zróżnicowane. W artykule wykorzystano koncepcję rozwoju przestrzennego wspierającego ekonomiczne i społeczne aspekty spójności i na tej podstawie skonstruowano wielowymiarowy indeks spójności terytorialnej oparty na pięciu wymiarach (ekonomicznym, demograficznym, infrastrukturalnym w dwóch aspektach i środowiskowym) zjawiska. Miara ta została zastosowana do ogółu ludności gmin (2175) na obszarach wiejskich w Polsce, w latach 2005-2017. Celem badania była ocena spójności terytorialnej gmin w Polsce w ujęciu statycznym i dynamicznym oraz wykorzystanie narzędzi ekonometrycznych do identyfikacji potencjalnej konwergencji spójności i określenia efektu „doganiania", według Jeffreya G. Williamsona [1965], gdzie gminy o niższym poziomie spójności podążają za gminami o wyższym poziomie spójności. Wyniki dotychczasowych badań prowadzonych na różnych poziomach regionalnych wskazują na wzrost polaryzacji dochodów na obszarach wiejskich i tworzenie się wysp konwergencji, gdzie regiony o najwyższym i najniższym poziomie zamożności upodabniają się wewnątrzgrupowo, ale nie międzygrupowo. Wyniki badania wskazują na spadek względnej spójności terytorialnej na obszarach wiejskich w Polsce w latach 2005-2017 na poziomie gmin i tendencję do tworzenia się skupisk przestrzennych jednostek o zbliżonym poziomie cechy. Nie pozwalają natomiast na potwierdzenie poglądu o konwergencji spójności między jednostkami o różnych poziomach cechy.

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