EQUILIBRIUM
Quarterly Journal of Economics and Economic Policy
Volume 13 Issue 3 September 2018
p-ISSN 1689-765X, e-ISSN 2353-3293
www.economic-policy.pl

ORIGINAL PAPER

Citation: Miłek, D. (2018). Spatial differentiation in the social and economic development level in Poland. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *13*(3), 487–507. doi: 10.24136/eq.2018.024

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Received: 6 April 2018; Revised: 4 July 2018; Accepted: 18 July 2018

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Spatial differentiation in the social and economic development level in Poland

JEL Classification: *B16; O11; O18*

Keywords: *region; regional development; regional differentiation; Hellwig's method, Ward's method; natural breaks classification*

Abstract
Research background: Social and economic development involves a broad spectrum of social, economic and spatial phenomena. The multi-faceted nature of regional development arises directly from the fact that it is shaped by multiple factors. Current discourse emphasises the role of endogenous factors, which indicate the specific nature and the distinctive features of the given territory. Mobilising the endogenous potential ensures stable regional development dynamics. At the moment, one of the fundamental economic problems are the increasing differences in the development of specific regions.
Purpose of the article: The purpose of this study is to assess the differentiation of the social and economic level development of Polish Voivodeships, applying the selected assessment methods for the years 2010 and 2015, draw up a rank list of regional units according to their development levels, and identify the groups of Voivodeships sharing similar development levels. The indicators used in this study, characterising the level of the social and economic development, have been systematised according to the following areas: demographics and labour market, regional entrepreneurship, local economy structure, innovation and research & development activities, technical infrastructure, social infrastructure, and the condition and protection of the natural environment.
Methods: The level of the social and economic development of Polish Voivodeships was assessed using Zdzisław Hellwig's development pattern method, which made it possible to rank them according to the level of development of Polish Voivodeship. The methodology is supplemented by Ward's agglomerative clustering method, which made it possible to distin-

guish other Voivodeships according to the analysed phenomenon. The Voivodeship clustering method used Jenks' natural breaks classification method.
Findings & Value added: Pursuing the research aims, the authors focused in particular on clear spatial differences. Through the analysis we were able to identify the changes in the social and economic development processes of the Polish regions. The Voivodeships were divided into groups according to their development level: the highest, high, low and the lowest.

> "*If everything was happening at the same time, there would be no development whatsoever. If everything was located in the same place, there would be no distinction whatsoever. Only space enables the existence of distinctions which then develop over time*" (Lösch, 1961, p. 380).

Introduction

The social and economic development processes always take place in a specific space and do not have a uniform character. The current conditions of regional development are characterised by clear differences in the social and economic development level of individual units (Pylak & Wojnicka-Sycz, 2016, pp. 2179–2183; Jędrzejczak, 2015). Different approaches to regional policy in Poland still fail to even out the imparity, which is clearly visible in particular in terms of the division of Poland into economically developed western part and economically underdeveloped eastern part. It should be pointed out that the dynamics of development processes, on both the national, regional and local level, are determined by the character of the space and the changes occurring over time. The results of the studies assessing the level of regional development may serve as the basis for formulating social and economic development strategies, explaining the reasons behind regional differences, and determining the methods and options for eliminating the existing inequalities.

The purpose of this study is to assess the differentiation of the social and economic level development of Polish Voivodeships, applying the selected assessment methods for the years 2010 and 2015, draw up a rank list of regional units according to their development levels, and identify the groups of Voivodeships sharing similar development levels. The analysis refers to the year 2015, for which there is unrestricted access to up-to-date statistical data, and the year 2010, which was used as the reference year to illustrate the changes in the social and economic development level of Polish Voivodeships. The indicators used in this study, characterising the level of the social and economic development, have been systematised ac-

cording to the following areas: demographics and labour market, regional entrepreneurship, local economy structure, innovation and research & development activities, technical infrastructure, social infrastructure, and the condition and protection of the natural environment. The conducted studies and the resulting conclusions aim to determine the social and economic development level of individual Voivodeships in the analysed years.

The level of social and economic development of the Polish regions was conducted with the use of Z. Hellwig's development pattern method (1972, pp. 115–134), which made it possible to rank the Voivodeships according to their development level. The methodology is supplemented by Ward's agglomerative clustering method (1963, pp. 236–244), which made it possible to distinguish Voivodeships that were similar in terms of the analysed phenomenon. The study was conducted using the data retrieved from the Local Data Bank and provided by the Central Statistical Office (GUS).

The study has two sections: the theoretical section and the empirical section. In the first section, the social and economic development was discussed as an economic category. In the analytical section, the social and economic development level of Polish regions was determined according to the set of properties selected for the study, dividing the regions in four groups according to their development level: the highest level group, the high level group, the low level group, and the lowest level group.

Social and economic development of the regions — definitions

The regional development is the outcome of the activity of multiple factors which determine such development to various extent. The key role is played by innovations which are considered to be the crucial impulses for the stimulation and growth of the economy (Markowska & Strahl, 2012). The efficiency of regional policy depends on increasing the efficiency of undertaken activities. It is essential to find new methods, tools and paths to increase the efficiency of spending the funds, which will in turn contribute to the development of the economy of the country or the regions. The regional development processes are closely connected to the endogenous potential of the individual. The internal potential of the region is the key driving force of its development, determining the developmental capabilities of resources in the individual areas thereof (Miłek & Nowak, 2015, pp. 115–135).

Referring the studies discussed herein to the category of regional social and economic development requires a more precise set of definitions of the economic category in question. Regional development is usually under-

stood as irrevocable quantitative and qualitative changes aimed at reaching a stable growth of the social, economic and cultural potential of the region (Kudełko, 2005, p. 57).

It is considered as a "*systematic improvement of human living conditions, the increase of social and cultural benefits based on comprehensive social progress and equal access to social devices, and the creation of optimal conditions for individual and social growth as a result of perfecting the forms and principles of social interactions*" (Piontek, 2006, p. 40).

According to J. Szlachta, "*regional development is a systematic improvement of the competitiveness of business entities and the standard of living of the citizens, and the growth of the economic potential of the regions contributing to the social and economic development of the country*" (Szlachta, 1996).

T. Kudłacz defines regional development as a "*permanent improvement of the standard of living of the citizens and the economic potential within a specified territorial unit*" (Kudłacz, 1999, p. 15). Kudłacz identifies the regional development with the changes occurring in the components thereof: the economic potential, the structure of the economy, the natural environment, the infrastructure, the spatial order, the standard of living of the citizens, and spatial development.

The definition proposed by A. Klasik (1997, p. 105) expands on Kudłacz's definition and highlights the competitiveness factor. In Klasik's view, regional development is a persistent growth of three elements: the economic potential of the regions, their competitive strength, and the standard and quality of life of the citizens, all contributing to the social and economic development of the country. Klasik distinguished eight main components of regional development.

The definitions provided above include the so-called components of regional development, which serve as the basis for defining the following areas of regional development (Strahl, 2006, p. 15):

- citizens of the region,
- regional ecosystem,
- infrastructure,
- regional economy,
- space – territory of the region.

The presented areas of regional development were decomposed into regional development components, which were characterised contextually by the adopted variables and are discussed in further chapters of the study. In consideration of the foregoing, the assessment of the progress stage of the processes of the social and economic development of the regions involves

the identification and measure of the changes within its components (Ginevičius *et al.*, 2015, pp. 141–153; Bell & Morse, 2008).

Diagnostic properties of the level of the social and economic development of regions

One of the key aspects of regional studies is the definition of the set of regional development factors. Those factors, referred to as diagnostic properties, are qualitative attributes of the analysed objects, allowing the analysed facilities to be distinguished from one another. Hence the essential nature of the selection of an optimal set of diagnostic properties. The diagnostic properties must ensure a substantive, sufficient description of the region, and must have the highest informative value (Suchecka, 1998). Fulfilment of the purpose of the study is based on the use of the so-called synthetic development measure. The selection of specific measures of the level of the social and economic development of the regions arises from the purpose of the study and the adopted method of analysis, and is the resultant of both data availability and the investigator's arbitrary decisions (Stanny, 2012).

The most general group of criteria for selecting the regional development factors, which also serve the purpose of diagnostic properties, includes: substantive, formal and statistical criteria (Strahl, 2006, p. 33; Markowska & Sobczak, 2002)[1].

The following areas were included in the assessment of the spatial differentiation in Poland: the demographic situation and the labour market, the regional entrepreneurship, the structure of the regional economy: industry, agriculture, services, innovation and R&D, technical infrastructure, social infrastructure, and the condition and protection of the natural environment. Within the areas, a set of properties was defined providing an as comprehensive and exhaustive as possible characteristics of the social and economic development level of specific facilities. Basing on the current state of knowledge as reported in the literature of the subject, as well as own experiences in the scope of the analysis at hand, the author has determined a list of properties corresponding to the need of studying the level of development of Polish regions. Additional criteria include topicality, accessibil-

[1] According to A. Zeliaś (2002, pp. 37–38), the substantive and formal analysis of diagnostic properties should include the following aspects: universality, measurability, availability, quality, cost-effectiveness, interpretability and the impact of the variables. Statistical criteria include the following requirements for the properties: high variability, representativeness for variables eliminated from the study, no mutual correlations, and strong correlation with the dependent variable(s) (Strahl, 2006, p. 33).

ity and comparability of the data covering the analysis of the studied phenomenon in the years 2010 and 2015.

On the basis thereof, a set of 77 properties was determined on the first stage of the study, as presented in Table 1[2]. Each of the aforementioned areas constitutes a set of properties characterising the structure of the social and economic space of the regions.

The properties illustrating the demographic situation and the labour market refer to the availability of workforce and the use thereof, the structure of the working population and their education (Table 1). The properties characterising the regional entrepreneurship include the resources of the region related to its attractiveness for investors, the scale of foreign investment capital influx, and the entrepreneurial activity rate. Certain diagnostic properties also refer to their attractiveness in terms of the influx of growth impulses and the quality of external conditions. Those properties are determined by the sectoral structure of the working population and the productivity of individual economy sectors, as measured by gross added value and production sold, the intensity of investment processes, and the level of the industry, agriculture and services. The competitiveness of the regional structure is determined by its capability to create and absorb innovations, which are defined by: the number of R&D units, the capital expenditures on R&D and innovations in businesses, and the number of granted patents which serves as the measure of R&D efficiency. The technical infrastructure properties selected for the study defined: the quality of roads and the density of railways, and the availability of mains water systems, sewers and laterals, gas mains, waste water treatment plant, and Internet connection. Other properties include the level of wealth of the communities in the region, and the quality of life of the citizens, as measured by the availability of social benefits in terms of housing policy, healthcare and culture. The list of variables selected for the study was completed with the properties characterising the quality of the environment in which the population resides.

At the second stage, the variables were reduced according to statistical criteria. The basis for the elimination of diagnostic properties was the cut-off value of the coefficient of variation — $V \leq 0.1$, and high mutual correlation of variables — correlation coefficient $r > |0.9|$[3]. Finally, after reduc-

[2] Due to the availability of data, the properties: X_{23}, X_{29} i X_{38} refer to 2014 (for 2015), whereas the properties: X_{35} i X_{39} for the West Pomeranian Voivodeship and Lubelskie Voivodeship refer to 2011 (for 2010).

[3] The properties written in italics are those that were discarded due to insufficient differentiation and due to strong mutual correlations. Some of the properties, albeit meeting the applied statistical criteria, were left out due to the purpose of the study (X_6, X_{20}, X_{22}, X_{24}, X_{35},

tion, 58 variables were adopted for the study (of which 10 were destimulants replaced with stimulants[4]).

During further stages of the analysis, the properties were treated as equal, and a unit weight system was adopted. The selected and adopted diagnostic properties appear to be a valid base for conducting a correct analysis of the level of differentiation in the social and economic development of Polish regions.

Methodology

The level of the social and economic development of the Polish regions was measured using Z. Hellwig's taxonomic method (1972, pp. 115–134; Cheba & Szopik-Depczyńska, 2017, pp. 487–504; Balcerzak, 2016a, pp. 11–27). It is a model method based on the structure of an abstract object P_0 referred to as development model[5]. One of the key advantages of this method is that it allows direct assessment of several statistical units.

In order to bring the data to comparable values, the properties were normalized by classic standardization of a variable value according to the following formula[6]:

$$Z_{ik} = \frac{x_{ik} - \bar{x}_k}{s_k} \tag{1}$$

for $x_k \in I$; for ($i = 1,\ldots, n$; $k = 1,\ldots, m$)

X_{36}, X_{56} and X_{58}).

[4] Stimulants are variables whose higher values indicate a higher level of development of the analysed phenomenon, whereas destimulants are variables which, if their value drops, indicate a higher level of development. In this study, destimulants were transformed into stimulants according to the formula: $x_{ij}^{S} = 2\overline{x_j} - x_{ij}^{D}$ (Zeliaś, 2002).

[5] In the study, a fixed model for both year was used, which was a prerequisite for the comparability of results.

[6] The variables were standardised using arithmetic mean and standard deviation calculated one time for the entire study period. This ensured the comparability of data (Zeliaś, 2002).

The development model was defined as an abstract object P_0 characterised by the highest values for stimulants, and having standardized coordinates:

$$P_0 = [z_{01}, z_{02}, ..., z_{0k}] \tag{2}$$

where:

$$Z_{0k} = \max\{z_{ik}\} \text{ — when } x_k \text{ is a stimulant} \tag{3}$$

With respect to the obtained model, multidimensional distances were calculated for each analysed object (region), using Euclidean metrics, which are expressed by the following formula:

$$c_{i0} = \sqrt{\sum_{k=1}^{m} (z_{ik} - z_{0k})^2} \qquad i = 1, 2, 3, ..., n \tag{4}$$

where:
I – set of stimulants;
Z_{ik} – standardized value of property k for the region i;
x_{ik} – value of property k in the region i;
$\bar{x}_k$ – arithmetic mean of variable k; S_k – standard deviation of variable k;
m – number of variables;
n – number of regions.

In order to stabilise the value of indicator d_i, a relative taxonomic measure of development was constructed, which had been calculated from the formula:

$$d_i = 1 - \frac{c_{i0}}{c_0} \quad , i = 1, 2, 3, ..., n \tag{5}$$

where:

$$c_o = \bar{c}_0 + 2 \cdot s_0 \tag{6}$$

$\bar{c}_0$, s_0 arithmetic mean, standard deviation c_{i0} (i = 1, 2, 3, ... n), respectively;
d_i – synthetic indicator;

whereby:

$$\bar{c}_0 = \frac{1}{n} \cdot \sum_{i=1}^{n} c_{i0} \tag{7}$$

and

$$s_0 = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} (c_{i0} - \bar{c}_0)^2} \tag{8}$$

The resulting synthetic development measure d_i (5) takes the values from the range [0,1]. The constructed taxonomic measure of development's value increases with the development level of the given object (Zeliaś, 2002, pp. 36–41). In this paper, the measure was used to arrange the Voivodeships according to their social and economic development level.

The units in the hierarchy were then grouped into classes of similar development level, applying the so-called *Jenks' Natural Breaks Classification* (Jenks, 1967, pp. 186–190; see also: Bartkowiak-Bakun, 2017, p. 422; Pietrzak, 2016, pp. 69–86; Balcerzak, 2016b, p. 12; Balcerzak & Pietrzak, 2017a, pp. 18–23). It is based on the so-called natural breaks and consists in dividing the variable into classes in such way as to minimize the variance within the classes maximize the variance between classes. The method is based on the following assumptions: data sharing similar values are placed within the same class; each class contains a specific number of values and each object must be assigned to one of the classes.

As a supplementary method, Ward's agglomerative clustering method (1963, pp. 236–244) was used to enable isolating regions similar in terms of the analysed phenomenon. Among other agglomerative methods, it is distinguished by the use of analysis of variance to the quantification of the distance between clusters. It is recognised as a reliable, efficient method, widely applied in analyses concerning the social and economic development of territorial units (Grabiński *et al*., 1984, pp. 63–80; Trąpczyński *et al*., 2016, pp. 29–50; Rollnik-Sadowska & Dąbrowska, 2018, pp. 143–158; Małkowska & Głuszak, 2016, pp. 269–283). The analysis yields a dendrogram which provides a graphic interpretation of the results[7].

[7] Other agglomerative methods include: nearest neighbour, farthest neighbour, average linkage, weighed average linkage, centre of gravity, and weighed centre of gravity.

Differences in the level of social and economic development of Polish regions in the years 2010 and 2015 — results

The application of Z. Hellwig's linear ordering method made it possible to classify the Voivodeships according to their social and economic development level. On the basis of the 58 properties adopted for the study, the regions were classified using a synthetic indicator. Mazovian Voivodeship took the lead in 2010 (indicator value — 0.343) — Table 2. In the second place was Silesian Voivodeship (0.279), followed by Pomeranian and Lower Silesian Voivodeships (0.272 for both regions). The last position was occupied by Warmian-Masurian Voivodeship (0.063).

In the second analysed year, i.e. 2015 — Mazovian Voivodeship retained its position as the most developed region (indicator value — 0.392), with the indicator showing a value higher by 0.049 points than in 2010 (Table 2). The regions with the highest social and economic development level also included Lower Silesian Voivodeship with the indicator value of 0.349. The developmental distance between Mazovian Voivodeship and the runner up was 0.064 in 2010, and 0.043 in 2015. The lowest developmental position remains with the Warmian-Masurian (0.041 — the indicator value dropped by 0.022 compared to 2010). The spatial differentiation of the regions in the years 2010 and 2015 was illustrated on Fig. 1 and 2.

The calculated synthetic indicator of the region development level for 2010 and 2015 made it possible to group the Voivodeships with similar level of development. Thus, four groups of regions were identified:

- Group I: regions with the highest social and economic development level;
- Group II: regions with a high social and economic development level;
- Group III: regions with a low social and economic development level;
- Group IV: regions with the lowest social and economic development level;

The group with the highest development level in w 2010 included the Mazovian and Silesian Voivodeships. In 2015, the aforementioned Voivodeships retained their position and the group was expanded to include the Lower Silesian region. The second and most numerous group in 2010 included the following Voivodeships: Pomeranian, Lower Silesian, Lesser Poland, Łódź, Greater Poland, Kuyavian-Pomeranian and West Pomeranian, with the Hellwig's indicator within the range of <0.279;0.146>. In 2015, Opole Voivodeship was addedd to the group and the Lower Silesian Voivodeship advanced to group I, while Kuyavian-Pomeranian and West Pomeranian Voivodeships dropped to group III. Group III in 2010 included only three Voivodeships: Opole, Lubusz and Lublin. In 2015, Kuyavian-

Pomeranian, West Pomeranian and Podlaskie Voivodeships were added to that group. The group with the lowest development indicator values in 2010 included the following Voivodeships: Subcarpathian, Świętokrzyskie, Podlaskie and Warmian-Masurian. In 2015, Podlaskie Voivodeship advanced to group III.

In order to identify Voivodeships which were similar in terms of the analysed phenomenon, they were grouped using Ward's clustering method (1963, pp. 236–244). On the basis of the adopted properties, three groups of spatial units were created that were relatively homogeneous, with linkage distance of 13 (Fig. 3). The first group included two regions: Mazovian and Silesian Voivodeships, which differ markedly from the others. Cluster 2 includes five Voivodeships: Lublin, Subcarpathian, Świętokrzyskie, Podlaskie and Warmian-Masurian. The next group, which included: Lower Silesian Voivodeship, Lesser Poland Voivodeship, Kuyavian-Pomeranian Voivodeship, Pomeranian Voivodeship, Greater Poland Voivodeship, Łódź Voivodeship, Lubusz Voivodeship, Opole Voivodeship and West Pomeranian Voivodeship, made up cluster 3 (the group constitutes 56.3% of the analysed units). However, it should be noted that each Voivodeship in this cluster is characterised by its own specific nature and could be considered separately. Grouping of Voivodeships could be a stepping stone for further, in-depth studies[8].

The result of grouping the Voivodeships on similar development levels in 2015 was the dendogram presented on Fig. 4. Three groups of relatively homogeneous spatial units were distinguished (linkage distance of 13). The first group included the following Voivodeships: Lower Silesian, Łódź, Pomeranian, Lesser Poland, Greater Poland, Silesian and Opole. Cluster 2 is a singleton, containing the Mazovian region which is markedly different in terms of development level from other regions. Cluster 3 includes the following Voivodeships: Kuyavian-Pomeranian, Lubusz, West Pomeranian, Podlaskie, Świętokrzyskie, Warmian-Masurian, Lublin and Subcarpathian (the group constitutes 50.0% of the analysed units). The grouping results may encourage further, in-depth studies to determine the variables which had the crucial influence on the allocation of the regions to specific clusters.

The analysis of the social and economic development level indicator in the years 2010 and 2015 highlighted the changes of the development level in most of Poland's regions. The synthetic indicator for 2015 increased in 14 Voivodeships, as compared to 2010. The leaders of development, both

[8] The efficiency of Ward's method is held in high regard in the literature (Grabiński *et al.*, 1984, pp. 63–79; Strahl, 2006, pp. 235–236).

in 2010 and in 2015, were Mazovian and Silesian Voivodeships. Particularly positive processes were observed in Lower Silesian Voivodeship (where the synthetic indicator rose by 0.077 points), and Opole and Podlaskie Voivodeships (where the indicator rose by 0.061 and 0.056 points, respectively).

The inequalities in the development level between the Polish regions are deeply rooted and arise from a variety of factors, including, among others, the attractiveness of location, the available natural resources, the differences in economy structures, the quality of human capital, and the accessibility of the transport and IT infrastructure, and public utility services. The differences are an objective phenomenon observed in the social and economic development processes, which are responded to by actions aimed at reducing them.

The comparative analysis of Poland's Voivodeships in terms of their social and economic development serves the purpose of identifying the regions which are most alike in terms of the applied criteria. Numerous publications show the differences in the social and economic development between the Voivodeships (Bartkowiak-Bakun, 2017, pp. 417–432; Kuc & Sobiechowska-Ziegert, 2018, pp. 229–239; Sobiechowska-Ziegert & Mikulska, 2013, pp. 200–209; Balcerzak & Pietrzak, 2017b, pp. 5–18; Pietrzak & Balcerzak, 2017a, pp. 257–268; Pietrzak & Balcerzak, 2017b, pp. 310–318; Murawska, 2010, pp. 211–221; Stec, 2011, pp. 232–251; Winiarczyk-Raźniak & Raźniak, 2011, pp. 31–36).

The applied grouping methods yield very similar results. The most developed regions are Mazovian, Lower Silesian, Silesian and Pomeranian Voivodeships, while the most underdeveloped ones are Lublin, Świętokrzyskie, Subcarpathian, Warmian-Masurian and Podlaskie Voivodeships. The results of the study on the development levels of the analysed regions may serve as the starting point for a more in-depth analysis and assessment of the development potential of individual units, e.g. in the context of the driving factors of the development. One key benefit of the performed measure would be the inclusion in further analysis of variables other than proposed herein, so as to make it easier to compare the obtained results.

Conclusions

The analysis of the results highlighted the development level changes in Poland's Voivodeships in the analysed years. Hellwig's indicator rose in as many as 14 of them. The development processes in the analysed units are quite diverse. The position of the economically powerful regions, i.e. Ma-

zovian, Silesian and Lower Silesian, is reinforced. In 2015, Lower Silesian Voivodeship was the runner-up (the indicator value increased by 0.077 ponts as compared to 2010); in Opole Voivodeship, the indicator rose by 0.061 points, and Podlaskie Voivodeship advanced from the 15th to 12th position over the analysed years. Kuyavian-Pomeranian and Subcarpathian Voivodeships dropped by one position. The lowest development level in the analysed years was retained by Warmian-Masurian, Subcarpathian and Świętokrzyskie Voivodeships.

The applied agglomeration method made it possible to distinguish the regions which were similar in terms of the adopted variables. This could serve as the stepping stone for further, in-depth, quality research to increase the efficiency of the regional policy and, as a result, to increase the competitive edge of the Voivodeships.

The social and economic development is a multi-dimensional phenomenon due to the variety of factors which influence it. Hence the significance of the presented empirical studies, in the scope discussed, for the economic policy. An added value of this study is the monitoring of changes in terms of regional disproportions, which should be conducted on an ongoing basis. The results of this study may encourage further, in-depth studies on the role played by individual factors in the social and economic development, in order to isolate the group of properties which determine the economic success of a region. This, in turn, would make it possible to identify the regions with established strengths and those which are still building up the potential for the development of their territory.

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Annex

Table 1. Properties used to analyse the social and economic development level in Poland — the original set

Diagnostic properties
Demographics and labour market
X_1 *Population density per 1 km^2 of territory*;
X_2 Urban population as a % of total (urbanization level);
X_3 Balance of internal and external migration for permanent residence per 1,000 inhabitants;
X_4 Infant mortality per 1,000 of live births;
X_5 People working in national economy per 1,000 inhabitants;
X_6 The number of students aged 19–24 per 1,000 inhabitants;
X_7 *People in working age as a % of total population;*
X_8 Average monthly disposal income per capita [in PLN];
X_9 Recorded unemployment rate [%];
X_{10} Work accident victims per 1,000 of working persons;
X_{11} *People in non-working age (pre- and post-working age) per 1,000 people in working age;*
X_{12} Recorded unemployed persons who are without employment for more than 1 year;
X_{13} The number of unemployed per 1 job offer;
Regional entrepreneurship
X_{14} Persons working in private sector (outside agriculture) per 1,000 of inhabitants;
X_{15} The number of business entities registered in REGON statistical system per 1,000 of inhabitants in working age;
X_{16} The share of commercial law companies in the total number of business entities;
X_{17} The share of companies with foreign capital in the total number of commercial law companies;
X_{18} *The gross value of tangible assets in the private sector as a % of the value of total tangible assets;*
X_{19} Investment expenditures in the private sector as a % of total investment expenditures ;
X_{20} The percentage of companies with access to broadband Internet connection [%];
Structure of the economy of the region: industry, agriculture, services
X_{21} The number of people working in industry and construction per 1,000 of inhabitants;
X_{22} The Voivodeship's share in the national sold industrial production;
X_{23} Gross Value Added in the industry per 1 working person
X_{24} Sold industrial production (current prices) in thousand PLN per 1 inhabitant ;
X_{25} *The share of people working in services in the total number of working persons [%];*
X_{26} Gross value of tangible assets in the industry (current fixed prices) in thousand PLN per 1 person working in the industry;
X_{27} Investment expenditures in the industry (current prices) in thousand PLN per 1 person working in the industry;
X_{28} The share of investment expenditures in industry and construction in the total investment expenditures [%] ;
X_{29} Gross Value Added in agriculture per 1 working person;
Structure of the economy of the region: industry, agriculture, services
X_{30} *The share of usable agricultural land in the total land [%];*
X_{31} Cattle per 100 hectares of usable agricultural land;
X_{32} Pigs per 100 hectares of usable agricultural land;
X_{33} Milk production per 1 hectare of usable agricultural land [litres];
X_{34} The production of slaughter animals per 1 hectare of usable agricultural land [kg];

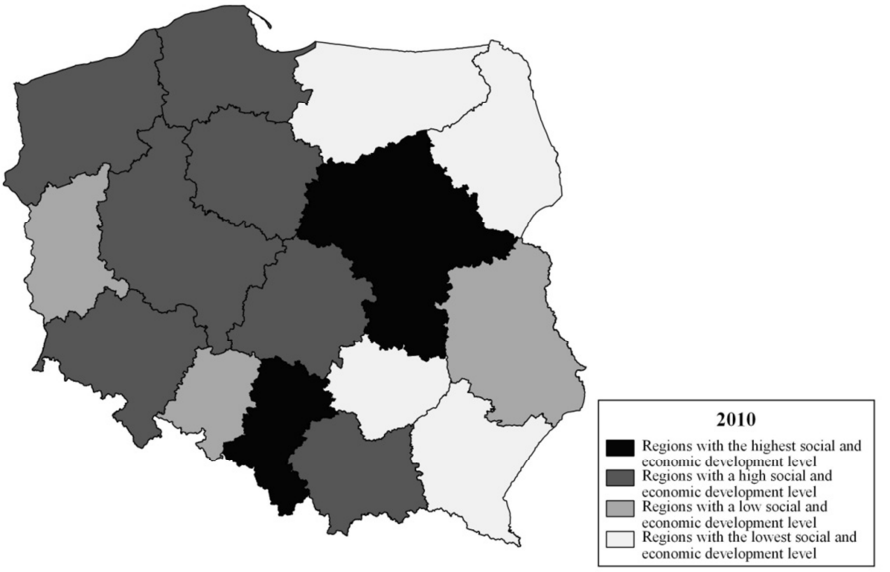
Table 1. Continued

Diagnostic properties
Innovations and research & development
X_{35} Employment in R&D per 1,000 of professionally active persons (total);
X_{36} Expenditures on innovations in the industry (in companies employing more than 49 persons) as percentages (% share of the Voivodeship in the country total);
X_{37} *Expenditures on R&D per capita in PLN;*
X_{38} The share of R&D expenditures (current prices) with respect to gross domestic product [%];
X_{39} The share of employees with higher academic degrees (professors, assistant professors, doctors) in the total number of people working in R&D;
X_{40} The number of innovation and entrepreneurship centres per 10,000 of inhabitants;
X_{41} The number of patents granted per 10,000 of inhabitants;
Technical infrastructure
X_{42} Public hard-surfaced roads per 100 km^2 – road density [km];
X_{43} Railways per 100 km^2 - railway density [km];
X_{44} The number of inhabitants per 1 office of the designated postal operator;
X_{45} *The percentage of inhabitants using mains water systems [%];*
X_{46} *The percentage of inhabitants using sewers and laterals [%];*
X_{47} The percentage of inhabitants using gas mains systems [%];
X_{48} *The percentage of inhabitants serviced by waste water treatment plants in total population [%]*;
X_{49} *Dust pollution stopped by pollution reducing devices in the % of generated pollution [%]*;
X_{50} Gas pollution (without CO_2 stopped by pollution reducing devices in the % of generated pollution [%];
X_{51} Collective tourist accommodation facilities - the number of accommodated tourists per 1,000 of inhabitants;
X_{52} Expenditures on tangible assets protecting the environment, in PLN per capita;
X_{53} The number of retail outlets per 100 km^2;
X_{54} *The number of cars per 1,000 of inhabitants*;
X_{55} Road accident fatalities per 100,000 of inhabitants;
X_{56} Households with computers with broadband Internet connection [%];
Social infrastructure
X_{57} *Average housing usable area per capita [m^2]*;
X_{58} Housing resources - the number of apartments per 1,000 of inhabitants;
X_{59} The number of doctors per 10,000 of inhabitants;
X_{60} The number of dentists per 10,000 of inhabitants;
X_{61} *The number of hospital beds per 10,000 of inhabitants*;
X_{62} *The number of doctor's and dentist's appointments per capita*;
X_{63} The number of persons on welfare benefits per 10,0000 of inhabitants;
X_{64} The number of children aged 3-5 attending pre-schools as a % of children aged 3-5;
X_{65} The number of high school students as a % of the population aged 16–18;
X_{66} *The number of books borrowed in public libraries in volumes per 1 reader*;
X_{67} The number of seats in cinemas per 1,000 of inhabitants;
X_{68} Spectators in theatres and musical institutions per 1,000 of inhabitants;
X_{69} Voivodeship budget income per capita [PLN];
The condition and protection of the natural environment
X_{70} *Dust pollution emissions per 1 km^2 [t];*
X_{71} Gas pollution emissions per 1 km^2 [t];
X_{72} Untreated industrial and municipal waste water per 1 km^2 [dam^3];
X_{73} *Treated waste water as a % of waste water requiring treatment (% of treated waste water)*;
X_{74} The surface area of classified sites in total surface area of the Voivodeships;
X_{75} *Parks, green spaces and greenery in the total surface area;*
X_{76} Investment expenditures on environment protection per capita [PLN];
X_{77} Investment expenditures on water management per capita [PLN];

Table 2. The social and economic development level in Polish regions in the years 2010 and 2015 on the basis of Hellwig's taxonomic development measure (according to *Jenks' Natural Breaks*)

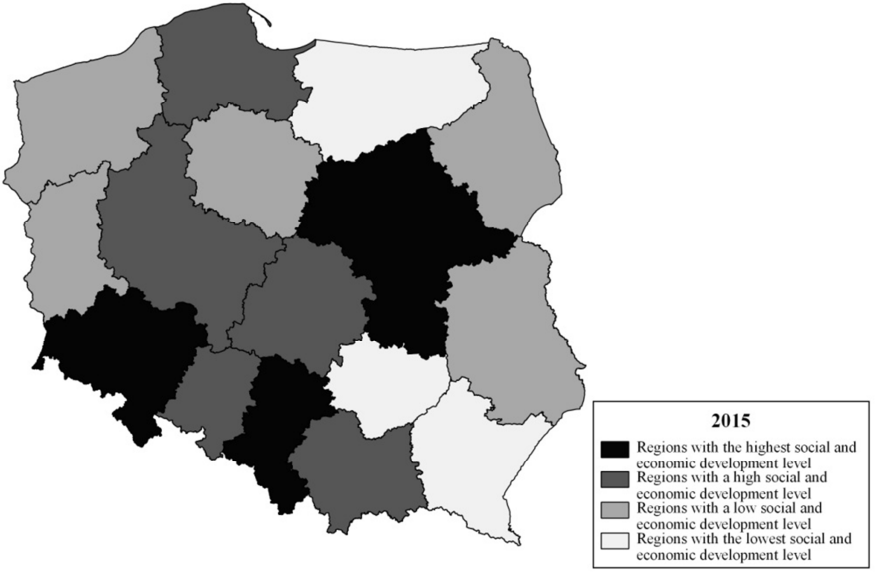
2010			2015		
Item	**Voivodeship**	d_i indicator	**Item**	**Voivodeship**	d_i indicator
		GROUP I			
	<0.343;0.279>			<0.392;0.309>	
1	Mazovian	0.343	1	Mazovian	0.392
2	Silesian	0.279	2	Lower Silesian	0.349
			3	Silesian	0.309
		GROUP II			
	<0.279;0.146>			<0.309;0.203>	
3	Pomeranian	0.272	4	Pomeranian	0.291
4	Lower Silesian	0.272	5	Lesser Poland	0.271
5	Lesser Poland	0.250	6	Greater Poland	0.268
6	Łódź	0.245	7	Łódź	0.263
7	Greater Poland	0.237	8	Opole	0.203
8	Kuyavian-Pomeranian	0.207			
9	West Pomeranian	0.146			
		GROUP III			
	<0.146;0.088>			<0.203;0.105>	
10	Opole	0.142	9	Kuyavian-Pomeranian	0.195
11	Lubusz	0.130	10	Lubusz	0.179
12	Lublin	0.088	11	West Pomeranian	0.178
			12	Podlaskie	0.133
			13	Lublin	0.105
		GROUP IV			
	<0.088;0.063>			<0.105;0.041>	
13	Subcarpathian	0.083	14	Świętokrzyskie	0.096
14	Świętokrzyskie	0.078	15	Subcarpathian	0.058
15	Podlaskie	0.077	16	Warmian-Masurian	0.041
16	Warmian-Masurian	0.063			

Figure 1. The social and economic development level of Polish regions in 2010



Source: own study on the basis of data from Table 2.

Figure 2. The social and economic development level of Polish regions in 2015



Source: own study on the basis of data from Table 2.

Figure 3. Clusters of Polish Voivodeships with similar social and economic development levels in 2010.

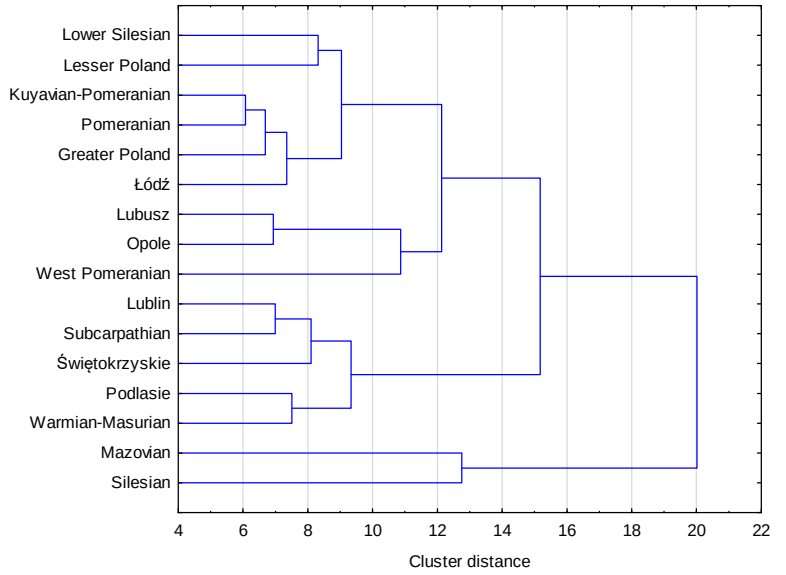


Figure 4. Clusters of Polish Voivodeships with similar social and economic development levels in 2015.