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INSTITUTIONAL INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT: ANALYSIS OF EASTERN POLAND DISTRICTS

Summary: The aim of this paper is to determine the strength and nature of relationships between synthetic indicators of sustainable development level and institutional infrastructure development in eastern Poland districts, taking into consideration the spatial interactions between the aspects studied (data from 2016). The study covered 101 districts in Lublin, Podkarpackie, Podlaskie, Świętokrzyskie and Warmian-Masurian voivodships. The TOPSIS method was used to assess the development of institutional infrastructure and the sustainable development level. An analysis of Spearman's rank correlations was carried out for the constructed synthetic measures. Moreover, an analysis of spatial autocorrelation based on Moran *I* statistics was carried out.

Keywords: sustainable development, institutional infrastructure, spatial dependencies.

JEL Classification: Q01, O18.

Introduction

The last decades have witnessed a major reorientation in the approach to local socio-economic development. Today, local government is confronted with tasks related to strategic management of territorial units in accordance with the constitutional principle of sustainable development, and must perform them. As a consequence, it becomes necessary to prioritise and raise the profile of actions focused on: new technology transfer, development of innovation and enterprise, and environmental enhancement (e.g. through eco-innovation). In this context, it becomes particularly important to saturate the different geographic areas with institutional infrastructure which acts as a specific regulator of the local population's social and economic life (including through the rationalisation of social attitudes or by stimulating the diffusion of technological progress). By driving innovation, the institutional environment contributes to more efficient working methods, quality improvements in production processes and service delivery and accelerates the time-to-market of goods and also enables a resilient response to changes in the environment. Institutional infrastructure components act as a catalyst for growth in many national economy sectors and play an important role in the context of attracting foreign capital.

The economic space (where economic activities take place), the ecological space and the social space (related to population distribution) do not consist of units isolated from one another. Therefore, the analyses of spatial units should take into account the interactions between particular geographic areas. For a relatively long time the economists have been reluctant to take the spatial factor into consideration in their empirical studies (the achievements of the New Economic Geography should be considered as a milestone). It is difficult not to agree with R. Domański [2007, p. 17] who claims that the "economic theory assertions that ignore the geographic aspects are incomplete and reflect reality in an overly simplified way".

The purpose of this paper is to determine the strength and nature of relationships between synthetic indicators of sustainable development level and institutional infrastructure development in eastern Poland districts, taking into consideration the spatial interactions between the aspects studied. The TOPSIS method was used in order to determine the development level of aspects covered by this analysis. To determine the strength of spatial relationships between institutional infrastructure development and the level of sustainable development in different districts, an analysis of spatial autocorrelation was carried out. This study covered 101 districts in the Lubelskie, Podlaskie, Podkarpackie, Świętokrzyskie and Warmińsko-Mazurskie voivodships.

1. Local sustainable development

The definition of 'sustainable development' has been evolving over time along with the changing economic reality. Because of the wide spectrum of definition components, the relevant literature fails to provide an unambiguous definition of this economic category. According to T. Borys [2013, p. 22], even in the 2010s, "sustainable development, as a new development paradigm, is still not sufficiently established in economic sciences. This is equally true for economic sciences as for management sciences". The definition most frequently referred to by the authors is the one formulated for the purposes of the Our Common Future 1987 UN report [United Nations, 1987]. Accordingly, sustainable development is described as a development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [United Nations, 1987, p. 41]. Also, R.K. Turner and D.W. Pearce [1992, pp. 16-17] note that the concept of sustainable development is directly related to that of inter-generative justice. They believe sustainable development means that the next generation should not be 'worse off' in development terms than the current one. This means leaving the next generation with a stock of capital assets that provides them with the capability to generate at least as much development as is achieved by the current generation. P. Dasgupta [2007, p. 3] defines sustainable development as "an economic program where the average prosperity of present and future generations, taken together, does not decrease over time".

The effectiveness of the practical implementation of sustainable development assumptions depends on the effectiveness of the tools used at local and regional level. It is difficult not to agree with S. Kozłowski [1993, p. 8] who claims that "local development should not entail the degradation of natural resources and ecosystems but should take into account natural and social conditions".

Sustainable development at the local level means, in particular: matching local skills and needs to the availability of employment; protecting the environment based on an ecosystem-based approach to minimise natural resource consumption, waste and pollution; meeting local needs at a local level; participation of all local community sectors in local planning and decision-making; high quality of and universal access to basic services; and high quality of cultural heritage [Borys (Eds.), 2005]. P. Szewczyk and K. Midor [2007, pp. 58-59] believe that local sustainable development should be an integrated process which takes place in the following 5 dimensions:

- the socio-cultural dimension,
- the economic dimension, through the development of economic operators,
- the spatial dimension, through a rational distribution of economic operators,
- the environmental dimension, reflected by the protection of ecological resources and values,
- the political dimension which takes into account the objective laws of sustainable development in the area of politics and management.

The idea of moving the assumptions of sustainable development from the macroeconomic level to the local level was laid down in Agenda 21 (primarily in Part III and in Chapter 28. Local authorities' initiatives in support of Agenda 21"). Being closest to the local community, the local government has to play an important role in educating and mobilising the society (and in making them respond) in order to promote sustainable development. Local authorities create, operate and maintain the economic, social and environmental infrastructure; supervise the planning process; establish local environmental policies and legal regulations; and help with implementing national and international environmental policies.

2. The term 'institutional infrastructure'

In the era of knowledge economy based on innovativeness, the saturation of individual geographic areas with institutional infrastructure (which is a key driver of innovative entrepreneurial activities and a key determinant of the population's environmental awareness) becomes extremely important.

According to W. Buhr [2003, p. 4], the institutional infrastructure extends across all habits and rules established in the society and across objects and procedures which enable these rules to be implemented by the government. An equally broad approach to the institutional environment (the institutional structure, to be more specific) was presented by I. Pietrzyk [2000, p. 26] who defined it as "the playing field for the society or the anthropogenic conditions that shape the interactions between humans". According to him, it includes a broad spectrum of institutions (such as banks, development agencies, economic organisations) as well as their operational frameworks. The institutional infrastructure is often defined only as a heterogeneous set of organisations, composed of [Przygodzki, 2007, pp. 149-150]: public institutions (including universities, state authorities), public-private institutions (including regional development agencies), non-government civic institutions (including foundations supporting the development of entrepreneurship), private institutions (including economic organisations and banks), and private associations (including business representative organisations). According to M. Reichel [2006, p. 6], the institutional infrastructure includes regional institutions focused on supporting entrepreneurship and innovation, such as local government, local and regional development agencies and foundations, universities, R&D centres, technology transfer centres, consultancy centres, and financial institutions. A similar view on the institutional infrastructure is presented by C. Longhi [1999, p. 334] who considers it to be the business environment institutions, including the local government, regional banks and service centres. According to the terms used by the Polish Business and Innovation Centers Association, the institutional infrastructure means innovation and entrepreneurship centres which deliver a series of service functions allowing the economic operators to boost their development processes and implement their strategies [Bąkowski and Mażewska (Eds.), 2015, p. 8].

Such diverse interpretations of the institutional infrastructure could be explained by different ways of interpreting the 'institution', either as the principles governing the relationships between operators or as an organisation. While the first approach is typical of the sociological analysis, the second one is characteristic for deliberations based on the organisation and management theory [Ratajczak 1999, p. 19]. Whereas the above considerations, the author will focus on the tangible institutional infrastructure, primarily including the institutions that support innovativeness and entrepreneurship.

An important condition for attaining the sustainable development goals is to create and absorb innovations (especially eco-innovations). In the nomenclature used by the Central Statistical Office, eco-innovations mean "a new or considerably improved product (good or service), process or an organisational or marketing method which produce environmental benefits" [GUS, 2016, p. 64]. Such innovations contribute to sustainable development by "improving the efficiency of natural resources used in the economy, reducing the adverse environmental impact of human activities or making the economy more resistant to environmental pressures" [Szpor and Śniegocki, 2012, p. 3]. A well-developed network of institutional infrastructure elements, together with an extended range of services offered by such institutions, are the very factors that may contribute to the increased absorption of state-of-the-art technologies, to the creation of environmentally-friendly and other innovations, to the facilitation of the knowledge flow, and to the creation of new competition forms. Also, it may result in the development of many economic operators. This is because the wide adoption of innovation becomes "one of the main conditions for strengthening the development drivers and improving their effectiveness" [Brzeziński (Ed.), 2001, p. 26].

The institutional infrastructure also plays a major role in identifying the entrepreneurs' needs for environmentally-friendly and other innovations, contributes to assessing the commercial potential of new (technological, organisational and product) solutions, provides support in searching for state-of-the-art technologies or direct contacts with technology producers who are able to implement such technologies as per the buyer's requirements. Also, it participates in searching for buyers of state-of-the-art technologies by taking measures to promote state-of-the-art solutions (e.g. the activity of technology transfer centres), which includes organising conferences. Furthermore, such institutions develop procedures which enable assessing and applying for legal protection of innovations (e.g. R&D centres). They also provide the financial support to operators interested in deploying innovative solutions in their operations (e.g. local loan funds), and support the process of putting innovation into commercial practice (including training and consultancy centres), for instance by checking the operator's adaptability.

3. Spatial autocorrelation

This study covered 101 districts in five voivodships: the Lubelskie, Podlaskie, Podkarpackie, Świętokrzyskie and Warmińsko-Mazurskie. At the end of 2016 [www 1], that territory had a population of 8,136,888 and an area of 99,039 km^2 (over 31% of the national area).

In order to determine the degree of availability of infrastructural elements in individual eastern Poland districts, the weighted average index of spot density was used, taking into account both the population and the area of the geographic unit considered:

$$g_{aw} = \frac{l}{p \cdot m}$$

where:
l – the number of objects,
p – the surface area,
m – the population.

Based on substantive criteria (considering the definitions of economic categories covered by this analysis, as referred to above), the following set of 11 diagnostic variables was used to build the synthetic indicator of institutional infrastructure development levels (SII): I1: weighted average density (WAD) of universities; I2: WAD of remote units of universities; I3: WAD of technology transfer centres; I4: WAD of innovation centres; I5: WAD of seed capital funds; I6: WAD of loan funds; I7: WAD of business incubators; I8: WAD of technology incubators; I9: WAD of technology parks; I10: WAD of training and consultancy centres; I11: share of councillors at tertiary education levels present in district or municipal bodies with a capacity to pass resolutions.

In turn, to build the synthetic measure of sustainable development levels (SMSD), 35 sub-indicators were proposed which reflect the levels of sustainable development split into three dimensions [cf. Borys (Ed.), 2005; GUS, 2011]:

- the environmental dimension: OS1: municipal and industrial wastewater treated vs. total volume of wastewater; OS2: share of population served by sewage treatment plants in the total population; OS3: afforestation rate; OS4: particulate matter emissions by particularly noxious plants per sq. km; OS5: emission of gaseous pollutants by particularly noxious plants per sq. km; OS6: area of walking and leisure parks per sq. km; OS7: share of green areas in the total area; OS8: per capita water consumption;
- the social dimension: S1: population density; S2: population growth rate per 1,000 population; S3: infant deaths per 1,000 live births; S4: graduates of junior high schools per 1,000 population; S5: share of apartments equipped with central heating; S6: share of apartments served by gas networks; S7 number of books per 1,000 population; S8: library members per 1,000 population; S9: population per library; S10: population per cinema seat; S11: doctors per 1,000 population; S12: hospital beds per 1,000 population; S13: number of apartments per 1,000 population; S14: number of kindergarten pupils per 1,000 children aged 3 to 5; S15: number of passenger cars per 1,000 population; S16: traffic accidents per 1,000 population;
- the economic dimension: G1: employees per 1,000 population; G2: share of employees in the working-age population; G3: hard-surfaced municipal roads in the district per sq. km; G4: sewage network length per sq. km; G5: water supply network length per sq. km; G6: share of commercial enterprises in the total number of operators registered in the REGON system; G7: permanent marketplaces per 1,000 population; G8: hotel beds per 1,000 population; G9: foundations, organisations and associations per 1,000 population; G10: output sold per inhabitant; G11: CAPEX in enterprises per inhabitant.

The choice of variables was determined by the availability of complete, up--to-date data for all objects. The discriminating capacity of variables and their capacity, i.e. the degree of correlation with other variables, was examined in order to obtain the final set of variables. When choosing the variables, specific observations must demonstrate adequate variation because a non-diversified variable is of limited analytical value. The characteristics with a classic coefficient of variation below the critical threshold value of 10% (fixed arbitrarily) were eliminated from both sets of variables. Based on the above procedure, OS1 was the only variable to be eliminated.

To assess the information value the inverse correlation matrix [more: Młodak, 2006, pp. 30-31] was used. In the case of variables related to sustainable development levels the inverse correlation matrix was calculated for each thematic sub-group of variables. Next, the variable with the highest diagonal entry, above the threshold set at r* = 10, was eliminated. This resulted in eliminating OS7 and G1. Considering the capacity criterion, for each variable referring to the saturation level of institutional infrastructure in districts, diagonal values not exceeding the established threshold were recorded.

The nature of each of them was specified (the effect it has on the phenomenon covered by this analysis was: a stimulating effect, an inhibiting effect or a neutral effect). In the case of institutional infrastructure, all the considered variables were found to have a stimulating effect. Conversely, in the case of the variables illustrating the sustainable development level, OS4, OS5, OS8, S3, S9, S10 and S16 were included in the set of the variables with an inhibiting effect. The other variables have a stimulating effect.

Different weights were attributed to the variables depending on their discriminatory and information capacity (separately in both sets of variables). The modified *BVP*[1] method was used for this purpose. It relies on a more adequate measure of information capacity than the linear correlation coefficients used in the original BVP which fail to take the presence of collinearity into account. The analytical form of weights may be expressed as:

$$w_j = w_j^a \cdot w_j^b,\ j = 1,2,...,m$$

where:

w_j^a – the measure of discriminatory capacity of diagnostic variable *j*,

w_j^b – the measure of information capacity of diagnostic variable *j*.

The measure of discriminatory capacity, based on the classic coefficient of variation, is expressed as:

$$w_j^a = \frac{V(x_j)}{\sum_{j=1}^{m} V(x_j)}\text{'}\ j = 1,2,...,m.$$

[1] A modification of the method by G. Betti and V. Verma was proposed by T. Panek [Panek, Zwierzchowski, 2013].

In turn, the measure of information capacity may be defined as:

$$w_j^b = \frac{\sum_{\substack{j'=1 \\ j' \neq j}}^{m} r_{j.j'}^2}{\sum_{\substack{j=1 \\ j' \neq j}}^{m} \sum_{\substack{j'=1 \\ j' \neq j}}^{m} r_{j.j'}^2}, \ j = 1,2,...,m.$$

where:

$r_{j.j'}^2$ – squared coefficient of partial correlation between variable *j* and variable *j'*.

Table 1. Weights of diagnostic variables

Variables	Weights	Variables	Weights	Variables	Weights	Variables	Weights
I1	0.00967	OS2	0.00040	S6	0.00070	G2	0.00066
I2	0.00724	OS3	0.00026	S7	0.00006	G3	0.00165
I3	0.01191	OS4	0.00313	S8	0.00025	G4	0.00258
I4	0.00971	OS5	0.00284	S9	0.00088	G5	0.00165
I5	0.01304	OS6	0.00372	S10	0.00050	G6	0.00080
I6	0.00882	OS8	0.00116	S11	0.00216	G7	0.00027
I7	0.01000	S1	0.00351	S12	0.00086	G8	0.00047
I8	0.00949	S2	0.00079	S13	0.00010	G9	0.00015
I9	0.00880	S3	0.00012	S14	0.00025	G10	0.00041
I10	0.00235	S4	0.00068	S15	0.00004	G11	0.00035
I11	0.00025	S5	0.00016	S16	0.00013		

With a view to ensure the comparability of the characteristics expressed with the different units and of the different orders of magnitude, a standardisation-based normalisation procedure was performed. The classic TOPSIS method was used to linearly order eastern Poland districts by the level of the phenomena studied. In this case, the synthetic indicator is based on Euclidean distance from both the pattern and the anti-pattern. The smaller is the distance from the pattern (and the greater is the distance from the anti-pattern), the higher is the value of the synthetic variable. The steps of building the synthetic measure are as follows [Hwang, Yoon, 1981, pp. 128-140]:

1. Creating a normalised decision matrix.
2. In the case of weighted variables, the weighted matrix and, afterwards, the weighted normalised decision matrix need to be created.
3. For the normalised features, the coordinates of the 'ideal' (A^+) and anti-ideal (A^-) solution are determined:

$$A^+ = (\max_i(v_{i1}), \max_i(v_{i2}), \ldots, \max_i(v_{iN})) = (v_1^+, v_2^+, \ldots, v_N^+),$$

$$A^- = (\min_i(v_{i1}), \min_i(v_{i2}), \ldots, \min_i(v_{iN})) = (v_1^-, v_2^-, \ldots, v_N^-),$$

4. Determining the Euclidean distance of each object from the pattern and the anti-pattern:

$$s_i^+ = \sqrt{\sum_{j=1}^{N}(v_{ij} - v_j^+)^2},\ s_i^- = \sqrt{\sum_{j=1}^{N}(v_{ij} - v_j^-)^2},\ i = 1,2,\ldots,M,\ j = 1,2,\ldots,N$$

5. Calculating the value of the synthetic feature: $C_i = \dfrac{s_i^-}{s_i^+ + s_i^-}$ with $0 \le C_i \le 1$.

Table 2. Values of the synthetic indicator of sustainable development (I) and of development levels of institutional infrastructure (II) in eastern Poland districts; local Moran's I values

District	SISD		Moran's *I*		District	SISD		Moran's *I*	
	I	II	I	II		I	II	I	II
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
augustowski	0.43	0.07	−0.23*	0.22	łukowski	0.35	0.12	0.99*	0.29
bartoszycki	0.39	0.05	0.24	0.20	mielecki	0.45	0.16	−0.08	−0.12*
bialski	0.29	0.11	−0.44	−0.05	moniecki	0.36	0.06	0.51	0.29
Biała Podlaska	0.51	0.39	−4.49**	−1.88	mrągowski	0.40	0.05	0.11	0.24
białostocki	0.34	0.08	0.42	0.10	nidzicki	0.39	0.10	0.17	0.09
Białystok	0.45	0.36	−1.09*	−1.70	niżański	0.39	0.12	0.11	0.01
bielski	0.40	0.11	0.11	0.25	nowomiejski	0.39	0.14	0.15	0.1
bieszczadzki	0.48	0.12	0.54	0.02	olecki	0.39	0.15	0.18	0.05
biłgorajski	0.36	0.10	0.43*	0.22	Olsztyn	0.56	0.38	−2.71*	−1.75
braniewski	0.38	0.07	0.24	0.20*	olsztyński	0.36	0.13	−0.1	0.03
brzozowski	0.42	0.09	−0.10	0.17	opatowski	0.41	0.09	0.01	0.15
buski	0.40	0.08	0.04	0.20	opolski	0.39	0.12	0.06	0.16
Chełm	0.51	0.25	−1.12	−0.81	ostrowiecki	0.40	0.13	0.11	0.01
chełmski	0.38	0.09	−0.11	0.07	ostródzki	0.42	0.13	−0.07*	0.2
dębicki	0.41	0.11	−0.01	0.09	parczewski	0.41	0.04	−0.02	0.24
działdowski	0.39	0.11	0.10	0.11	pińczowski	0.40	0.08	0.05	0.11
Elbląg	0.41	0.26	−0.03	−0.59	piski	0.40	0.17	0.14*	0.18
elbląski	0.39	0.06	0.07	−0.01	przemyski	0.38	0.04	−0.26	0.04
ełcki	0.36	0.10	0.25	0.03	Przemyśl	0.53	0.30	−1.41	−0.96
giżycki	0.40	0.14	0.11	0.09	przeworski	0.37	0.13	0.30	0.18
gołdapski	0.38	0.07	0.16	0.03	puławski	0.42	0.12	−0.07	−0.03
grajewski	0.37	0.12	0.51*	0.17*	radzyński	0.40	0.03	0.18**	0.32
hajnowski	0.42	0.04	−0.1	0.21	ropczycko-sędziszowski	0.39	0.12	−0.02	0.1
hrubieszowski	0.37	0.08	0.3	0.32	rycki	0.39	0.12	0.18	0.08
iławski	0.39	0.09	0.09	0.17	rzeszowski	0.39	0.09	−0.01	0.01
janowski	0.37	0.12	0.26	0.13	Rzeszów	0.55	0.39	−0.99	−1.75
jarosławski	0.41	0.10	−0.03	0.27	sandomierski	0.39	0.11	−0.06	−0.01
jasielski	0.39	0.10	0.14	0.19	sanocki	0.42	0.14	0.08	0.01*
jędrzejowski	0.38	0.04	0.18	0.12	sejneński	0.40	0.04	−0.01	0.18
kazimierski	0.39	0.04	0.04	0.13	siemiatycki	0.41	0.10	−0.04*	0.18
kętrzyński	0.39	0.12	0.17	0.16	skarżyski	0.39	0.16	0.18	0.07
Kielce	0.46	0.34	−0.88*	−0.91	sokólski	0.40	0.12	0.17	0.34
kielecki	0.36	0.13	0.09	0.04	stalowowolski	0.44	0.16	−0.25	−0.02
kolbuszowski	0.41	0.04	0.00	0.06	starachowicki	0.40	0.17	0.11	0.02
kolneński	0.36	0.04	0.67*	0.23	staszowski	0.41	0.06	0.00	0.14
konecki	0.39	0.13	0.16	0.14	strzyżowski	0.39	0.11	0.08	0.15
krasnostawski	0.39	0.07	0.15	0.23	suwalski	0.40	0.11	0.06	−0.12
kraśnicki	0.38	0.09	0.12	0.18	Suwałki	0.44	0.42	−0.14	−1.25
Krosno	0.52	0.39	−1.37	−1.73	szczycieński	0.39	0.12	0.19	0.25
krośnieński	0.38	0.05	−0.23	−0.21	świdnicki	0.42	0.18	0.19	0.02

Table 2 cont.

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
leski	0.49	0.05	1.21	0.02	Tarnobrzeg	0.47	0.33	−0.41	−0.63
leżajski	0.39	0.13	0.16	0.07	tarnobrzeski	0.39	0.06	−0.11	−0.1
lidzbarski	0.39	0.08	0.14	0.21	tomaszowski	0.41	0.08	0.02*	0.26
lubaczowski	0.40	0.11	0.09	0.23	węgorzewski	0.40	0.05	0.04	0.07
lubartowski	0.39	0.09	0.09	0.23*	włodawski	0.43	0.09	−0.28	0.23
lubelski	0.40	0.04	−0.02	0.03	włoszczowski	0.41	0.08	0.04	0.16
Lublin	0.62	0.36	0.18	−0.43	wysokomazowiecki	0.38	0.07	0.34*	0.26
łańcucki	0.40	0.14	0.06	0.12	zambrowski	0.37	0.08	0.68**	0.23
łęczyński	0.43	0.12	−0.02	0.14	zamojski	0.38	0.03	−0.06	0.08
Łomża	0.47	0.44	−0.89	−1.94*	Zamość	0.57	0.30	−2.02	−31.36*
łomżyński	0.37	0.03	0.50*	−0.08					

Symbols: *, **, ***: statistically significant at p < 0,05, p < 0,01, p < 0,001, respectively.

Source: Based on: [www 1]; Bąkowski and Mażewska (Eds.) [2015].

The highest SISD levels were recorded in Lublin and Zamość whereas the lowest were in the districts of Białystok and Biała Podlaska. In this context, note that the districts located in the immediate vicinity of current or former voivodship capitals, i.e. Chełm district (81st), Zamość district (83rd), Łomża district (89th), Olsztyn district (93rd) and Kielce district (95th), are ranked relatively low. This is because municipal districts accumulate a significant part of the voivodship's social and economic potential (including enterprises, cultural facilities). The above contributes to understating the indicators of living standards and economic development in the corresponding land districts. The analysis of the coefficient of variation for SISD (12.26%) and the maximum-to-minimum ratio (2.09) suggests that the phenomenon under consideration varies moderately across the geographic areas. In turn, the coefficient of asymmetry (1.86) shows the distribution is strongly asymmetric. In 75% of districts, SISD did not exceed 0.4116 and reached a maximum of 0.6148.

In the SII ranking, the top 14 consisted of urban districts, the highest values being recorded in Łomża and Suwałki. The highest value of all land districts (0.1820) was recorded in the Świdnica district. The lowest values were identified in the districts of Zamość, Łomża and Radzyń. The coefficient of variation was 74.66% which suggests that the phenomenon under consideration varied strongly across the regions. Also, SII demonstrated right-side asymmetry (the coefficient of asymmetry was 1.78) which suggests the dominance of values equal to or below the arithmetic mean. As regards three quarters of districts covered by this analysis, SII was not above 0.1312, with a maximum and minimum of 0.4414 and 0.0271, respectively.

A correlation analysis was used to examine the relationship between the concentration of the institutional infrastructure in eastern Poland districts and the levels of sustainable development. In order to eliminate the negative impact of outliers, if any, on the results of the correlation analysis, the nonparametric Spearman rank correlation coefficient was used. The calculated coefficient of the correlation between the defined indicators was 0.4142, which suggests a moderately strong relationship between the aspects covered by the analysis, and allows to conclude that the correlation coefficient was significant at $p < 0.05$.

In economic studies on spatial units, the interactions between particular geographic areas should be taken into account. The structural elements of different local government units (such as natural resources, infrastructure) form a specific set of interrelated and interdependent components going beyond administrative boundaries. As a consequence, some spatial relationships (referred to as spatial autocorrelation) may exist between neighbouring units.

Spatial autocorrelation is defined as the correlation degree between the identified value of a variable in a specific location and the value of the same variable in another location. This means the values of the variable under consideration determine, and are determined by, the corresponding values recorded in other locations. There are two variants of the spatial correlation: positive autocorrelation and negative autocorrelation. The positive autocorrelation means the spatial concentration of high or low values of a variable. In turn, the negative autocorrelation means that high and low values are adjacent to each other [Suchecki (Ed.), 2010]. In such analyses, another problem is to address the impacts of the existing spatial structure. To do that, the neighbourhood structures are specified with the use of spatial weights, a parameter created based on the distance or the neighbourhood matrix (the weights are non-zero if two locations share a border or are separated by a specific, predefined distance). The approach used in this paper considers a shared border to be the proximity criterion. This is the most widely adopted neighbourhood modelling method which uses a binary matrix as the starting point: 1 means that the areas share a border; 0 means they do not. This is a symmetric square matrix. Defined as above, the binary matrix is standardised by rows so that the sum of all entries is equal to 1 [cf. Anselin, 2003, pp. 310-313; LeSage and Pace, 2009, pp. 1-7].

To analyse the interactions between SISD and SII observed in the specific districts, on one side, and the corresponding values recorded in the neighbouring districts, on the other side, the global Moran's *I* was used [Suchecki (Ed.), 2010, p. 112]:

$$I = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \cdot \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2},$$

with:

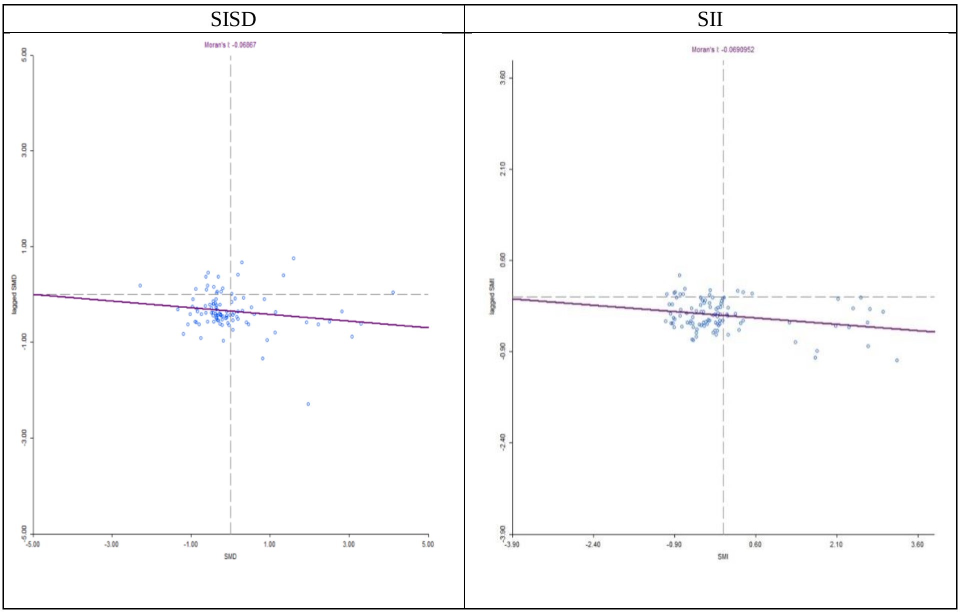
x_i, x_j – the values observed in locations i and j (i, j = 1, 2, … , n),

$\bar{x}$ – the average value in all the areas under consideration,

w_{ij} – entries of the spatial weight matrix.

The identified global Moran's *I* statistics are negative and statistically insignificant for both the institutional infrastructure and sustainable development levels (−0.0691 and −0.0687, respectively). The negative values of these statistics are interpreted as *hot spots*, i.e. the isolated areas where distinctly different values are recorded [Kopczewska, 2007, p. 73]. The statistical insignificance means that the variable follows a random distribution. To deepen the analysis (Figure 1), a dot plot was constructed for the global Moran's *I* statistic (the slope of the regression line plotted on the chart is equivalent of the value of the global Moran's *I* statistic). As most points are located in the third quadrant of the graph of the global Moran's *I* statistic, it may be assumed that the most of the considered districts are grouped into the clusters by low level of synthetic indicators.

Figure 1. Dot plot of the global Moran's *I* statistic



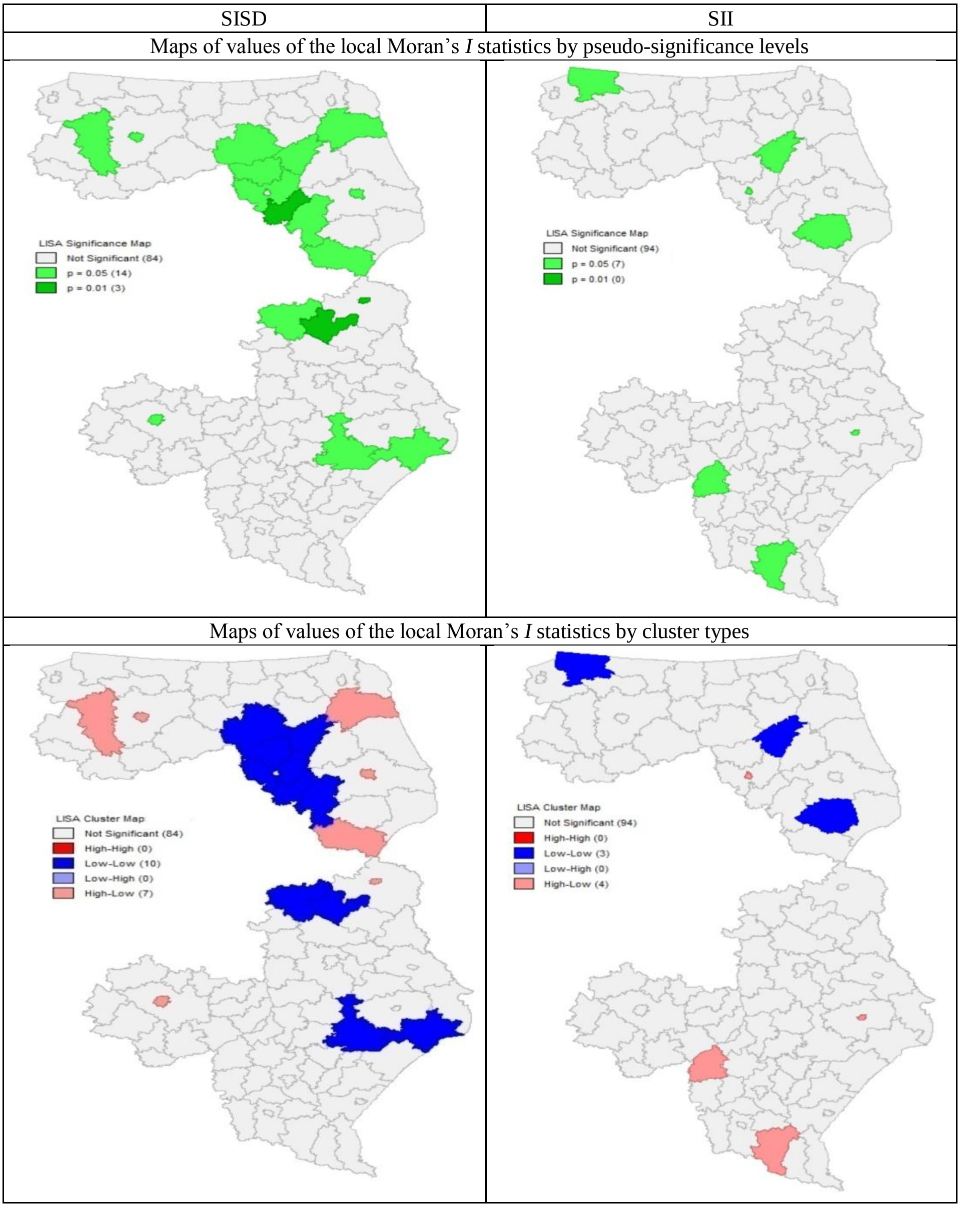
The use of the global spatial autocorrelation coefficient (Moran's *I*) enables detecting the strength and nature of the spatial relationship. However, it is insensitive to the local deviations from the averaged pattern of the spatial autocorrelation and does not include the information on the pattern's instability degree. Hence, neither the areas with a locally stronger spatial relationship nor the outliers may be identified. The local statistic is a way to circumvent this inconvenience as it allows to determine whether an area is surrounded by the neighbouring units with high or low values of the variable under consideration [Kołodziejczak and Kossowski, 2016, p. 26]. For non-standardised variable values and for a weight matrix standardised by rows, the local Moran's I_i statistic is as follows [Suchecki (Ed.), 2010, p. 123]:

$$I_{i(w)} = \frac{(x_i - \bar{x}) \sum_{j=1}^{n} w_{ij}^{*} (x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2},$$

The results of the analysis of Moran's local I_i statistics may be represented with a cluster map showing the clustered areas with similar levels of the feature under consideration and outliers (areas characterised by different values of synthetic indicators).

Ten low-low areas (reporting low values of the variable under analysis) were identified for SISD. These were two adjacent two-element clusters comprising districts located in the southern (the districts of Tomaszów and Biłgoraj) and north-western part (the districts of Radzyń and Łuków) of the Lubelskie Voivodship, as well as a vast compact cluster composed of six districts in the Podlaskie Voivodship (the districts of Wysokie Mazowieckie, Zambrów, Łomża, Kolno and Grajewo) and one district in the Warmińsko-Mazurskie Voivodship (Pisz district). The structure of the analysed districts also included four high-low areas (a high value of the indicator surrounded by low values in the neighbourhood): Kielce, Biała Podlaska, Siematycze district, Białystok, Augustów district, Olsztyn and Ostróda district. In turn, three low-low areas (Braniewo district in the Warmińsko-Mazurskie Voivodship, Grajewo and Bielsk Podlaski districts in the Podlaskie Voivodship) and four high-low areas (Łomża, Zamość and the districts of Sanok and Mielec) were identified based on the local Moran's I_i maps.

Figure 2. Maps of values of local Moran's I_i statistics



As shown by the analyses (Table 2), the local Moran's I_i statistic is positive (and statistically significant) in 10 districts, meaning that these districts are adjacent to the areas with similar SISD values. In seven districts, the local statistics are negative (and statistically significant), suggesting that these districts are surrounded by relatively low SISD levels. As regards other districts, the values of the local Moran's I_i statistics calculated for the variable under consideration were positive in 52 cases and negative in 32 cases. However, as the negative values were not statistically significant, no particular attention should be paid to these results. In turn, as regards the calculated SII values, the local Moran's I_i statistics were positive and statistically significant in four districts (statistically significant negative values were recorded in three districts). In other districts, most (73) of the local statistics were positive but statistically insignificant.

Conclusions

The quantitative and qualitative condition of the institutional infrastructure is an important driver of the economic restructuring at all territorial (national, regional and local) levels. As a part of the socioeconomic system, the institutional infrastructure plays a major role in implementing the sustainable development concept through a series of measures, such as increasing the environmental awareness, greening the economy or increasing the efficiency of the economic activities while respecting the natural environment.

The results of the spatial autocorrelation analysis allow to identify the clusters of the similar spatial units and to indicate those which differ from their neighbours by the level of the phenomena studied. It results from the analysis that in eastern Poland districts no spatial relationships exist between sustainable development levels and institutional infrastructure development levels within the entire area studied. Conversely, the analysis of local spatial autocorrelation statistics reveals the presence of the vast compact clusters of districts at similar levels of the sustainable development. In addition to the areas which are alike in the terms of the phenomena covered by this study, the analysis also enabled the identification of the areas exhibiting considerable differences in their levels of the sustainable development (and in the development levels of their institutional infrastructure). When it comes to SISD, 10 low-low areas (reporting low values of the variable under analysis) and four high-low areas (a high value of the indicator surrounded by low ones) were identified. In turn, three low-low areas and four high-low areas were identified based on the local Moran's *I* maps created to examine the SII.

The results of such analyses may provide indirect support for the local authorities in planning their local development and land use policies. The identification of the spatial structures for such an important economic category as the sustainable development may support the initiation of the development efforts (including measures taken by local authorities to establish local strategies for the sustainable development) towards achieving the highest possible standards of living for the population while respecting the environment in specific geographic areas.

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INFRASTRUKTURA INSTYTUCJONALNA A ZRÓWNOWAŻONY ROZWÓJ – ANALIZA NA PODSTAWIE POWIATÓW POLSKI WSCHODNIEJ

Streszczenie: Celem artykułu jest określenie siły i charakteru zależności (przestrzennych) między poziomem rozwoju zrównoważonego a nasyceniem powiatów w infrastrukturę instytucjonalną dla danych z 2016 r. Badaniem objęto 101 powiatów w województwach lubelskim, podkarpackim, podlaskim, świętokrzyskim i warmińsko-mazurskim. Do oceny poziomu rozwoju infrastruktury instytucjonalnej i rozwoju zrównoważonego wykorzystano metodę TOPSIS. Dla skonstruowanych syntetycznych mierników dokonano analizy korelacji rang Spearmana. Ponadto przeprowadzono analizę autokorelacji przestrzennej na podstawie statystyki Morana *I*. Obliczona wartość współczynnika korelacji wynosiła 0,41, co świadczy o umiarkowanej sile związku między analizowanymi zjawiskami. Podczas analizy wartości lokalnych statystyk autokorelacji przestrzennej uwidaczniają się rozległe przestrzennie skupiska powiatów o podobnym poziomie rozwoju zrównoważonego.

Słowa kluczowe: infrastruktura instytucjonalna, rozwój zrównoważony, zależności przestrzenne.