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SPATIAL CONCENTRATION OF WESTERN POLAND DISTRICTS IN THE FUNCTION OF SUSTAINABLE DEVELOPMENT LEVEL AND INSTITUTIONAL INFRASTRUCTURE

KONCENTRACJA PRZESTRZENNA POWIATÓW POLSKI ZACHODNIEJ ZE WZGLĘDU NA POZIOM ROZWOJU ZRÓWNOWAŻONEGO A INFRASTRUKTURA INSTYTUCJONALNA

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Summary: This paper attempts to identify the spatial relationships between synthetic measures of sustainable development and synthetic measures of institutional infrastructure development levels in Western Poland districts. The territorial scope of this study covered 112 districts in five voivodeships: Dolnośląskie, Lubuskie, Opolskie, Wielkopolskie and Zachodniopomorskie. The timeframes for this study are limited to one year (2015). Because of the multidimensionality of categories covered by the analysis, this study used TOPSIS-based taxonomic measures. In order to determine the strength of spatial relationships between the districts in terms of the subject matter of this study, the analysis of spatial autocorrelation (based on the developed proprietary measures of sustainable development and of the institutional infrastructure development levels) was performed with the use of the global and local Moran's *I* statistics.

Keywords: sustainable development, institutional infrastructure, spatial relationships.

Streszczenie: Celem artykułu jest podjęcie próby identyfikacji zależności przestrzennych zachodzących między syntetycznymi miernikami poziomu rozwoju zrównoważonego oraz poziomu rozwoju infrastruktury instytucjonalnej na poziomie powiatów Polski Zachodniej. Zakres terytorialny badań obejmował 112 powiatów wchodzących w skład pięciu województw: dolnośląskiego, lubuskiego, opolskiego, wielkopolskiego i zachodniopomorskiego. Zakres czasowy badań ograniczono do 2015 roku. Ze względu na wielowymiarowość analizowanych kategorii w badaniach wykorzystano mierniki taksonomiczne skonstruowane w oparciu o metodę TOPSIS. W celu określenia siły powiązań przestrzennych pomiędzy powiatami w zakresie rozpatrywanych zjawisk, z wykorzystaniem skonstruowanych autorskich mierników poziomu rozwoju zrównoważonego i poziomu rozwoju infrastruktury instytucjonalnej, przeprowadzono analizę autokorelacji przestrzennej w oparciu o globalne i lokalne statystyki Morana I.

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

1. Introduction

Sustainable development is a modern economic development trend aimed at transforming the economy by increasing the efficiency of production processes, reducing environmental pollution and improving social equality. In that context, an important role is played by the territorial concentration of institutional infrastructure elements providing environmental education, support for innovation development and absorption etc. (this primarily means innovativeness centers, including technology transfer centers and technology incubators).

The importance of the institutional environment in the context of economic processes stimulation is increasingly analyzed. However, the authors usually focus on institutional disparities between countries and on relationships between the institutional structure and economic performance of specific countries (including the research by D. Acemoglu, R. Kormendi, P. Meguire, or R. Levine and D. Renelt). In turn, relationships between the institutional environment and the level of sustainable development of local government units (e.g. districts) are often of secondary interest. Research regarding the impact of institutional infrastructure on the level of sustainable development of poviats is rarely conducted in Poland, especially when it comes to spatial concentration of local government units (poviats) due to the level of sustainable development, as well as analyzes of spatial dependencies between the considered phenomena.

This paper attempts to identify the spatial relationships between synthetic measures of sustainable development and synthetic measures of institutional infrastructure development levels in Western Poland districts. The territorial scope of this study covered 112 districts included in two territorial units for statistics (NUTS 1), i.e. the south-western macro-region (Dolnośląskie and Opolskie voivodeships) and the north-western macro-region (Lubuskie, Wielkopolskie and Zachodniopomorskie voivodeships). The analysis of statistical data at the level of districts allowed to extend the set of diagnostic features compared to the analysis of municipality data. The timeframes for this study are limited to one year (2015). Because of the multidimensionality of categories covered by the analysis, this study used TOPSIS-based taxonomic measures. In order to determine the strength of spatial relationships between the districts in terms of the subject matter of this study, the analysis of spatial autocorrelation (based on the developed proprietary measures of sustainable development and of the institutional infrastructure development levels) was performed. Diagnostic variables were selected based on relevance, statistical and formal criteria (primarily including the completeness and availability of data for the objects under consideration in 2015).

2. Institutional infrastructure vs. sustainable development

Sustainable development is a term introduced at the 1972 UN Stockholm Conference[1] where international cooperation on environmental protection was initiated. The definition most frequently referred to by the authors is the one formulated for the purposes of the "Our Common Future" 1987 UN report. Accordingly, sustainable development is 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]. As defined in the Environmental Protection Law Act of April 27, 2001, sustainable development means "social and economic development which integrates political, economic and social activities while maintaining natural balance and permanence of basic natural processes in order to guarantee the ability to satisfy basic needs of particular communities or citizens of both the existing and future generations".

The measurement of sustainable development, having in mind its multifaceted nature, becomes a major problem. As the traditional measures of national economic development (e.g. GDP, NNP) are subject to criticism (some claim that these measures do not take the non-market activities into account, do not include the value of free time and neglect negative external costs), various aggregate indicators were developed for the sustainable development concept. This paper gives a synthetic account of some of them.

An interesting concept used in the context of measuring the levels of sustainable development is the "ecological footprint" which measures the population's demand for the broadly defined natural capital. According to Lazarus et al., the "ecological footprint" specifies the amount of biologically productive land and marine areas required to produce the resources a population consumes and absorbs the corresponding waste, using prevailing technology combined with specific human resource management practices [Lazarus et al. 2014]. One of the weaknesses of this measure is that its estimation should also include data on imported goods. Widely available data statistically do not allow the precise association of imported goods with the place of their production.

The "green" Net Domestic Product is used relatively rarely as a measure of well-being. It is based on the "green" GDP calculated as the sum of consumption, savings and environmental services consumed directly. The "green" NDP is obtained by converting the gross value into net value. Instead of all savings, this indicator includes only those that increase the capital value. Also, environmental damages (costs incurred to compensate for environmental benefits lost) are deducted from the value of environmental services. The "green" NDP does not include revenue from selling capital (including natural resources) [Kronenberg, Bergier (eds.) 2010].

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[1] Works on the "sustainable development" concept begun at the 1968 UNESCO Intergovernmental Conference of Experts in Paris on the mutual interactions between humans and natural environment.

Another measure used to quantify the sustainable development level is the Environmental Performance Index (EPI) which takes two strategic objectives into account: human health protection and ecosystem preservation. In 2016, EPI was based on more than 20 indicators aggregated in 9 thematic areas: impact on human health, air quality, drinking water and sanitation, aquatic resources, agriculture, forests, fisheries, biodiversity of species and habitats, climate and energy [Hsu (ed.) 2016]. This indicator helps to identify key priorities and offers a framework within which one can measure the progress in achieving its objectives. The biggest disadvantage of this indicator is the difficulty in tracking of trends in the comparative analysis at the global level due to the heterogeneous method of collecting statistical data, as well as marginalizing the impact of trade flows on the environment [Inhobe 2013].

Often used to measure the levels of sustainable development (especially in the social sphere), the Human Development Index (HDI) takes into account per capita GDP, life expectancy at birth and education levels [UNDP 2015a]. It allows to determine the distance that divides the level of civilization development of poor countries and developing countries. An unquestionable advantage of this index is the ease of calculation and the possibility of applying international comparisons (however, due to the change in the methodology of calculating (for instance in 1997), the comparability of these measures over a longer period of time is very limited). An undoubted weakness of this measure is the omission of social inequalities and the objective level of life quality.

The Multidimensional Poverty Index (MPI), a derivative of HDI used for the first time in 2010, is a relatively new measure which replaced the Human Poverty Index (HPI) in use since 1997. It covers 10 elements aggregated in 3 dimensions [UNDP 2015b]: I. Education (1. No household member has completed 6 years of schooling; 2. A school-aged child is not attending school); II. Health (1. At least one member of household suffers from undernourishment; 2. Child mortality); III. Standard of living (1.Tthe household has no electricity; 2.The household does not have access to safe drinking water; 3 The household does not have access to sanitary facilities; 4. Use of “dirty” cooking fuel (e.g. charcoal); 5. Clutter in the household; 6. The household does not own more than one asset related to: information access (radio, TV, phone), mobility or subsistence (refrigerator, arable land, livestock). The simplicity of the model (a small number of partial variables) makes it relatively easy to interpret. On the other hand, one of the weaknesses of this measure is the omission of inequality in households.

The above measures meet the sustainable development assumptions to a various degree. While the construction of the ecological footprint refers to environmental protection aspects, it excludes social and economic issues. In turn, such indexes as HDI or MPI take account of social and (to a lesser extent) economic matters while marginalizing the environmental aspects. According to the approach adopted by the author, sustainable development goals are addressed to a much greater extent in the structure of EAW, ISEW and GPI.

One of the first economic prosperity measures to take greater account of environmental aspects is the Index of the Economic Aspects of Welfare (EAW) used by X. Zolotas in 1981. More importantly it takes into account the depletion of natural resources, but omits the issue of capital accumulation and sustainability of management. Based on the current flow of goods and services, it includes expenditure on public buildings; the value of household work, expenditure on consumer durables; advertising; the value of free time; the value of public sector services adjusted with healthcare and education expenditure; costs related to environmental pollution and depletion of natural resources [Redclif (ed.) 2005; Bleys 2005].

The Index of Sustainable Economic Welfare (ISEW) was developed in 1989 by H. Daly and J. Cobb. As the name states, this index takes into account the principle of development durability and the problem of exploiting non-renewable resources is addressed in a broader sense than previously. In addition, the negative impact of natural resources exploitation on welfare has been taken into account. On the other hand, its internal structure is not homogeneous (which poses difficulties in collecting data in individual countries). The first step towards calculating its value is to adjust the population's personal expenditure with the income differentials index. Then, that value is modified by adding or subtracting pecuniary values from a predefined set of social, economic and environmental factors, depending on whether a factor has a positive or negative effect on welfare. Expenditures such as those involved in education and healthcare, as well as the value of services resulting from household work increase the base value; in turn, the subtracted factors include the natural environment exploitation costs, commuting expenses, losses resulting from unemployment, and costs related to crime [Lawn 2003; Gasparatos et al. 2008].

Many other, alternative measures of sustainable development were created in an attempt to eliminate the downsides of conventional measures of socio-economic development by taking into consideration such factors as life quality and environmental protection. There are multiple measures (other than listed above) which, to a various degree, integrate the social, economic and environmental aspects. Among them, worth mentioning are the Gender Inequality Index (GII), the Inequality-adjusted Human Development Index[2] (IHDI) or the Sustainable Net Benefit Index (SNBI).[3] Śleszyński, based on a literature review, presented a list of advantages and disadvantages of synthetic measures of sustainable development. The advantages include: the synthetic index presented in a sufficiently long period creates a time series that allows tracking the basic trends characterizing a given national economy; only a synthetic assessment with a sufficiently motivated methodology creates a chance of quantitative and evaluative expression when issues as diverse as economic, social and environmental are at stake; in the case of measures that aggregate many different sub-indices, it is possible to achieve a standardized measurement of features and

[2] For a broader description, see: [UNDP 2015a].

[3] For a broader description, see: [Lawn 2003].

phenomena that are expressed in different units or even are only recognized qualitatively; synthetic indicators are great for international comparisons. On the other hand, the disadvantages of synthetic measures can be: frequent transformations of national statistics may result in low credibility of the trends discovered on their basis; without professional commentary and additional interpretive effort, one can expose themselves to the objection of covering up weaknesses in one of the spheres (economic, social and environmental) through non-transparent summing up of achievements in all spheres; assessing the weight of individual components, and above all drawing decision-making conclusions about the current state and direction of desired changes are not a simple task; difficulties resulting from the availability of homogeneous and comparable statistical data [Śleszyński 2011].

In addition to the attempts to quantify the sustainable development levels, another important issue is to identify the sustainable development drivers. In modern economic theory, prominence is given to the institutional environment of economic processes as a factor which affects efficient management processes consistent with the sustainable development principles.

One of the first scientists who referred to the "institutional infrastructure" in an economic context was R. Jochimsen who defined it as norms and ways of behavior, in their constitutional dimension, which provide a framework for autonomous actions of specific economic operators [Ratajczak 1999]. An equally broad approach to the institutional environment (the institutional structure, to be more specific) was presented by I. Pietrzyk who defined it as "the playing field for the society or the anthropogenic conditions that shape the interactions between humans". According to Pietrzyk, it includes a broad spectrum of institutions (such as banks, development agencies, economic organizations) as well as their operational frameworks [Pietrzyk 2000]. The institutional infrastructure is often defined only as a heterogeneous set of organizations, composed of [Przygodzki 2007]: 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 organizations, banks and other financial institutions), and private associations (including business representative organizations). According to M. Reichel, 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 centers, technology transfer centers, consultancy centers and financial institutions [Reichel 2006]. A similar view on the institutional infrastructure is presented by C. Longhi who considers it to be the business environment institutions, including the local government, regional banks and service centers [Longhi 1999]. According to the terms used by the Polish Business and Innovation Centers Association, institutional infrastructure means innovation and entrepreneurship centers which deliver a series of service functions allowing the economic operators to boost their development processes and implement their strategies [Bąkowski, Mażewska (eds.) 2015]. M. Ratajczak [1999] identifies two subsystems within the institutional infrastructure: the tangible (physical capital and intellectual capital) and intangible (formal and informal principles) institutional infrastructure.

Such diverse interpretations of the institutional infrastructure could be explained by different ways of interpreting the “institution” either as principles governing the relationships between operators, or as an organization. While the first approach is typical of sociological analysis, the second one is characteristic for deliberations based on the organization and management theory [Ratajczak 1999]. Having the above in mind, later in this paper, the author focuses 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. 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, Śniegocki 2012]. A well-developed network of business environment institutions, 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].

Business environment institutions also play a major role in identifying the entrepreneurs’ needs for environmentally-friendly and other innovations, assess the commercial potential of new (technological, organizational, product) solutions, provide 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, they participate 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 centers), which includes organizing conferences and direct meetings. Furthermore, they develop procedures which enable assessing and applying for legal protection of innovations (e.g. R&D centers, universities). Business environment institutions also provide 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 centers), for instance by checking the operator’s adaptability.

3. Data type and empirical research methodology

When analyzing the spatial differentiation of districts by sustainable development level, it is necessary to compare many research fields described with a broad set of variables. The same applies to the concentration of institutional infrastructure in specific areas. Therefore, to quantify the sustainable development levels of western Poland districts (and the development levels of institutional infrastructure), TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), a multidimensional statistical analysis method based on synthetic development measures, was used. According to this method, the synthetic measure is created based on Euclidean distance both from the pattern and from 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]:

1. Creating a normalized decision matrix.

2. In the case of weighted variables, the weight matrix and, afterwards, the weighted normalized decision matrix needs to be created.

3. For the normalized features, the coordinates of the "ideal" (A^+) and anti-ideal (A^-) solution are determined:

$$A^+ = \left(\max_i(v_{i1}), \max_i(v_{i2}), \dots, \max_i(v_{iN})\right) = (V_1^+, V_2^+, \dots, V_N^+),$$
$$A^- = \left(\min_i(v_{i1}), \min_i(v_{i2}), \dots, \min_i(v_{iN})\right) = (V_1^-, V_2^-, \dots, V_N^-).$$

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

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

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

Based on substantive and formal criteria, to build the synthetic measure of institutional infrastructure development levels (SMI) in the districts, the following set of diagnostic variables was used: I1 – universities per sq. km; I2 – local university branches per sq. km; I3 – technology transfer centers per sq. km; I4 – innovation centers per sq. km; I5 – seed capital funds per sq. km; I6 – loan funds per sq. km; I7 – business incubators per sq. km; I8 – technology incubators per sq. km; I9 – technology parks per sq. km; I10 – training and consultancy centers per sq. km.

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 3 dimensions [cf. Borys 2011; 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 10,000 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 100,000 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, organizations and associations per 1,000 population; G10 – output sold per inhabitant;[4] G11 – CAPEX in enterprises per inhabitant.

The sufficiently high differentiation of sub-variables and the adequate degree of their correlation with other variables were important selection criteria. OS1 was the only variable to be eliminated from both sets due to low values of its coefficient of variation (below the critical threshold value of 10%, fixed arbitrarily). To assess the information value, the inverse correlation matrix[5] was used. For each thematic sub-group of variables related to sustainable development levels, the inverse correlation matrix was calculated. Next, the variable with the highest diagonal entry, above the threshold set arbitrarily (r* = 15), was eliminated. Based on the above procedure, only G1 was eliminated from the set of diagnostic variables. Among the institutional infrastructure variables covered by this analysis, only the concentration of training and consultancy centers in the districts was above[6] the critical threshold value (r* = 15). However, because these are the most popular institutions which provide

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[4] The data relates to enterprises and operators with more than 9 employees.

[5] For a broader description, see: [Młodak 2006].

[6] This variable equaled 24,26 and demonstrated the highest diagonal value of the inverse correlation matrix.

support for entrepreneurship and innovativeness while playing a special role in stimulating the living standards of the local population and the efficient operation of economic operators, the corresponding variable was taken into consideration further in this analysis.

The nature (stimulating effect/inhibiting effect/neutral effect) of each selected variable was specified in both sets. In the set of variables related to the concentration of institutional infrastructure in the districts, all variables have a stimulating effect (high values are desired). In turn, in the second set, the following variables should be considered as having an inhibiting effect (from the perspective of the aspect under consideration, low values are desired): OS4, OS5, OS8, S3, S9, S10, S16. Other variables have a stimulating effect.

Analysis of spatial autocorrelation will be carried out in order to determine the similarities (and differences) between districts in terms of sustainable development level and development level of institutional infrastructure, based on created earlier synthetic measures of sustainable development level and development level of institutional infrastructure (based on Moran's *I* statistics).

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 spatial correlation: positive autocorrelation and negative autocorrelation. Positive autocorrelation means spatial concentration of high or low values of a variable. In turn, 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, neighborhood structures are specified with the use of spatial weights, a parameter created based on the distance or neighborhood 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 neighborhood modeling 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 standardized by rows so that the sum of all entries is equal to 1 [cf. Anselin 2003; LeSage, Pace 2009].

To analyze the intensity of spatial interactions between the values of synthetic measures of sustainable development and of institutional infrastructure levels in specific districts, on one side, and the corresponding values recorded in neighboring districts, on the other, the global Moran's *I* statistic was calculated. It enables determining the strength and nature of correlations throughout the area under analysis, and is calculated as follows [Suchecki (ed.) 2010]:

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

with: x_i, x_j – values observed in locations *i* and *j* (i, j = 1, 2, … , *n*), $\bar{x}$: – average value in all areas under consideration, w_{ij} – entries of the spatial weight matrix.

In the analysis of spatial data, a major role is played by local autocorrelation statistics (e.g. the Morans' *I*). For non-standardized variable values and for a weight matrix standardized by rows, the local Moran's I_i statistic is as follows [Suchecki (ed.) 2010]:

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

with: w_{ij} – entries of the spatial weight matrix of rank 1standardized by rows, $x_{i,}$ x_j – values observed in locations *i* and *j* (*i*, *j* = 1, 2, … , *n*); $\bar{x}$: – average value in all areas under consideration.

4. Correlation and spatial autocorrelation between synthetic measures of sustainable development and of institutional infrastructure development levels

As shown by the calculations, the districts are characterized by a quite moderate spatial differentiation of sustainable development levels. As at 2015, the maximum--to-minimum ratio for SMSD was 2,39 while the coefficient of variation was above 21.32%.[7] Nine out of ten districts with the highest SMSD levels were urban districts. The highest SMSD values were recorded in Poznań (0,482), Wrocław (0,466) and Opole (0,450).The top-ranked (8th) land district was the Krapkowice district. The reasons for this include the high values of sub-indicators related mainly to the area of walking and leisure parks, number of books, library members or the density of hard-surfaced municipal roads. As regards three quarters of Western Poland districts, SMSD was not above 0,276 with a maximum and minimum at 0,482 and 0,202, respectively.

The analysis shows a relatively low variation of SMI values, even though two thirds of institutional infrastructure elements covered are concentrated in urban districts. Note, however, that the sub-variables used as the basis for calculating the synthetic measure were indicators rather than absolute values. This allowed to partially avoid the disturbance related to specific features of some objects (e.g. an area largely beyond that of other districts). Despite such a selection of variables, 14 out of 15 highest SMI values were identified in urban districts. This is largely caused by the fact that usually a strong relationship exists between the extension of the institutional infrastructure, on one side, and demographic factors and settlement patterns, on the other. As a consequence, the institutional infrastructure tends to be concentrated

[7] It is assumed that if the coefficient of variation is below 10%, the sample does not demonstrate significant differentiation [Zeliaś 2000].

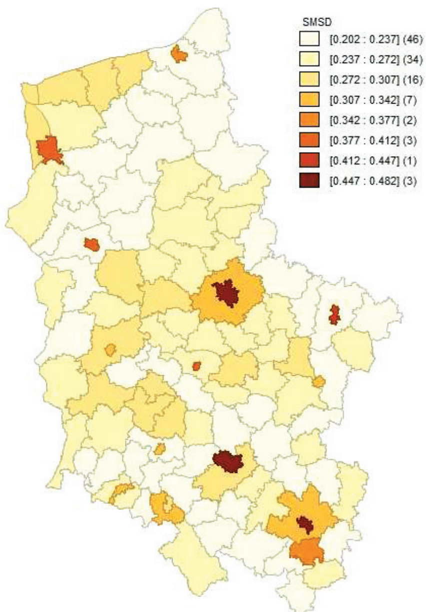
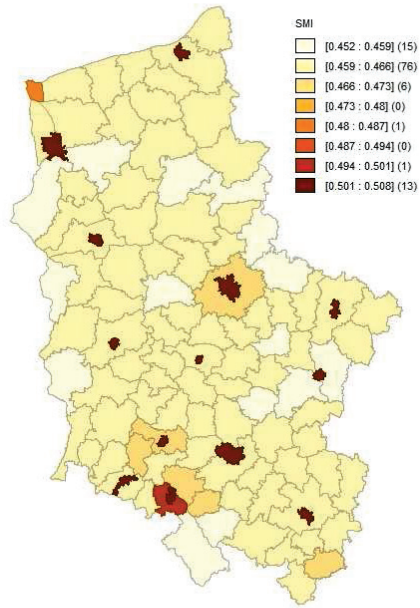
Synthetic measure of sustainable development levels	Synthetic measure of institutional infrastructure development
	

Fig. 1. Values of the synthetic measure of sustainable development and of institutional infrastructure development levels in Western Poland districts (as at 2015)

Source: own study based on [Bank Danych... 2017; Bąkowski, Mażewska (eds.) 2015].

in large urban centers. This is related to the functional and spatial arrangement of most of the regions (in the western part and elsewhere in Poland) which historically evolved around a single focal point. That pattern is especially noticeable in the case of universities, innovation centers or organizationally complex technological parks extending over a large area. As at 2015, the coefficient of variation for SMI was less than 3%. In three quarters of districts, SMI did not go beyond 0,462, reaching a maximum of 0,508.

To verify the relationship between the concentration of institutional infrastructure in Western Poland and the levels of sustainable development, an analysis based on the Pearson linear correlation coefficient was performed. The calculated coefficient of correlation between the defined synthetic measures was 0,786, which suggests a very strong relationship between the aspects covered by the analysis, and allows to conclude that the correlation coefficient was significant at $p < 0{,}001$.

Obviously, the developments in specific territorial units are determined by a series of (spatial) factors which are at the origin of various links and impacts.

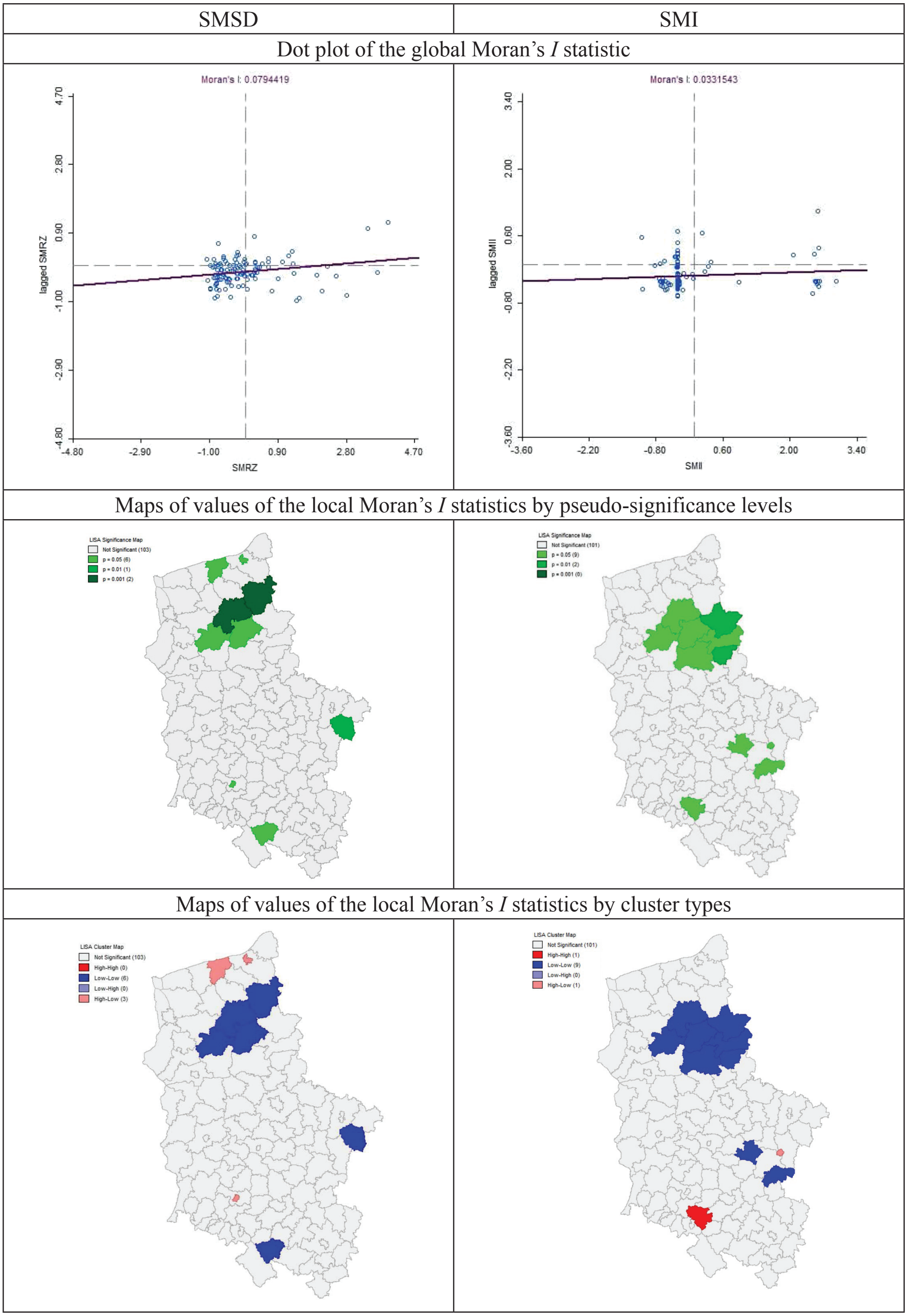


Fig. 2. Dot plot of the global Moran's *I* statistic for the synthetic measure of sustainable development levels (SMSD) and institutional infrastructure (SMI); maps of local statistic values (as at 2015)

Source: own study.

Therefore, the analysis of socio-economic events based on cross-sectional data should cover the impact of the spatial structure of objects (e.g. districts) on the phenomenon considered. This is because the spatial structure is usually impacted by specific factors, mostly historic, cultural or sociological in nature [Zeliaś 1991]. As a consequence, spatial relationships (referred to as spatial autocorrelation) may exist between neighboring units.

Global Moran's *I* statistic was used to calculate the strength and character of autocorrelation in the entire analyzed area. The global Moran's *I* statistic calculated for SMSD was positive (0,079) but, most importantly, was not statistically[8] significant (statistical insignificance means the value of the variable under consideration is distributed randomly across specific spatial locations). To deepen the analysis, the Moran's dispersion diagram was drawn up (the slope of the regression line plotted on the graph is equivalent to the value of the global Moran's *I* statistic). As most of the points are located in the third quadrant of the graph of the global Moran's *I* statistic, it may be assumed that most of the objects (districts) considered are clustered due to low SMSD levels.

In turn, the global Moran's *I* statistic calculated for SMI was 0,032 and was statistically insignificant.

Then, the local statistics of Moran *I* was set, included in the so-called LISA (Local Indicator of Spatial Association). An important feature of the local statistic is the proportionality of the amount calculated for all locations to the global statistic value. Local statistics values allow to identify clusters of areas with similar levels of the feature under consideration and areas characterized by different SMSD and SMI values. Based on local statistics, 6 low-low areas (reporting low values of the variable under analysis) were identified for SMSD. These include 4 adjacent districts of Zachodniopomorskie voivodeship, i.e. Choszczno, Drawsko, Szczecinek and Wałcz districts, Turek district (Wielkopolskie voivodeship) and Ząbkowice district (Dolnośląskie voivodeship). Also, 3 spatially dispersed high-low areas (where units demonstrating high and low values are adjacent to each other) were identified in the analyzed structure: Kołobrzeg district, city of Koszalin and city of Legnica. As regards SMI, a very large and compact cluster of low-low districts was identified. It includes 3 districts in the Zachodniopomorskie voivodeship, i.e. Choszczno, Drawsko and Wałcz districts, and 4 districts in the Wielkopolskie voivodeship: Złotów, Piła, Chodzież, and Czarnków-Trzcianka districts. From the perspective of this discussion, it should be noted that the cluster in the Zachodniopomorskie voivodeship is a group of territorial units with similar levels of sustainable development. Also, the analysis identified 2 similar objects in the Wielkopolskie voivodeship: Ostrzeszów and Krotoszyn districts, as well as 1 high-high district (Świdnica) and 1 high-low district (city of Kalisz).

[8] The global statistic significance test was based on the analysis of histograms of the randomized permutation test. The hypothesis was verified based on the pseudo-significance level. The number of permutations was 9999.

Table 1. Values of local Moran's I_i statistics calculated for the synthetic measure of sustainable development levels (column I) and for the synthetic measure of institutional infrastructure development (column II) (as at 2015)

District	I	II	District	I	II	District	I	II
Białogardzki	0,40	0,20	Krapkowicki	–0,52	0,08	Słupecki	0,16	0,16
Bolesławiecki	0,08	0,07	Krośnieński	0,08	0,16	Stargardzki	0,07	–0,01
Brzeski	0,03	0,11	Krotoszyński	0,00	0,18*	Strzel.-drezd.	0,27	0,22
Chodzieski	–0,05	0,23**	Legnica	–1,39	0,92	Strzelecki	–0,46	0,04
Choszczeński	0,374*	0,18*	Legnicki	0,00	0,02	Strzeliński	0,26	0,10
Czarn.-trzcian.	0,06	0,29*	Leszczyński	–0,05	–0,03	Sulęciński	0,16	0,14
Drawski	0,51***	0,16*	Leszno	–0,72	–0,90	Szamotulski	–0,01	0,12
Dzierżoniowski	0,10	–0,01	Lubański	0,29	0,12	Szczecin	–0,08	–1,17
Głogowski	–0,05	0,11	Lubiński	–0,05	0,07	Szczecinecki	0,67***	0,22
Głubczycki	0,65	0,06	Lwówecki	0,28	0,09	Średzki (ds)	–0,15	–0,09
Gnieźnieński	0,00	0,21	Łobeski	0,20	0,16	Średzki (wp)	0,01	0,15
Goleniowski	–0,06	–0,06	Międzychodzki	0,03	0,17	Śremski	–0,08	0,04
Gorzowski	–0,04	–0,02	Międzyrzecki	–0,11	0,15	Świdnicki	–0,03	0,10*
Gorzów Wlkp.	–1,49	–0,93	Milicki	0,19	0,31	Świdwiński	0,45	0,15
Gostyński	–0,04	0,10	Myśliborski	0,39	0,15	Świebodziński	0,02	0,14
Górowski	0,10	0,12	Namysłowski	0,06	0,12	Świnoujście	0,07	–0,34
Grodziski	–0,07	0,10	Nowosolski	–0,03	0,12	Trzebnicki	–0,12	0,01
Gryficki	0,03	–0,06	Nowotomyski	0,02	0,19	Turecki	0,37**	0,15
Gryfiński	–0,02	0,24	Nyski	0,31	0,13	Wałbrzych	0,13	2,89
Jarociński	0,01	0,24	Obornicki	0,00	0,12	Wałbrzyski	–0,34	0,44
Jaworski	0,17	–0,08	Oleski	0,05	0,10	Wałecki	0,22*	0,33*
Jelenia góra	0,05	–0,88	Oleśnicki	0,16	0,15	Wągrowiecki	–0,07	0,30
Jeleniogórski	–0,01	–0,10	Oławski	0,01	0,12	Wolsztyński	0,06	0,14
Kaliski	0,02	–0,04	Opole	3,49	–0,89	Wołowski	0,05	0,07
Kalisz	–0,29	–1,48*	Opolski	0,11	0,00	Wrocław	–0,71	–0,90
Kamiennogórski	–0,15	–0,08	Ostrowski	0,02	0,02	Wrocławski	–0,03	–0,06
Kamieński	0,02	0,01	Ostrzeszowski	0,22	0,13*	Wrzesiński	0,00	0,13
Kędz.-koziel.	0,05	0,01	Pilski	0,09	0,55*	Wschowski	0,17	0,12
Kępiński	0,12	0,11	Pleszewski	–0,06	0,02	Ząbkowicki	0,54*	0,25
Kluczborski	0,01	0,12	Policki	0,20	–0,24	Zgorzelecki	0,02	0,14
Kłodzki	0,05	–0,61	Polkowicki	–0,02	0,07	Zielona góra	0,52	–0,92
Kolski	0,61	0,12	Poznań	4,73	0,55	Zielonogórski	–0,02	0,02
Kołobrzeski	–0,51*	0,16	Poznański	0,32	–0,03	Złotoryjski	0,25	0,01
Konin	–2,35	–1,04	Prudnicki	–0,19	0,10	Złotowski	0,44	0,23**
Koniński	–0,03	–0,06	Pyrzycki	0,26	0,16	Żagański	–0,02	0,13
Koszalin	–1,36*	–1,03	Rawicki	–0,02	0,14	Żarski	0,00	0,21
Koszaliński	0,04	–0,07	Sławieński	0,77	0,13			
Kościański	0,00	0,07	Słubicki	–0,04	0,23			

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

Source: own study.

When analyzing the local Moran's I_i statistics for SMSD, it may be concluded that positive statistically significant values are identified only in 6 districts (which means these districts are adjacent to areas with similar values of the sustainable development measure). Also, negative statistically significant values of local statistics were identified in 3 districts. As regards other districts covered by this analysis, the local Moran's I_i statistics for the variable considered were positive in 64 cases and negative in 39 cases which, however, were not statistically significant. In turn, as regards the calculated SMIs, the local Moran's I_i statistics were statistically significant for 11 districts (including 10 positive values). In other districts, most (73) of the local statistics were positive but statistically insignificant.

5. Final considerations

The intensified and global competition of our times does not only refer to entities conducting business activity, but also concerns competition between individual countries or local government units. The implementation of the principles of sustainable development is conducive to increasing the competitiveness of individual areas. The reason for linking competitiveness with sustainable development is directly connected with the EU's growth strategy for the current decade. According to the EUROPE 2020 document, one of the main priorities of the European Union (thus individual Member States, including Poland) is sustainable development, which means "building a sustainable and competitive resource-efficient economy, using Europe's leading position in the race towards new processes and technologies, including eco-friendly technologies, accelerating the deployment of smart ICT-based networks, leveraging the power of EU-wide networks, and strengthening the competitive advantage of European business, especially manufacturing and SMEs, and helping clients appreciate the value of resource efficiency" [Komisja Europejska 2010]. This makes an analysis play an extremely important role to identify factors that stimulate the sustainable development of individual areas. It is worth emphasizing that the literature on the subject rarely addresses the problem of the impact of individual elements of institutional infrastructure on the sustainable development of local government units, and above all, spatial interactions occurring between the analyzed phenomena are marginalized. This is important because in the Polish reality there is a peculiar transformation of the institutional environment (for instance in connection with the political changes initiated in the 1990s or the inflow of EU funds), and at the same time it is difficult to find confirmation of the real role of this socio-economic system element in stimulating sustainable development at the local and regional level. Despite the existing opinions that infrastructural equipment determines sustainable development, these views have been poorly verified in an empirical way.

The efficiency and effectiveness of the institutional infrastructure, as well as the cooperation between its specific elements and economic operators, may be considered as one of the fundamental accelerators of sustainable development of territorial units. The economic importance of the institutional infrastructure is reflected by its functions. It includes elements responsible for such issues as environmental education, business stimulation, contributing to the transfer and distribution of state-of-the-art environmental and other technologies, or workforce productivity. That component of the socio-economic system plays a special role because institutional infrastructure investments require relatively small amounts of time and capital while contributing to many multiplier effects, thus providing numerous benefits both to economic operators and to the economy as a whole.

As shown by the analysis of results brought by the linear ordering (TOPSIS) method, in 2015, Western Poland districts were (at most) moderately differentiated by the level of sustainable development. Also, they were little diversified in terms of the concentration of institutional infrastructure. To determine the strength of associations among Western Poland districts as regards the levels of sustainable development and institutional infrastructure development, an analysis of spatial autocorrelation was carried out. As shown by the results, a positive but statistically insignificant spatial relationship exists among the synthetic measures of the features under consideration. The value of the global Moran's *I* based on 2015 data was 0,0794 for the sustainable development and 0,032 for the institutional infrastructure. For both of these economic aspects, positive values of the local Moran's *I* statistics were much more frequent: 70 occurrences in the case of SMSD (statistically significant values recorded in 6 districts) and 83 occurrences in the case of SMI (including 10 statistically significant ones).

The identification of spatial structures related to sustainable development and its determinants (e.g. the institutional infrastructure) could be an incentive for the authorities at various local government levels to take measures for the stimulation of environmentally-friendly methods of socio-economic development. This is all the more important since the level of features covered by this analysis may determine, and be determined by, the corresponding levels recorded in other locations. The results of the conducted research (including ranking of infrastructure attractiveness of poviats), can be indirectly used, among others by local government authorities responsible for local and regional development (including the development of individual elements of institutional infrastructure) in the context of choosing the direction of socio-economic restructuring of individual local government units. In addition, the results of the research may indirectly initiate actions aimed at more efficient use of the possibilities of financing investments from EU funds in material institutional infrastructure by local government authorities. Knowing the spatial structures of such an important economic category as sustainable development may support the initiation of activities (including local authorities in shaping the strategy of sustainable local development) aimed at stimulating development towards achieving the highest living standards with respect for resources in specific areas. This is important because sustainable actions should be consistent not only with the

National Ecological Policy, but also with the strategies of neighboring areas. This results from the fact that the level of sustainable development in one territorial unit may affect (positively or negatively) the level of development in neighboring units. This is due to the fact that the structural elements of individual local government units (such as population, natural resources, infrastructure) create a specific set of related and interdependent components, which goes beyond the administrative boundaries of territorial units, and atmospheric pollution and is of a cross-border nature. It seems that in order to develop common solutions by local authorities and the adaptation of good practices, sustainable development clusters – compact and spatially large areas, characterized by a high level of sustainable development – become particularly important. Spatial dependence analysis allows to determine the strength of links between spatial units in terms of the level of sustainable development, and also allows to identify clusters of poviats similar to each other due to the level of the analyzed phenomenon.

In further research, other spatial statistics could be used, including both global (i.e. *join-count*) and local ones (i.e. Getis-Ord statistics). Alternatively, another spatial neighborhood structure could be employed (i.e. higher order neighborhood). Also, it could be useful to develop a system of partial weights so that the variables covered by the analysis are not treated as equivalent. In further studies, it would be worthwhile to carry out an analysis regarding smaller spatial units. However, a smaller scope of data available for this level poses a significant problem.

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