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ANALYSIS OF REGIONAL DIFFERENTIATION OF POLAND'S AGRICULTURE IN THE YEARS 2016-2022

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Abstract: The work is a continuation of a series of works by A. Binderman-Dubik, published in the years 2004-2013, concerning the regional differentiation of Polish agriculture, in which she used two patterns (models): negative and positive. These studies showed the superiority of the two-pattern methods used over the single-pattern methods. Here, methods based on three patterns (negative, positive, indirect) are used. The author uses the method considered by the authors: Binderman Z., Borkowski B., Szczesny W. [2020].

Keywords: agricultural differentiation, synthetic measures, utility function, classification

JEL classification: C38, O18, Q1, R1

INTRODUCTION

Research by many authors has shown that the indicators of the development of Polish agriculture have clearly increased after Polish's accession to the European Union. Nevertheless, despite such a significant increase, the level of agricultural differentiation the provinces is not decreasing, and what is more, it shows an upward tendency. This was shown, among others, by the author's work [Binderman A. 2004, 2007, 2012], which examined the regional differentiation of agriculture in the periods 1989-1998, 1998-2005, and 1998-2010, respectively. The obtained results showed that in relation to the adopted characteristics, regional differentiation is clearly increasing. This paper shows that also in the years 2016-2022 the regional differentiation of agriculture increased. The pandemic and the war in Ukraine have not disrupted this trend. Compared to the economically developed countries of Western Europe [Fogelfors, H. (ed.) 2009; Rabinowicz E. 2020], Poland is a country with a significant agricultural production potential. In addition, the diversity of natural and economic and organizational conditions means that the degree of

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utilization of the potential of agriculture is regionally differentiation [Harasim 2006, 2009; Krasowicz, Kukuła 2006; Nermend, Miłaszewicz 2016; Poczta, Bartkowiak 2012; Zegar 2003]. In order to analyze complex phenomena, such as the level of development or the potential of agriculture, and to assess voivodships in this respect, it is necessary to consider many factors. The use of the potential of agriculture in the regions is a derivative of the impact of various groups of conditions, both favorable and restrictive.

The analyses show that Polish voivodships have significant resources of basic production factors and relatively favorable natural conditions. One of the main reasons for the low utilization of the potential of agriculture in Poland is the insufficient development of the agri-food industry. A significant part of the agricultural commodity production of the voivodships are raw materials for processing, and not processed products, characterized by a higher share of the so-called added value. The National Agricultural Censuses 2010, 2020 (NAC 2010, NAC 2020) showed that in the period of years 2010-2020 the importance of farms focused on market production increased. In the total number of farms, the number of the largest and smallest units increased, with an increase in the average area of the farm.

METHODS OF CONSTRUCTION FOR INIDICATORS OF DIFFERENTIATION

Ordering composed phenomena characterized in a summary way synthetic (aggregate) variables are used. The substitution of a sequence of many explanatory features by a synthetic variable gives a certain assessment of the phenomenon under study. Pattern methods assume the existence of a hypothetical model object. These methods use appropriately selected diagnostic variables characterizing the studied phenomenon and differ from each other as to the method of normalization of variables and the form of aggregate functions [Cieślak 2023; Hellwig 1968; Kukuła K. 2000; Malina 2004; Młodak 2006; Kisielińska 2021; Nowak 1990, Zeliaś 2000]. In this paper, both two patterns and three patterns will be used at the same time.

Let $X=\Re^n$, $\Re=(-\infty,\infty)$, $n\in\mathrm{N}$, denotes an n-dimensional vector space. Consider the problem of ordering $m\in\mathrm{N}$ objects $\mathbf{Q}_1$, $\mathbf{Q}_2$,...,$\mathbf{Q}_m$ by $n\in\mathrm{N}$ variables (features) meant to describe each of them. Without losing the generality of the considerations, let us assume that all features may be considered as stimulant. The symbol $\mathbf{x}_i=\left(x_{i1},x_{i2},\ldots,x_{in}\right)\in X$, for $i=1,2,\ldots,m$, will denote the vector of values of variables describing the i-th object $\mathbf{Q}_i$. Assume that $\mathcal{W}^*:=\{\mathbf{x}_1,\mathbf{x}_2,\ldots,\mathbf{x}_m\}$ denotes the set of vectors describing the objects $\mathbf{Q}_1$, $\mathbf{Q}_2$,...,$\mathbf{Q}_m$. We say that $\mathbf{x}_i>\mathbf{x}_j$, $(\mathbf{x}_i\geq\mathbf{x}_j)$ $(i,j=1,\ldots,m)$ if $x_{ik}>x_{jk}\,(x_{ik}\geq x_{jk})$ for $k=1,2,\ldots,n$. On the other hand, $\mathbf{Q}_0$, $\mathbf{Q}_{m+1}$ and $\mathbf{Q}_{sr}$ will denote objects described by vectors with coordinates:

$$x_{0,k} = \min_{1 \le i \le m} x_{ik}, \quad x_{m+1,k} = \max_{1 \le i \le m} x_{ik}, \quad x_{sr,k} = \frac{1}{m}\sum_{i=1}^{m} x_{ik}; \; k = 1, 2, \ldots, n.$$

It is obvious that the objects: **Q**$_0$ – described by the vector **x**$_0$ and **Q**$_{m+1}$ – described by the vector **x**$_{m+1}$ are respectively not worse or better than the remaining objects **Q**$_1$, **Q**$_2$,...,**Q**$_m$. The components of the vector **x**$_{sr}$ are the averages of the components of the vectors under consideration, respectively. Directly from the definition, holds the inequality $\mathbf{x}_0 \le \mathbf{x}_{sr} \le \mathbf{x}_{m+1}$. The three objects **Q**$_0$, **Q**$_{sr}$ and **Q**$_{m+1}$ (perhaps fictitious) can be treated as patterns (extra models) added to the initial, input objects **Q**$_1$, **Q**$_2$,...,**Q**$_m$. Let d*(**x**,**y**) be the Euclid distance between the vectors $\mathbf{x},\mathbf{y} \in \Re_+^n$ and d*(**x**$_0$,**x**$_{m+1}$)≠0. The most well-known synthetic indicators in the literature built on the basis of patterns intended for ordering objects are following measures:

$$\mu_1(\mathbf{x}) = d^*(\mathbf{x}_0, \mathbf{x}) / d^*(\mathbf{x}_0, \mathbf{x}_{m+1}) \tag{1}$$

$$\mu_2(\mathbf{x}) = 1 - d^*(\mathbf{x}_{m+1}, \mathbf{x}) / d^*(\mathbf{x}_0, \mathbf{x}_{m+1}) \tag{2}$$

$$\mu_3(\mathbf{x}) = \frac{\mu_1(\mathbf{x}) + \mu_2(\mathbf{x})}{2} = \frac{1}{2} + \frac{d^*(\mathbf{x}_0, \mathbf{x}) - d^*(\mathbf{x}_{m+1}, \mathbf{x})}{2d^*(\mathbf{x}_0, \mathbf{x}_{m+1})} \tag{3}$$

$$\mu_4(\mathbf{x}) = \frac{\mu_1(\mathbf{x})}{1 + \mu_1(\mathbf{x}) - \mu_2(\mathbf{x})} = \frac{d^*(\mathbf{x}_0, \mathbf{x})}{d^*(\mathbf{x}_0, \mathbf{x}) + d^*(\mathbf{x}_{m+1}, \mathbf{x})}, \tag{4}$$

for **x**∈**[x**$_0$,**x**$_{m+1}$**]**.

As you can see, the μ_1 and μ_2 measures use a single model, while the μ_3 and μ_4 measures use two model, expressed as elementary functions of the μ_1 and μ_2 meters. In the paper [Hellwig 1968] a measure based on only single model (best model) is given. The theory and applications of the μ_3 measure are given in the series of works by A. Binderman **[**Binderman A. 2006, 2007, 2011**]** and in the work **[**Binderman Z. 2010**].** The μ_4 measure is related to the TOPSIS method) **[**Hwang, Yoon 1981**]**. In the next part of our discussions, let us normalize the distance d*(**x**,**y**) of the vectors $\mathbf{x},\mathbf{y} \in \Re_+^n$, relative to the assumed model vectors **x**$_o$, **x**$_{m+1,}$ using the formula:

$$d(\mathbf{x}, \mathbf{y}) := \frac{d^*(\mathbf{x}, \mathbf{y})}{d^*(\mathbf{x}_0, \mathbf{x}_{m+1})}.$$

Then $d(\mathbf{x}_0, \mathbf{x}_{m+1}) = 1$ a formulas (1)-(4) take for **x**∈**[x**$_0$,**x**$_{m+1}$**]** the form:

$$\mu_1(\mathbf{x}) = d(\mathbf{x}_0, \mathbf{x}) \qquad (1a)$$

$$\mu_2(\mathbf{x}) = 1 - d(\mathbf{x}_{m+1}, \mathbf{x}) \qquad (2a)$$

$$\mu_3(\mathbf{x}) = \left[1 + d(\mathbf{x}_0, \mathbf{x}) - d(\mathbf{x}_{m+1}, \mathbf{x})\right] / 2 \qquad (3a)$$

$$\mu_4(\mathbf{x}) = d(\mathbf{x}_0, \mathbf{x}) / \left(d(\mathbf{x}_0, \mathbf{x}) + d(\mathbf{x}_{m+1}, \mathbf{x})\right). \qquad (4a)$$

It is easy to see that the considered measures, defined by formulas (1a) - (4a) are standardized in relation to the accepted patterns, i.e. :

$\mu_i(\mathbf{x}_0) = 0$, $\mu_i(\mathbf{x}_{m+1})=1$ and $0 \leq \mu_i(\mathbf{x}_{sr}) \leq 1$ for $i=1,2,3,4$,

where *m* is the number of objects considered. These measures are standardized utility functions [Panek 2000; Binderman Z. Borkowski, Szczesny 2020]. Note that if a given utility function u induces preference relations in the set of *m*+3 objects

$$\mathcal{W} := \mathcal{W}^* \cup \{ \mathbf{x}_0, \mathbf{x}_{m+1}, \mathbf{x}_{sr}\} = \{\mathbf{x}_0, \mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_m, \mathbf{x}_{m+1}, \mathbf{x}_{sr} \},$$

then a composite function g($u(\mathbf{x})$), where g: $\Re \to \Re$ is an increasing function, as well as a utility function, generating the same preference relation in the set of objects $\mathcal{W}$ as the function u($\mathbf{x}$).

Using the above property, it is expedient to normalize the utility function by choosing such a function g that its value for the worst object $\mathbf{x}_0$ is equal to 0, and the value for the best object $\mathbf{x}_{m+1}$ is equal to 1, i.e. that:

1. g(u($\mathbf{x}_0$)) =0 ; 2. g(u($\mathbf{x}_{m+1}$)) =1.

Using the well-known forms of the u($\mathbf{x}$) function in our work (realizing that there are infinitely many such functions), we give an example of such a function of one variable *g*(u), which would satisfy one more condition:

3. g(u($\mathbf{x}_{sr}$))=1/2.

The simplest function that satisfies these above three conditions is the linear picewise function [Binderman Z., Borkowski, Szczesny 2020]

$$g(u) = \begin{cases} \frac{1}{2\alpha} u & dla \ 0 < u < \alpha \\ \frac{(u-1)}{2(1-\alpha)} + 1 & dla \ \alpha \leq u \leq 1 \end{cases} \qquad (5),$$

where α:= u($\mathbf{x}_{sr}$).

EMPIRICAL RESEARCH

A set of ten features was selected to describe the regional differentiation of agriculture after the analysis. All the selected variables were stimulant, which means that higher values of these features informed about a higher level of development of the studied phenomenon. The selected variables determine the overall level of agriculture in given years in Poland, at the same time making it possible to show the differences that occur between voivodships. Below is the final list of the ten selected diagnostic variables.

X_1	Share of agricultural area as % of total area.
X_2	Gross domestic product in zł., per 1 inhabitant.
X_3	Sugar beet yield in tons per 1 hectare.
X_4	Stocking density of cattle per 100 hectares of agricultural land.
X_5	Purchase of potatoes in kilograms per 1 hectare of agricultural land.
X_6	Yields of oilseeds in dt per 1 hectare of cultivated area.
X_7	Purchase of fruit from trees in kg per 1 hectare of cultivated area.
X_8	Total purchase value of agricultural products in zł per 1 ha of agricultural land.
X_9	Global crop production per 1 ha of agricultural land in zł, according to the new definition.
X_{10}	Capital expenditures in agriculture, forestry and hunting, in zł per 1 ha of agricultural land, current prices.

The data considered in the paper do not include the results of the National Agricultural Census (NAC, NSR - polish), conducted in 2020 by the Central Statistical Office (CSO, GUS -polish). The results of the work are used only by the data of the CSO. It is worth mentioning here that the comparison of the results of NAC 2010 and NAC 2020 shows that the number of farms decreased significantly, while the average total area and agricultural area increased at the same time [CSO NAC 2020]. On farms, the number of livestock per 100 hectares of agricultural land increased in the number of cattle with a marked decrease in the number of pigs. The area of orchards decreased significantly (by approx. 14%).

The data analyzed in the paper can be presented by means of a three-dimensional matrix (*voivodship × value of feature × year*), or by means of a matrix in which each row represents an object represented by the features of a given voivodship in a given year. In the work, the latter method was chosen. Proceeding in this way, $m=16\times7=132$ objects $\mathbf{Q}_1,\mathbf{Q}_2,\dots,\mathbf{Q}_{132}$ were obtained, each of which was described by $n=10$ features $X_1,X_2,\dots,X_{10}$. The values of the adopted diagnostic variables for 16 voivodships and for 7 years (2016-2022) formed a matrix $\mathbf{X}$, the matrix with dimensions of 10×132. On the basis of the values assumed by the diagnostic variables for 16 voivodships in the individual 7 years of the studied period, three fixed (static), hypothetical voivodships were created: "minimal" ("the worst" in relation to each voivodship) $\mathbf{Q}_0$, "maximum" ("the best" in relation to each voivodship) Q_{133} and Q_{134} "average", Objects $\mathbf{Q}_0, \mathbf{Q}_{133}$ described appropriately by the least, most favorable set of feature values. The "mean" object Q_{134} is described by the average values of the features under consideration between 2016 and 2022. The hypothetical provinces $\mathbf{Q}_0, \mathbf{Q}_{133}, \mathbf{Q}_{134}$ in this paper will be represented by vectors $\mathbf{x}_0$, $\mathbf{x}_{133}$ and $\mathbf{x}_{134}$ with 10 components each, respectively. These vectors are the benchmark models for the entire period 1998-2010, they determine the cube $[\mathbf{x}_0,\mathbf{x}_{133}]$ in n-dimensional Euclid space $\Re_+^n$, which means that for every $i \in [1,132]$: $\mathbf{x}_i \in [\mathbf{x}_0,\mathbf{x}_{133}]$. In this way, a data matrix was obtained for further analysis, $\mathbf{X} = \left[x_{ij}\right]_{135\times 10}$ with 135 rows and 10 columns. Since the selected diagnostic variables had different titers and different orders of magnitude, these variables were normalized. In order to reduce the variables to comparability, zero unitarization was selected and applied from among many types of norming. The choice of the method of normalizing variables was a consequence of the results obtained by the author (Binderman A 2006, 2010). Normalized values for individual variables with m=135, n=10 were calculated according to the formulas [Kukuła K. 2000]:

$$z_{ij} = \left(x_{ij} - x_{0j}\right) / \left(x_{m+1j} - x_{0j}\right) \quad \text{for } 0 \le i \le 134,\ 1 \le j \le 10 \tag{6}$$

The features transformed in this way, by eliminating the units of measurement, became mutually comparable. The z_{ij} variables transformed by the zero unitarization method (MUZ) take values in the closed interval [0,1]. The transformations made can be symbolically written: $\mathbf{Z}=[z_{ij}]_{135\times 10}=\varphi(\mathbf{X})$, where $\mathbf{X}$ is the observation matrix,. After the transformation of the variables, the static pattern vectors are as follows:

$$\mathbf{z}_0 = \mathbf{0} := [0,0,...,0],\ \mathbf{z}_{133} = \mathbf{1} := [1,1,...,1],$$

i.e. in the created **Z** matrix**,** the first row consists of only zeros, while the penultimate row consists of only ones.

RESEARCH RESULTS

Let $\mathbf{w}_1, \mathbf{w}_2, ..., \mathbf{w}_{16} \in \Re_+^7$ $\left(\mathbf{w}_{1s}, \mathbf{w}_{2s}, ..., \mathbf{w}_{16s} \in \Re_+^7\right)$ denote vectors, assigned alphabetically to voivodeships ($\mathbf{w}_1$ – Dolnośląskie,...,$\mathbf{w}_{16}$ – Zachodniopomorskie), whose components are the values of the m($\mathbf{z}$) ($m_s(\mathbf{z})$), measure of development in the individual, seven years of the period 1998-2010, where m($\mathbf{z}$) ($m_s(\mathbf{z})$) is determined by the formula (3a) ((5)). Table 1 shows the results of the research, in which the rows are the coordinates of the vectors $\mathbf{w}_1$, $\mathbf{w}_2$,...,$\mathbf{w}_{16}$ ($\mathbf{w}_{1s}$, $\mathbf{w}_{2s}$,...,$\mathbf{w}_{16s}$).

Table 1. Values of the measures $m(\mathbf{z})$, $m_s(\mathbf{z})$ for the voivodships

Voivodships	Measure of development	2016	2017	2018	2019	2020	2021	2022
Dolnośląskie	w_1	0.35	0.38	0.35	0.33	0.38	0.41	0.40
	w_{1s}	0.44	0.48	0.45	0.41	0.48	0.51	0.51
Kujawsko-pomorskie	w_2	0.39	0.44	0.38	0.39	0.46	0.47	0.50
	w_{2s}	0.50	0.54	0.48	0.50	0.55	0.56	0.59
Lubelskie	w_3	0.34	0.36	0.37	0.35	0.41	0.41	0.46
	w_{3s}	0.43	0.46	0.47	0.44	0.51	0.51	0.55
Lubuskie	w_4	0.24	0.29	0.17	0.18	0.20	0.24	0.27
	w_{4s}	0.30	0.36	0.21	0.22	0.26	0.31	0.35
Łódzkie	w_5	0.40	0.45	0.42	0.43	0.50	0.50	0.54
	w_{5s}	0.51	0.54	0.52	0.53	0.59	0.58	0.62
Małopolskie	w_6	0.35	0.36	0.35	0.35	0.37	0.39	0.39
	w_{6s}	0.45	0.46	0.45	0.44	0.46	0.49	0.49
Mazowieckie	w_7	0.50	0.52	0.57	0.57	0.63	0.64	0.71
	w_{7s}	0.59	0.61	0.65	0.65	0.70	0.70	0.76
Opolskie	w_8	0.37	0.38	0.39	0.39	0.40	0.48	0.47
	w_{8s}	0.47	0.48	0.50	0.50	0.50	0.57	0.56
Podkarpackie	w_9	0.25	0.23	0.26	0.23	0.26	0.28	0.27
	w_{9s}	0.31	0.29	0.33	0.29	0.33	0.36	0.35
Podlaskie	w_{10}	0.43	0.46	0.44	0.43	0.49	0.55	0.54
	w_{10s}	0.53	0.56	0.54	0.53	0.58	0.63	0.62
Pomorskie	w_{11}	0.36	0.40	0.40	0.41	0.42	0.46	0.47
	w_{11s}	0.46	0.51	0.51	0.52	0.53	0.55	0.56
Śląskie	w_{12}	0.35	0.40	0.33	0.40	0.37	0.43	0.43
	w_{12s}	0.44	0.51	0.42	0.51	0.47	0.53	0.53
Świętokrzyskie	w_{13}	0.33	0.33	0.33	0.32	0.36	0.36	0.39
	w_{13s}	0.42	0.42	0.42	0.41	0.46	0.46	0.50
Warmińsko-mazurskie	w_{14}	0.28	0.35	0.32	0.35	0.37	0.38	0.40
	w_{14s}	0.36	0.44	0.41	0.45	0.48	0.48	0.50
Wielkopolskie	w_{15}	0.61	0.60	0.58	0.59	0.65	0.70	0.75
	w_{15s}	0,68	0.67	0.65	0.66	0.71	0.75	0.79
Zachodnio-pomorskie	w_{16}	0.28	0.25	0.20	0.26	0.31	0.32	0.33
	w_{16s}	0.36	0.32	0.25	0.33	0.40	0.40	0.42
gap	w	0.37	0.37	0.41	0.42	0.44	0.46	0.48
	w_s	0.37	0,38	0.44	0.44	0.45	0.44	0.45
average	w	0.36	0.39	0.37	0.37	0.41	0.44	0.46
	w_s	0.45	0.48	0.45	0.46	0.50	0.53	0.54

Source: Author's own calculations

In Table 1, for example, the components of the vector $\mathbf{w}_1$ are the values of the $m(z)=\mu_{3(}\mathbf{z})$ measure, calculated according to the formula (3a)) for the Dolnośląskie Voivodeship in each year of the period 2016-2022 under consideration. On the other hand, the components of the vector $\mathbf{w}_{1s}$ form the values of the measure $m_s(\mathbf{z})=$ $=g(m(\mathbf{z}))$, calculated according to the formula (5).It should be noted that the values of the range (max-min) given in Table 1 show the growing diversity of voivodships in the years 2016-2022. Differentiation increased by nearly 30% (22%) in this period when determining development coefficients according to the formula (3a) ((5)). The designated measures made it possible to make a ranking of the objects under consideration. As it is easy to see directly from the definition of the functions $m=\mu_3$ and g(m), defined by formulas (3a), (5), it follows accordingly that the function g does not change the relation of preferences in the set of vectors $\mathcal{W}$, induced by the utility function m.

The tables below present the classification of voivodships, according to the obtained measures of the level of development in the years 2016-2022.

Table 2. Classification of voivodships in 2016-2022

Voivodships	2016	2017	2018	2019	2020	2021	2022	2016-2021
Dolnośląskie	9	9	10	12	9	10	10	10
Kujawsko-pomorskie	5	5	7	7	5	6	5	5
Lubelskie	11	11	8	11	7	9	8	9
Lubuskie	16	14	16	16	16	16	16	16
Łódzkie	4	4	4	3	3	4	3	4
Małopolskie	8	10	9	10	12	11	13	11
Mazowieckie	2	2	2	2	2	2	2	2
Opolskie	6	8	6	8	8	5	7	7
Podkarpackie	15	16	14	15	15	15	15	15
Podlaskie	3	3	3	4	4	3	4	3
Pomorskie	7	7	5	5	6	7	6	6
Śląskie	10	6	12	6	11	8	9	8
Świętokrzyskie	12	13	11	13	13	13	12	13
Warmińsko-mazurskie	13	12	13	9	10	12	11	12
Wielkopolskie	1	1	1	1	1	1	1	1
Zachodnio-pomorskie	14	15	15	14	14	14	14	14

Source: Author's own calculations

Analyzing the arrangement of voivodships according to the level of utility, it can be seen that in the analyzed period the Wielkopolskie and Mazowieckie voivodships were at the top of the ranking list. The final places were taken by the Zachodniopomorskie Voivodeship, the Podkarpackie Voivodeship, and the Lubuskie Voivodeship in the last place.

Using the results of calculations presented in Table 1, voivodships were divided into 4 groups, characterized by a similar level of agricultural development. The division of voivodships into classes for the entire period under study was based on the values of the average measure of development. For this purpose, distributive interval series were used, in which the spans of class intervals were equal to approximately one-quarter of the range for the entire period.

To group the voivodships into four groups I, II, III and IV, the upper class boundaries given in Table 3 below were used, in relation to the method of calculating the development rate and years.(the calculations obtained by the function $m=\mu_3$ –

the first four rows, the calculations obtained by the function g(m) – last four rows), the function m, g(m) are defined by formulas (3a), (5)

The results of the grouping of voivodships for the analyzed period are presented in Table 4. Analyzing the regional diversity of agriculture in Poland, four typological groups of voivodships were distinguished.

Table 3. Upper Class Boundaries , according to the method of calculating the synthetic measures in the years 2016-2022

class	2016	2017	2018	2019	2020	2021	2022
IV	0.33	0.32	0.27	0.28	0.31	0.36	0.39
III	0.42	0.42	0.37	0.38	0.42	0.47	0.51
II	0.52	0.51	0.48	0.49	0.53	0.59	0.63
I	0.61	0.60	0.58	0.59	0.65	0.70	0.75
IV	0.396	0.388	0.323	0.333	0.369	0.422	0.457
III	0.489	0.483	0.433	0.443	0.482	0.532	0.568
II	0.583	0.578	0.542	0.554	0.595	0.643	0.680
I	0.676	0.673	0.652	0.664	0.708	0.754	0.792

Source: Author's own calculations

Table 4. Division of voivodships into groups according to the method of calculating the synthetic measures in the years 2016-2022

I	Wielkopolskie, Mazowieckie
II	Łódzkie, Podlaskie, Pomorskie
III	Kujawsko-pomorskie, Dolnośląskie, Małopolskie , Śląskie, Świętokrzyskie, Warmińsko-mazurskie, Lubelskie, Opolskie
IV	Lubuskie, Podkarpackie, Zachodnio-pomorskie
I	Wielkopolskie, Mazowieckie
II	Łódzkie, Podlaskie, Kujawsko-pomorskie, Dolnośląskie, Opolskie
III	Lubelskie, Małopolskie, Śląskie, Świętokrzyskie, Warmińsko-mazurskie, Pomorskie
IV	Lubuskie, Podkarpackie, Zachodnio-pomorskie

Source: Author's own calculations

A synthetic summary of results indicates that Poland is a country clearly differentiated in terms of the level of agricultural development. The change in the method of calculating voivodeship development indices used in the paper, without changing the order, changes their grouping. Regardless of the method of calculating the measure of development, the highest rated group I includes the Wielkopolskie and Mazowieckie voivodships, the second group is Łódzkie and Podlaskie voivodships, the third group is Śląskie, Świętokrzyskie and Warmińsko-Mazurskie groups, and the fourth group is Lubuskie, Podkarpackie and Zachodniopomorskie. The fourth group includes voivodships that are characterized by the lowest level of agricultural development in Poland, according to the adopted characteristics and research methodology. In almost every year of the period under consideration, the lowest level of agricultural development was shown by the Lubuskie voivodeship. Comparing the obtained results with the results of the work [Binderman A. 2007, 2012] it is possible to observe a clear progress and advancement of the following voivodeships: Mazowieckie, Łódzkie, Podlaskie, a slight increase in the following voivodeships: Podkarpackie, Lubuskie, Małopolskie and Zachodnio-Pomorskie.

CONCLUSION

The results of the conducted research showed that the indicators of development of Polish agriculture clearly increased in the studied period 2016 – 2022. Despite this significant increase, the level of diversification of agricultural development in Polish voivodships is not decreasing, and what is more, it shows an upward tendency. In order to confirm this phenomenon, it is advisable to carry out a further, multidimensional analysis of the existing dependencies. The change in the method of calculating voivodeship development indices used in the paper, without changing the order, only changes their grouping.

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