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THE MULTIVARIATE COMPARATIVE ANALYSIS OF REGIONAL DEVELOPMENT IN POLAND IN THE CONTEXT OF THE COHESION POLICY

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1. Justification for the choice of topic

Regional development is one of the important issues related to the functioning of the national economy. Development processes always take place in a specific space that significantly shapes the course and dynamics of development processes throughout the country. Regions are not isolated socio-economic entities, but they are an integral part of the national economy. Supporting and monitoring development in the regional system is therefore one of the most important tasks affecting the development process on a macro scale.

The differences in geographical, economic, social and cultural space, as well as the effects of many heterogeneous socio-economic factors, cause that particular regions are characterized by a different economic and environmental situation, as well as the level of management and development. Different conditions result in the fact that development does not occur everywhere at the same pace and direction [Kudełko, 2005]. The results of uneven development in territorial systems are polarization and divergence processes that can lead to depopulation and degradation of some areas [Gawlikowska-Hueckel and Szlachta, 2014].

The issue concerning sources of variations and their degree is an important issue considered in the field of economics for many years. Continuous work in this area results from the currently dynamically changing conditions and development factors. The bases for the study of development processes in the region are theories of regional development. As part of these theories, regularities related to the occurrence of development processes were identified, while identifying their causes, dynamics and structure. Considering the subject of the paper and its goals, theories of regional development that focus on processes and factors that enable the accelerated development of some and causing stagnation of others deserve special attention. Among others F. Perroux, G. Myrdal, A.O. Hirschman, P. Romer, R. Lukas and P. Krugman dealt with the problem of uneven spatial development.

Uneven development of regions, observed in all countries of the world, has become one of the most important problems of modern economy that is unfavorable for the processes of socio-economic development. Excessive interregional differentiation is a very unfavorable phenomenon, negatively affecting functioning economic and social systems. Due to the observed disproportions in development, in recent years, the European Union devotes a lot of attention to regional development, implementing the cohesion policy, whose instruments are designed to bridge the differences in development. For years, the European Union has been struggling with diversities in socio-economic development on a regional basis, adapting

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to the changing conditions and the priorities of the cohesion policy implemented. The treaty aim of cohesion policy is the development of regions that are lagging behind in economic, social and spatial terms and reduce their distance from the EU average, leading to the main goal of European integration, which is the convergence of European regions. The importance of this task is demonstrated by the amount of funds allocated for the implementation of this policy. Thus, reducing disparities in regional development is considered a very important challenge for the entire EU. Ultimately, it is planned that the Union will be a cohesive economic, social and spatial area, achieving the highest level of innovation, competitiveness and economic efficiency in the world [Prusek, 2010]. Regional diversification does not serve this purpose, as it reduces the competitiveness level of the EU economy through lower economic efficiency and suboptimal allocation of resources to cover the costs of their occurrence or limiting their social impact [Ryszkiewicz, 2013].

Diversification in the level of development is a key problem of the theory and practice of regional policy, affecting the economic and social spheres. In this situation, public authorities play a significant role, by conducting active regional policy to eliminate regional differences [Kudełko, 2005].

2. The purpose of the dissertation and research hypotheses

The analysis of the impact of the EU cohesion policy on the socio-economic development of the voivodeships and the observed interregional inequalities is an indispensable element of the policy implemented to assess its effects. Due to the high level of funds allocated for financing various types of activities, the assessment of the effects of cohesion policy is particularly important.

The aim of the multivariate comparative analysis was to examine the diversity of development of individual voivodeships in the context of cohesion policy. Cohesion policy is designed to reduce the distance of Poland towards the most developed countries of the European Union and thus ensure sustainable economic growth throughout the EU, as well as to reduce internal disparities in socio-economic development.

Achieving the main goal determined the need to formulate the following sub-objectives:
— reviewing the theory of regional development, including in particular related to the subject analysis,
— recognition of determinants of regional development based on literature studies,

— systematizing knowledge about the genesis of the EU cohesion policy, its objectives, principles and instruments,

— measurement and assessment of regional development in Poland on the basis of specified diagnostic variables using selected methods.

The results of empirical research so far provided the basis for formulating the following thesis: socio-economic development in the regional dimension is characterized by a large diversity determined mainly by the specificity of voivodeships and the conditions of their development.

The following hypotheses are also verified in the dissertation:

— in the diversified level of socio-economic development of voivodeships, tendencies of decreasing disparities are observed,

— fuzzy sets method is an effective tool for studying the diversification of regional development,

— in the area of regional development, the phenomenon of economic, social and territorial polarization is not observed.

3. Research methods and database

The multivariate statistical comparative analysis is used to detect the regularity in the community of study objects described by the numerous sets of their characteristics. In comparative analyses carried out, taxonomic methods are one of the most commonly used methods. Taxonomic methods play an important role in the study of the diversity of territorial units in the context of observed socio-economic phenomena. Under these methods, the comparison includes both organizing sets of objects and grouping them in subsets of similar entities to each other due to the characteristics characterizing them and the selection of representatives of the groups received [Panek and Zwierzchowski, 2013].

The multivariate analysis of the development of individual voivodeships first covered the ordering of voivodeships according to the degree of membership to a fuzzy subset of developed regions using the fuzzy sets method, then grouping voivodeships according to the level of development using the standard deviation method, and in the final stage - assessment of economic polarization using the Morris-Bernhardt-Handcock index (MBH), including individual data.

The analysis covered all voivodeships, and their development was examined in three dimensions of cohesion policy: economic, social and territorial. In order to determine changes

in time and emerging trends, the results from 2005-2015 were taken into account after Poland's accession to the EU.

In the fuzzy sets method, the key issue was the selection of diagnostic variables andthe method of determining the degree of membership to a fuzzy subset of developed regions.

Regional development is multifaceted, and the selection of features reflecting its level is characterized by a large multidimensionality enabling the selection of different sets of variables. In order to determine the degree of voivodeships' membership in the fuzzy subset of developed regions, a base set of potential diagnostic variables collected by public statistics was adopted. Variables were verified due to substantive and formal criteria. Thirty diagnostic variables were selected for the analysis in question, each with 10 variables referring to individual dimensions of cohesion policy (table 1).

The data base for selected variables were the results of statistical surveys conducted in a continuous manner within public statistics. In the economic dimension, the variables used come, among others, from regional accounts, public finances, REGON register, statistical surveys on entities with foreign capital as well as science and technology. In the social dimension, data were used, among others, from birth statistics and statistical surveys in the field of household budgets, labor market, education and health. In the territorial dimension, the focus was on the results of research in the field of transport and telecommunications infrastructure.

Among the selected variables, data on environmental status and protection (area of protected areas, emission of dust pollution, sewage management, municipal waste) and energy consumption, so important in the context of sustainable development, could not be missing. The principle of sustainable development is one of the fundamental principles of cohesion policy introduced in recent years and obliging member countries to protect the environment, use resources efficiently and combat climate changes.

Table 1. Specified diagnostic variables according to the dimensions of cohesion policy

No.	Diagnostic variables	Unit	The nature of the variable
	THE ECONOMIC DIMENSION		
1	Indices of GDP (constant prices) – previous year = 100	–	stimulant
2	Gross value added per 1 employed person	zl	stimulant
3	Sold production of industry per capita	zl	stimulant
4	Share of own revenues in total revenues of local government units	%	stimulant
5	Share of investment outlays in GDP	%	stimulant
6	The number of dwellings completed per 1000 population	–	stimulant
7	The number of entities of the national economy in the REGON register per 1000 population in the working age	–	stimulant
8	The number of entities with foreign capital participation per 10 thous. population	–	stimulant
9	The number of units conducting R & D activity per 100 thous. population	–	stimulant
10	Share of innovative enterprises in total number of industrial enterprises (enterprises with 50 employees and more)	%	stimulant
	THE SOCIAL DIMENSION		
1	Live births per 1000 population	–	stimulant
2	Dependency ratio (population at post-working age per 100 persons in the pre-working age)	–	destimulant
3	Average monthly per capita available income in household	zl	stimulant
4	Percentage of people in households with expenditure below relative poverty line	%	destimulant
5	Employed persons per 1000 population in the working age	–	stimulant
6	Registered unemployment rate	%	destimulant
7	The number of doctors per 10 thous. population	–	stimulant
8	The number beds in general hospitals per 10 thous. population	–	stimulant
9	Graduates of higher education institutions per 10 thous. population	–	stimulant
10	The number of children covered by pre-primary education per 1000 children aged 3-5	–	stimulant
	THE TERRITORIAL DIMENSION		
1	Population density (number population per 1 km^2)	–	stimulant
2	Index of urbanization	%	stimulant
3	Density of national roads per 100 km^2	km	stimulant
4	Railway lines operated per 10 thous. population	km	stimulant
5	Percentage of enterprises with broadband Internet access	%	stimulant
6	Total energy consumption per capita	kWh	destimulant
7	Share of protected areas in total area	%	stimulant
8	Emission of dust pollutants from particularly burdensome plants	tonnes/ km^2	destimulant
9	Share of treated industrial and municipal sewage discharged into water or to the ground in the amount of sewage requiring purification	%	stimulant
10	Share of municipal waste collected selectively in the total amount of municipal waste	%	stimulant

Source: own study.

After selecting the diagnostic variables, the next step was to determine the degree of membership of individual provinces to the fuzzy subset of developed regions. The level of surveyed features and their basic statistical measures was determined by the degree of membership to a given province[1]. Due to the occurring stimulant and destimulant variables, the determination of the degree of membership adopted two variants depending on the nature of the variables (table 2).

Table 2. **The method of determining the degree of membership of voivodeships to the fuzzy subset of developed regions**

STIMULANT VARIABLES	DESTIMULANT VARIABLES
1 – well developed region, then $x_j \geq b$	1 – well developed region, then $x_j \leq a$
0 < intermediate region <1, then $x_j - a / b - a$	0 < intermediate region <1, then $b - x_j / b - a$
0 – underdeveloped region, then $x_j \leq a$	0 – underdeveloped region, then $x_j \geq b$

where: x_j, is the selected diagnostic variable, $j = 1, 2, \dots 10$,
a, then arithmetic average x_j– standard deviation x_j,
b, then arithmetic average x_j + standard deviation x_j.

Source: own study.

In determining the degree of membership, a system of weights that preferred the data with the highest variability was used.

The degree of membership of individual voivodeships to the fuzzy subset of developed regions were calculated within the three dimensions of cohesion policy. The next stage consisted in determining the degree of membership joining partial degrees in the scope of economic, social and territorial cohesion. The degree of membership was determined by means of the arithmetic mean of membership levels within particular dimensions of cohesion policy, which were given the same meaning by constant weight.

Then voivodeships were grouped based on the degree of membership to the fuzzy subset of developed regions using the standard deviation method. The determination of the arithmetic mean and standard deviation allowed the division of voivodeships into four groups according to the level of development in accordance with the following principle:

- I group $\overline{SP} + s(SP) \leq SP$ the highest level of development
- II group $\overline{SP} \leq SP < \overline{SP} + s(SP)$ average level of development

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[1] The arithmetic mean and standard deviation of the tested variable were determined on the set covering all the analyzed years. Variables such as: gross value added per 1 employed person, sold production of industry per capita and average monthly disposable income per one person in a household to maintain comparability and eliminate the impact of price changes on their level in 2006-2015 were converted into relevant price indices: sold production of industry, global production and consumer goods and services.

- III group $\quad \overline{SP} - s(SP) \leq SP < \overline{SP}$ $\qquad$ low level of development
- IV group $\quad SP < \overline{SP} - s(SP)$ $\qquad$ the lowest level of development

where: SP – degree of membership

$\overline{SP}$ – average value of membership

$s(SP)$ – standard deviation of the membership degree.

The final stage of the analysis was to assess the polarization of the analyzed phenomenon in individual years as part of the dimensions of cohesion policy. The evaluation was made using the Morris-Bernhardt-Handcock index (MBH), based on the degree of membership of voivodships to the fuzzy subset of developed regions.

In order to eliminate the impact on the polarization index of shifts in the distribution of membership levels in comparable periods, a relative distribution of membership levels was created using the rate of change in the median value in the analyzed period 2005-2015.

The multivariate analysis used in the dissertation may be an important source of information about regional development in Poland after joining the EU. So far, no standard set of indicators for studying socio-economic development has been developed. The reason is the multi-faceted nature of regional development. Features affecting its level are characterized by a large multidimensionality. Each attempt to determine a set of variables that quantifies the level of development as much as possible is the added value of the research being carried out. The dissertation also contains an attempt to select such variables. In addition, in specifying the diagnostic variables, the context of the dissertation, that is cohesion policy, was taken into account by reviewing strategies and programs related to the implementation of cohesion policy in terms of key indicators for monitoring and assessing the effectiveness of this policy.

4. Results of multivariate comparative analysis

Obtained results of the analyzes carried out on economic, social and territorial cohesion can be used to assess the cohesion policy implemented. Comparison of results from 2005-2015 indicates diversification in the level of development between voivodeships, with the tendency to decrease in disparities.

Mazowieckie voivodeship is the undisputed leader among voivodeships in terms of achieved results, mainly in economic and social terms. Significant progress in achieving the best results within the analyzed dimensions of cohesion policy has been made by the following provinces: Dolnośląskie, Małopolskie and Łódzkie voivodeships. The least

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favorable in the same rankings were mainly voivodeships located in the eastern part of Poland. Weaker results, especially in economic terms, of voivodeships in north-eastern Poland result, among others, from rich environmental resources, on the basis of which a functional area was created under the name *Green Lungs of Poland*. These resources determine the economic structure and influence the type of economic .activity of the inhabitants, constituting a barrier to development due to, for example, restrictions on the implementation of industrial and road investments and the inability to expand the infrastructure. The special charm of the natural environment, which determines the competitiveness and attractiveness of these regions, means that the natural resources located on their territory are to be protected from development and irrational urbanization, and prepared operational programs adapted to the specific regional conditions of particular areas. Such activities are part of the objectives of cohesion policy regarding the preservation and protection of the environment and the promotion of resource efficiency.

Over the period 2005-2015, the degree of voivodeship to a fuzzy subset of developed regions in the economic and social dimension has increased the most in the case of Małopolskie and Dolnośląskie voivodeships. The results representing the territorial dimension also influenced the improvement of the situation of voivodeships. In this dimension, the highest increase in the degree of membership in 2015 in comparison with 2005 was recorded by Małopolskie and Mazowieckie voivodeships. Attention is drawn to the great progress of Małopolskie voivodeship in increasing the degree of membership to the fuzzy subset of developed regions in all dimensions.

However, the pace and scale of obtained results was of key importance to achieve the best results, which meant that voivodeships with the lowest level of development, despite better and better results, were still losing to the best voivodeships, which achieved much favorable changes much faster.

In most cases, the changes observed in the grouping of voivodeships according to the level of development using the standard deviation method were positive. As part of total cohesion in 2015, in relation to 2005, five provinces advanced to a group with a higher level of development, and only one voivodeship was moved to a group with a lower level of development. At the same time, the number of voivodeships in the group with lower and the lowest level of development decreased. The development at the same level throughout the analyzed period was maintained by six voivodeships, including the Mazowieckie voivodeship, which had the first investments in total cohesion and in the economic and social dimension. The fastest growing regions were those with the largest metropolises, and active

research and development and innovation units are active, generating modern technologies. These regions are relatively densely populated and have well-developed broadly understood infrastructure.

To the less favorable aspects in this respect belongs persistent, due to the geographical location, division into better and worse developing voivodeships. The method of grouping territorial units arranged in a linear manner confirmed the diversity mainly between the eastern and western parts of Poland. Much slower development, despite the inflow of EU funds, primarily recorded voivodeships of the Eastern macroregion (Podkarpackie, Świętokrzyskie, Lubelskie, Podlaskie and Warmińsko-mazurskie voivodeships). The largest number of voivodeships classified into the group with an average level of development is located in the western part of Poland, while the voivodeships located at the eastern border present a low level of development. Development spans in a spatial arrangement are a consequence of, among others historical events taking place in the past, as well as contemporary development conditions. These results confirm the thesis that the socio-economic development in the regional dimension is characterized by a large diversity determined mainly by the specificity of voivodeships and the determinants of their development.

In the diversified socio-economic development of voivodeships, tendencies of decreasing disparities can be noticed. To verify this hypothesis, the coefficient of variation was determined for the values of the voivodeships belonging to the fuzzy subset of developed regions according to the dimensions of cohesion policy. The coefficient over the years 2005-2015 decreased in all dimensions, and a significant decrease was recorded especially in the economic dimension. Thus, changes in the level of the coefficient confirmed the original assumption.

The obtained results using the fuzzy sets method are reliable and comparable with the results obtained in studies devoted to this issue, prepared, among others, by the European Commission[2] or the ministry responsible for development[3]. The results encourage further work on the use of these methods in the analysis of development level diversification, including more advanced computational techniques. Thus, the second hypothesis concerning the method of fuzzy sets as an effective tool for studying the diversification of regional development has also been confirmed.

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[2] European Commission, *My region, my Europe, our future - Seventh report on economic, social and territorial cohesion*, COM (2017) 583 final, Brussels 9/10/2017.
[3] Ministry of Development, *The impact of cohesion policy on socio-economic development of Poland and regions in 2004-2015*, Warsaw 2016

The third partial hypothesis, assuming that there is no economic, social and territorial polarization phenomenon in the area of regional development was also confirmed. The observed changes did not cause a drop in the number of voivodeships presenting the average level of development, and the designated MBH index pointed to the convergence process in the analyzed period, especially in the economic and territorial dimension.

The analysis showed both the potentials and development gaps of the voivodeships. The results of the conducted analysis can be a significant support in taking actions to further create the socio-economic development of the regions. A good example of the fact that the level of development should be studied, taking into account its various aspects, is Warmińsko-mazurskie voivodeship, which in the economic dimension achieved one of the weakest results, while in the territorial dimension it was unmatched. All this results come from the specificity of this province, the small development of the areas and charming landscapes that are the advantages of this region.

The extension of the analysis with the polarization index in the field of regional development has increased the scope of information on the level of development and observed trends. The results in this respect did not confirm the polarization taking place, which seems particularly advantageous in the context of cohesion policy.

In the new concept of sustainable development an increased role of social development is observed. The main goal of the concept of sustainable development is to maximize social welfare. The existing dependencies between its three dimensions, i.e. economic, social and environmental, and their changes imply positive or negative social effects. In addition, a relatively large scale of changes in social processes is observed. Hence the need to monitor social development and eliminate disproportions in the development of various social groups.

All kinds of analyzes of regional development, including those of a multidimensional character, constitute an indispensable element of the implemented cohesion policy, serving first of all to assess the effects of this policy. Analyzes using a new approach in the form of a research tool or substantive scope contribute to an ever better study of regional inequalities. The solutions used in this dissertation may also be an important contribution to research in this area.

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