agriculture

MDPI

Article

Spatial Differentiation of Agricultural Potential and the Level of Development of Voivodeships in Poland in 2008–2018

Piotr Prus [1,*], Paweł Dziekański [2], Małgorzata Bogusz [3] and Małgorzata Szczepanek [4]

1 Laboratory of Economics and Agribusiness Advisory, Department of Agronomy, Faculty of Agriculture and Biotechnology, UTP University of Science and Technology in Bydgoszcz, 430 Fordońska St., 85-790 Bydgoszcz, Poland
2 Department of Economics and Finance, Jan Kochanowski University in Kielce, Uniwersytecka 15 str., 25-406 Kielce, Poland; pawel.dziekanski@ujk.edu.pl
3 The Faculty of Agriculture and Economics, University of Agricultue in Krakow, 21 Mickieiwcza Av., 31-120 Kraków, Poland; malgorzata.bogusz@urk.edu.pl
4 Department of Agronomy, Faculty of Agriculture and Biotechnology, UTP University of Science and Technology in Bydgoszcz, 7 Kaliskiego St., 85-796 Bydgoszcz, Poland; malgorzata.szczepanek@utp.edu.pl
* Correspondence: piotr.prus@utp.edu.pl; Tel.: +48-52-340-80-84

Abstract: Polish agriculture is characterized by regional differentiation. These differences affect the production potential, generate income, or development which is an indispensable element of economic efficiency. The aim of the article is to assess the spatial diversification of agriculture potential in relation to the development of voivodeships in Poland using a synthetic measure. Choice of variables in 2009–2018 was conditioned by the availability of data collected in the city system at the Central Statistical Office. Method of Technique for Order Preference by Similarity to an Ideal Solution was used to build synthetic measures. The synthetic measure of agricultural potential in voivodships in Poland was negatively correlated with the measure of the natural environment, the measure of infrastructure, the number of unemployed and the area of forest land. It was correlated with the area of arable land, number of tractors, cattle population, pigs and the production of milk, basic crops, sugar beet. The measure of the voivodeship development is negatively correlated with the synthetic measure of agricultural potential, area of arable land, arable land and number of people employed in agriculture. Conclusions drawn may allow local governments to define potential directions of optimization of socio-economic development of rural communes.

Keywords: economic development; synthetic measure; voivodship; agricultural potential; statistics Morana

Citation: Prus, P.; Dziekański, P.; Bogusz, M.; Szczepanek, M. Spatial Differentiation of Agricultural Potential and the Level of Development of Voivodeships in Poland in 2008–2018. *Agriculture* **2021**, *11*, 229. https://doi.org/10.3390/agriculture11030229

Academic Editor: Sanzidur Rahman

Received: 4 February 2021
Accepted: 5 March 2021
Published: 10 March 2021

1. Introduction

Polish agriculture is characterized by regional differentiation. They are shaped by demographic, natural, economic, as well as historical and many other conditions. The low level of development, concentration of agricultural land in small and medium-sized farms or high employment in the agricultural sector hinder the process of multifunctional and sustainable development of rural areas. It is important that the concentration processes in agriculture become more intense, which would allow more rational use of the existing labor force [1]. Differences in the spatial level of agricultural development affect the production potential, efficiency and ability to generate income. The integration of the state policy with the rural development policy is necessary to compensate for the existing disproportions [2].

Agriculture is an important sector of the Polish economy. It is the source of the most important product of mankind. It also affects the socio-economic situation of rural inhabitants and the condition of the natural environment. Agriculture is a pillar of the agribusiness sector and an element of the food chain, whose share in total production and employment is high compared to other sectors of the economy [3,4].

Apart from international and regional processes, those of a local (regional) nature are shaped by the development taking place in the region's economy [5]. Their role is even more important as they are directly associated with human social and economic activity, which is carried out in a defined place and time. Development is an enormous and complex concept, which results from the variety of goals it is to serve and the variety of activities that shape it. Socio-economic development is a set of changes directed at increasing satisfaction of the needs (collective and individual) of the people of the local community. The spatial polarization of development in the current economy occurs mainly between cities (areas of regional growth) and peripheral areas. The development opportunities of individual areas are hugely determined by functional links between regions, access to raw materials or distance from potential sales markets. New development factors include, mainly, the quality of human capital or the quality of business environment institutions. The subject of spatial dependencies was dealt with, among others, by Kopczewska (2006), Zeliaś (1991) [6,7].

The aim of the article is to assess the spatial differentiation of the potential of agriculture in relation to the development of voivodeships in Poland using a synthetic measure. Voivodship is a local government unit, a regional self-government community, the highest level of the territorial division in Poland, created to perform public administration. Difficulties in the description and measurement of the phenomena occurring in agriculture result from the variety of processes and variables used in the processes taking place in the development of the local economy. This is because of regional differentiation of production conditions, demographic and social processes, financial resources. The synthetic measure was developed in accordance with the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method. It helps us to compare units in a multidimensional space and sort them in a ranking according to the adopted criterion. Empirical data (available at the voivodeship level) were obtained from the Local Data Bank of the Central Statistical Office (BDL GUS) in the period of 2009 to 2018 for 16 voivodeships of Poland.

The main objective of the article was to achieve the answer to the research question. The basic question was: Whether and how the agricultural potential of voivodships depends on variables influencing development (endogenic social and economic variables). Successively, answers were sought to the following questions: What is the spatial distribution of development and agriculture potential? Which of the endogenic potential variables shape the level of agriculture and which of development? To what extent do transfers from the state budget shape the level of the financial situation, including development and agriculture?

2. Literature Review

The basic manifestation of human activity in the natural environment is agriculture. It is also an important branch of the national economy. Polish agriculture is characterized by a different degree of production use. It is related to a significant diversity of soil and climatic conditions. As pointed out by S. Krasowicz and J. Igras [8], natural conditions are less and less important for the production potential, and the role of organizational and economic factors (e.g., human capital) is growing. This subject was dealt with, among others, by W. Poczta and F. Wysocki [9], W. Poczta and N. Bartkowiak [10]. Differences in the spatial level of agricultural development affect the production potential, efficiency and ability to generate income. The integration of the state policy with the rural development policy is necessary to compensate for the existing disproportions [2].

The potential of agriculture is an enormous phenomenon that cannot be determined by one variable, but by many. The analysis of its level can be done one-dimensional (for each feature separately), however, a multidimensional approach seems to be more appropriate. One of the methods of analysis is the linear ordering of objects, based on synthetic variables determined on the basis of many features characterizing the studied phenomenon [11]. Examples of the use of linear ordering methods in agricultural economics were presented by A. Majchrzak and F. Wysocki [12]. Examples of works describing agriculture in Poland include the publications of F. Wysocki and A. Kozera [13], W. Poczta and N. Bartkowiak [10], L. Osowska and D. Janiszewska [14]. Individual authors used different tools characterizing the potential of agriculture, the common feature was that their size was independent of the size of the studied objects. Selected characteristics were usually converted into hectares (or 100 ha) or one employee.

The potential of agriculture is assessed in terms of the size of the resources of production factors and the mutual relations between them and the way of their use [13,15]. Its knowledge allows you to set directions in the development strategy of the agricultural sector of a territorial unit [16]. Both the quantity and quality of the accumulated agricultural potential factors should be taken into account [17].

Polish farms are forced to compete not only with each other, but also with farms from other countries. In order to cope with competition, they must increase land efficiency, take care of the quality of products, reduce production costs, make better use of fixed assets, use other resources more effectively, increase work efficiency and manage more efficiently [18]. The number of people employed in agriculture is also decreasing. Land resources per 1 employee are declining. In Polish agriculture, the gross value of fixed assets is systematically increasing. Common agricultural policy measures improved the technical equipment of farms. However, this situation concerns mainly development farms with sufficiently high potential. The high level of working resources in agriculture is not conducive to improving labor productivity, causing income and development problems for a large part of farms. The assessment of changes in farm production factor resources and the relationship between them is one of the most important assessments of changes in agriculture [19].

As a rule, the potential of agriculture is understood as all its organized production factors. According to F. Tomczak, this potential is determined by such factors as: natural resources, natural conditions, workforce resources, technical resources and economic conditions [20]. The potential of agriculture is determined by the location that includes environmental conditions (agroclimate, soil, water conditions, topography), economic (market, infrastructure, production services), and social conditions (labor market, social services, cultural services). This potential determines the competitive ability of the sector, and its effective use determines the competitive position. The skillful use of the potential determines the competitiveness of agriculture and is an element of the development of the agricultural sector [9,21].

The economic aspect indicates the satisfaction of today's needs and the needs of the next generations. The ecological aspect indicates no limitation of the use of the natural system. The social aspect is connected with education and getting skills to solve major social problems as well as participation in development activities [22,23]. This potential of communes is built by financial resources, professional activity of people, local labor market, infrastructure, the condition of the natural environment. B. Vermeulen and A. Pyka (2018) suggested that a certain group of factors is common, while others may occur and interact only in certain places and certain moments of time [24].

3. Materials and Methods

The level of socio-economic development, agricultural potential, demographic processes, potentials of the natural environment and infrastructure are mutually dependent phenomena. The indicated voivodship potentials constitute a difficult-to-measure category. It is difficult to express them with a single universal measure that would reflect all their important features while allowing for assessments of the surveyed regions [25]. They create a multidimensional space of functioning. Since they are interdependent when acting for the benefit of a given community, they should be considered jointly [26,27]. Due to the multidimensional nature of the phenomenon of development, an aggregate measure was built, which was used to measure individual conditions for the expansion of rural areas and the synthetic level of development. It was assumed in the study that the level of development is the result of individual components [28].

A set of variables (creating a potential set of indicators) was initially proposed for research on the potential of agriculture and the socio-economic development of voivodships. In the case of voivodships, the choice of variables was largely determined by the availability of statistical data collected in the BDL CSO (for the years 2008–2018). The difficulties related to the implementation of the research are related to changes in legal provisions regarding the income system, the scope of tasks performed by territorial units, budget reporting and reporting by statistical offices. Significant problems in spatio-temporal research (indicators are calculated for 10-year variables) include: changes in the administrative division (e.g., transformation of a commune from rural into urban–rural), changes in the socio-economic situation, random events. Therefore, in this article, the authors focused on selected variables described in Table 1.

Table 1. List of variables describing the financial situation and economic and social development of communes.

Number Variable	Name of Variables	Unit	S/D
	The potential of agriculture		
X1	share of agricultural land (UAA) in% of the total area of the voivodeship	%	s
X2	the share of arable land in% of the total area of the voivodeship	%	s
X3	working in (agriculture, forestry, hunting and fishing) in general	%	s
X4	unemployed living in rural areas in total unemployed	%	d
X5	Number of tractors per 100 ha of UAA	pcs.	s
X6	consumption of mineral fertilizers per 1 ha of agricultural land	kg	d
X7	consumption of calcium fertilizers per 1 ha of agricultural land	kg	d
X8	Cattle stock per 100 ha of arable land	pcs.	s
X9	Number of livestock Pigs (pigs) per 100 ha of arable land	pcs.	s
X10	Production of livestock for slaughter per 100 ha of agricultural land	kg	s
X11	Milk production per 1 ha of agricultural land	litr	s
X12	Egg production per 1 ha of agricultural land	kg	s
X13	Vegetable yields per 1 ha of agricultural land	kg	s
X14	Fruit harvest from trees per 1 ha of agricultural land	kg	s
X15	Yields Basic cereals per 1 ha of arable land	dt	s
X16	Potato yields per 1 ha of agricultural land	dt	s
X17	Yields of sugar beet per 1 ha of agricultural land	dt	s
X18	grain maize per 1 ha of agricultural land	dt	s
X19	green maize per 1 ha of arable land	dt	s
X20	rape and turnip rape per 1 ha of agricultural land	dt	s
	Development potential		
	Demographic potential and the labor market		
X21	Natural increase per 1000 inhabitants	person	S
X22	Balance of migration per 1000 inhabitants	person	S
X23	Demographic dependency rate for the elderly	person	D
X24	Population per km^2 (population density)	person	S
X25	The unemployed registered in communes per 1000 inhabitants	person	D
X26	People working in communes per 1000 inhabitants	person	S
	Economic potential		
X27	Entities entered in the REGON register per 1000 population	pcs.	S
X28	Foundations, associations and social organizations per 1000 inhabitants	pcs.	S
X29	total sold production of industry per capita	Zł	s
X30	Investment outlays per capita	zł	S
X31	Gross value of fixed assets in the national economy per capita	zl	s
X32	Natural persons running a business per 1000 population	pcs.	S
X33	Own income/total income (financial independence ratio)	%	S
X34	Transfer revenues/total revenues (financial state interference rate)	%	D
X35	Investment expenditures/total expenditures (investment attractiveness index)	%	S
	Potential of the natural environment		
X36	The area of forest land in the total area	%	S
X37	Emission of dust pollutants per 1 km^2	T	D
X38	Emission of gaseous pollutants per 1 km^2 in tonnes (D),	T	D

Table 1. *Cont.*

Number Variable	Name of Variables	Unit	S/D
X39	Total waste recovered per km^2	1000/t	s
X40	Legally protected areas in total	%	S
X41	Untreated industrial and municipal sewage per 1 km^2	dam3	D
X42	Wastewater treated during the year is treated together per 1 km^2	dam3	s
X43	Waste collected during the year, in total 1 km^2 of the area	t	d
X44	% Of the population using sewage treatment plants	%	S
	Infrastructure potential		
X45	housing per 1000 inhabitants	pcs.	S
X46	Users of installations in% of total population/water supply	%	S
X47	Users of installations in% of total population/sewage system	%	S
X48	Users of installations in% of total population/gas	%	S
X49	population per 1 library facility (including library points included in accordance with the seat of the parent unit)	pcs.	s
X50	Outpatient entities (as of December 31) outpatient clinics in total outpatient clinics per 10,000 Population	pcs.	s
X51	the population at a generally accessible pharmacy	pcs.	s
X52	beds in general hospitals per 1000 inhabitants	km	s
X53	public roads in total per 10 thousand Population	km	s
X54	accommodation places per 1000 people	pcs.	s

Foundations, associations and social organizations per 1000 inhabitants, Emission of dust pollutants per 1 km^2, Sewage treated annually together treated per 1 km^2, Waste collected during the year in total 1 km^2 of the area, Users of installations in% of the total population/sewage system, population per 1 the library facility (including library points recognized in accordance with the seat of the parent unit) was removed from further research due to the value of the coefficient of variation or correlations based on the merode of inverse correlation. Source: study based on Local Data Bank of the Central Statistical Office data.

The research was carried out in several successive stages. In the beginning, a set of simple variables describing the studied phenomenon was selected. The selected set of variables is presented in the form of an observation matrix in the form:

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} \quad (1)$$

where—denotes the values of the *j*-th feature for the *i*-th object, *i*—object number ($i = 1, 2, \dots, n$), *j*—variable number ($j = 1, 2, \dots, m$) [29–32].

In the next stage, the nature of each of the selected variables was examined, distinguishing stimulants (S) and destimulants (D), taking into account the substantive importance of the feature and its correlation connections. Most of the variables are of an obvious nature (it results from the substantive experience of the researcher and the analysis of the literature). In doubtful cases, the procedure of Grabiński (1985) can be used, which uses the fact that stimulants should be positively correlated with each other, similarly to destimulants, and negatively with destimulants [33].

Variables characterized by a greater discriminant ability (limit value of the coefficient of variation equal to 0.10) and a low correlation with others (a diagonal element in the inverse correlation matrix significantly exceeding 10) were removed from the structure of the synthetic measure [34,35].

All variables selected for the analysis are characterized by sufficient discriminant ability and are slightly correlated with the others. The analyzed indicators can be related to the three dimensions of cohesion, which is the European Union's objective of public authorities' actions in the implementation of regional policy, with economic, social and territorial cohesion.

Table 2 lists the basic descriptive parameters of the variables belonging to the final set, which are the basis for the construction of the synthetic measure. All the variables selected for the analysis are characterized by sufficient discriminant ability (spatial variability exceeds the assumed threshold Vj > 10%, low correlation). The value of the coefficient of variation for the variables used in the construction of the synthetic measure ranged from −1.63 to 1.942 in 2008 and −3.708 to 2.349 in 2018. The greatest differentiation was recorded in the variables X39, X38, X21, X18 in 2009 and X39, X38, X19, X9 in 2018. The smallest ones occurred for the variables X23, X46, X45, X22 in 2009 (X23, X46, X21, X22 in 2018). Moreover, it should be noted that 38 variables (in 2018; 40 in 2009) are characterized by a positive asymmetry, which in the case of stimulants (36 in the set) is not a favorable situation, as it means that a greater number of units has values of these variables lower than their values' average.

Table 2. Statistical characteristics of diagnostic variables in eastern Polish communes.

NumberVariable	R	SD	V_x	As	R	SD	V_x	As
	2008				2018			
The potential of agriculture								
X1	30.70	8.60	0.14	−0.58	30.00	8.54	0.14	−0.58
X2	0.27	0.08	0.19	−0.08	0.26	0.08	0.19	−0.04
X3	0.38	0.11	0.52	0.68	0.36	0.11	0.52	0.78
X4	3.09	0.73	0.31	2.42	2.68	0.63	0.28	2.19
X5	7.59	2.45	0.34	−0.14	10.45	3.27	0.35	−0.05
X6	0.12	0.03	0.84	1.62	0.04	0.01	0.45	0.95
X7	0.01	0.00	0.34	1.32	0.01	0.00	0.27	0.64
X8	57.88	14.98	0.57	1.29	74.75	20.12	0.69	1.40
X9	192.29	50.41	0.75	2.13	191.18	48.11	0.94	2.44
X10	47.67	11.40	0.47	1.90	66.74	18.31	0.54	0.96
X11	1.39	0.35	0.62	1.65	2.20	0.56	0.89	2.01
X12	1.70	0.41	0.81	2.47	2.09	0.50	0.93	3.06
X13	143.75	37.13	0.17	1.02	127.01	41.90	0.19	0.13
X14	118.60	33.36	0.36	0.19	164.60	60.27	0.46	0.40
X15	26.56	6.43	0.20	1.81	26.52	6.59	0.19	0.79
X16	26.52	6.59	0.19	0.79	143.10	34.01	0.14	0.33
X17	246.36	73.68	0.15	0.83	223.72	56.82	0.09	0.81
X18	4.18	1.18	1.08	1.93	4.70	1.24	0.61	1.02
X19	23.31	6.38	0.80	1.47	48.98	11.88	1.05	2.54
X20	3.49	1.08	0.91	0.84	2.94	0.92	0.70	0.80
Demographic potential and the labor market								
X21	5.89	1.58	1.774	−0.235	5.23	1.617	−1.692	0.391
X22	5.42	1.316	−1.63	0.487	5.63	1.682	−3.708	0.858
X23	0.014	0.005	0.096	0.232	0.009	0.003	0.066	−0.144
X24	318	77.103	0.599	2.469	309	75.928	0.589	2.331
X25	0.022	0.007	0.277	0.417	0.041	0.012	0.293	0.707
X26	109	30.489	0.143	0.57	122	35.178	0.149	0.485
Economic potential								
X27	57	16.929	0.178	0.318	69	20.107	0.187	0.597
X29	25,417.00	7576.55	0.386	0.887	35,574.00	11,252.87	0.347	0.669
X30	5582.00	1420.55	0.275	1.414	8015.00	1896.16	0.263	1.663
X31	46,538.10	11,284.31	0.206	2.576	80,106.40	19,270.04	0.195	2.122
X32	45	12.07	0.166	0.351	38	12.27	0.158	0.391
X33	0.48	0.144	0.282	0.787	0.64	0.193	0.427	0.758
X34	0.48	0.149	0.309	−0.79	0.36	0.107	0.464	0.15
X35	0.38	0.093	0.299	0.094	0.37	0.111	0.276	−0.114
Potential of the natural environment								
X36	29.4	7.406	0.244	1.279	29.3	7.423	0.24	1.261
X38	0.017	0.005	1.212	1.945	0.014	0.004	1.071	1.728
X39	2.566	0.667	1.992	3.064	1.006	0.248	2.349	3.687
X40	0.46	0.129	0.386	0.958	0.46	0.13	0.384	1.064
X41	0.469	0.145	0.694	1.029	0.455	0.135	0.646	0.957
X44	31.51	8.941	0.14	0.062	25.8	7.147	0.097	−0.664

Table 2. *Cont.*

NumberVariable	**R**	**SD**	**V_x**	**As**	**R**	**SD**	**V_x**	**As**
			2008				**2018**	
				Infrastructure potential				
X45	84.8	22.475	0.066	0.031	111.4	27.404	0.073	−0.016
X46	19.7	6.33	0.072	−0.972	15.9	5.103	0.055	−1.408
X48	43.4	11.827	0.241	0.02	43.9	11.639	0.235	0.221
X50	2	0.632	0.158	0.0	3	0.655	0.113	−1.429
X51	1637.00	434.649	0.121	−0.358	701	219.726	0.073	−0.513
X52	1.873	0.471	0.099	0.664	1.546	0.399	0.085	0.118
X53	110.6	29.224	0.267	0.106	171.2	41.423	0.337	0.966
X54	57.31	15.315	0.877	2.167	71.63	18.802	0.841	2.446

R—range, SD standard deviation, Vx coefficient of variation, As coefficient of asymmetry. Source: own elaboration based on data from Local Data Bank of the Central Statistical Office.

The set of diagnostic variables, on which the credibility of the results and the accuracy of decisions made on their basis depends, should be defined in such a way as to fully characterize the phenomenon under study.

Successively, the destimulant was replaced with a stimulant according to the formula [36]:

$$x_{ij} = \frac{1}{x_{ij}} \tag{2}$$

The selected variables were subjected to the zeroed unitarisation procedure using the formula:

$$z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, \text{ when } x_i \in S \tag{3}$$

where: S—stimulant, x_{ij}—denotes the value of the j-th feature for the i-th object, max $\{x_{ij}\}$—the maximum value of the j-th variable, min $\{x_{ij}\}$—the minimum value of the j-th variable. The value is in the range [0; 1]. The value of 1 means that the variable obtained the maximum value among all the examined objects in the whole examined period of time. A value equal to 0 means that the object took the minimum value [37,38]. The research was carried out dynamically, determining the values of min $\{xij\}$ and max $\{xij\}$ for the entire period, i.e., 2009 2018. As a result of the transformations, a matrix of unitized values of variables was obtained:

$$z_{ij} = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \tag{4}$$

where: denotes the unitary value of the j feature for the i object.

One of the solutions for conducting research on multifaceted phenomena with the use of aggregated values of diagnostic features is the use of synthetic measures. These measures allow for a numerical description of complex phenomena that cannot be directly measured. This enables a multidimensional view of the level of this phenomenon in individual examined objects, conducting comparative analyzes of objects (in spatial and time terms) and their linear ordering and classification [39].

The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method was used to build a synthetic measure of the agricultural potential of voivodships in Poland and its spatial differentiation. A significant advantage of the TOPSIS method is its computational simplicity, indication of the distance from the pattern and the anti-pattern within the studied area, a large number of alternative criteria in the process of assessing the phenomenon and the global ordering of objects, legibility of the obtained results [40–43].

Within the adopted method of determining the synthetic measure, the distance of the unit from the standard (=1) and the anti-template (=0) was determined separately for each commune [44,45]. The Euclidean distances of individual objects were calculated according to the formulas:

$$d_i^+ = \sqrt{\frac{1}{n}\sum_{j=1}^{m}\left(z_{ij} - z_j^+\right)^2} \quad (5)$$

$$d_i^- = \sqrt{\frac{1}{n}\sum_{j=1}^{m}\left(z_{ij} - z_j^-\right)^2} \quad (6)$$

where n—means the number of variables forming the pattern or anti-pattern, z_{ij}—means the unitized value of the j feature for the tested unit, z_j^- / z_j^+—means the pattern or anti-pattern object [46,47].

The values of the synthetic variable are estimated using aggregate functions. The synthetic measure according to the TOPSIS method for individual objects was determined on the basis of the formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \text{ gdzie } 0 \le q_i \le 1,\ i = 1,\ 2,\ \ldots,\ n; \quad (7)$$

where: $q_i \in [0; 1]$—value of synthetic maira; d_i^-—means the distance of the object from the anti-pattern (from 0), d_i^+—means the distance of the object from the pattern (from 1). A higher value of the measure indicates a better situation of an individual in the analyzed area [47,48].

The synthetic measure of development potential was determined as the average value of the synthetic measure of the studied areas, i.e., economic, demographic, natural environment, infrastructure. We can calculate it from the formula:

$$\overline{\mathrm{X}} = \frac{\sum_{i=1}^{n} q_i}{n} \quad (8)$$

$\overline{X}$— arithmetic mean as the value of a synthetic measure of development,
q_i— synthetic value of the potential category (according to the determined method, defined potential),
n— number of tested potentials (categories).

The analyzed research area (voivodeships) was divided into typological groups according to a synthetic measure. The first, second and third quartiles were adopted as threshold values. The size of the synthetic measure in the first group means the better unit, and in the next—weaker units. The correlation coefficient (Pearson), the scatter plot with the fit line and linear regression analysis were also presented [49,50].

Spatial autocorrelation is a situation in which the occurrence of one phenomenon in one spatial unit causes the increase or decrease of the probability of the occurrence of this phenomenon in neighboring units [51,52]. Spatial autocorrelation is defined as the influence of a phenomenon occurring in a spatial unit on the probability of its finding in neighboring spatial formations. It is therefore a measure of the homogeneity of spatial structures that can be classified as positive (positive), negative (negative) or zero (no autocorrelation).

Positive spatial autocorrelation occurs when we observe the spatial accumulation of high or low values of the observed variables. It means the spatial formation of clusters of high or low values of variables. Negative autocorrelation means neighboring high values with low values in the space, and low values with high values, the graphic image of which is a checkerboard pattern [53]. Lack of spatial autocorrelation means spatial randomness, i.e., high and low values of the observed variables are distributed independently [7]. By analyzing the autocorrelation result, it is possible to determine clusters of objects similar to each other. Knowing and understanding the structures of space enables better anticipation of changes and facilitates taking actions in development policy [54].

The global and local I Moran spatial correlation coefficient can be used to investigate spatial relationships [55–57]. They will indicate, pointing to statistically significant clusters of similar values in neighboring locations. The I Moran statistic takes a value from the interval (−1.1), where the value "0" means no spatial autocorrelation, negative values are negative autocorrelation (<−1.0; units with different values occur next to each other in space, differentiation of the examined objects), positive values signal a positive spatial correlation (0.1>; units with similar values occur next to each other, forming clusters) [58,59].

Moran I Global Statistics is an analysis that made it possible to check whether the adjacent plots form clusters with similar values of the synthetic measure. According to Kopczewska (2011) [60], the presence of spatial autocorrelation means that geographically close objects are more similar to each other in terms of the analyzed variable than distant ones and have the ability to form clusters. On this basis, it can be concluded that plots with a similar synthetic index can combine and form spatial clusters. Global autocorrelation results from the existence of correlation within the entire studied spatial unit. Global statistics *I* Moran allows to determine the general similarity of spatial units in terms of the studied phenomenon. According to Upton and Fingleton (1985) [61,62], the Moran global coefficient was determined on the basis of the following formula:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} wij(x_i-\overline{x})(x_j-\overline{x})}{S_o\,\sigma^2} \quad (9)$$

where:

n— number of spatial objects (number of points or polygons),
xi, these are the values of the variable for the compared objects,
$\overline{x}j$— is the average value of the variable for all objects,
wij—elements of the spatial weight matrix (weights matrix standardized with rows to one),

$$S_o = \sum_{i=1}^{n}\sum_{j=1}^{n} wij\,,$$

$$\sigma^2 = \frac{\sum_{j=1}^{n}(x_i-\overline{x})^2}{n}$$

—wariancja.

Local measures, on the other hand, show spatial relationships of a given variable with neighboring units in a specific location. Local statistics of spatial autocorrelation indicate statistically significant clusters of similar values in neighboring locations. They enable the assessment of stationarity assumptions, identification of non-stationarity areas, identification of outliers, clusters of large and small values and homogeneous sub-areas. Moreover, local statistics allow for the identification of the maximum distance of perceivable interdependencies in space.

The local version of the Moran statistics is the most popular analysis known as LISA (Local Indicators of Spatial Association). It determines the similarity of a spatial unit to its neighbors and examines the statistical significance of this relationship. The local form of the *I* Moran coefficient for observations *i* is given by the formula:

$$I_i = \frac{(x_i-\overline{x})\sum_{j=1}^{n} wij\,(x_j-\overline{x})}{\sigma^2} \quad (10)$$

where:

n— number of spatial objects (number of points or polygons),
xi, these are the values of the variable for the compared objects,
$\overline{x}j$— is the average value of the variable for all objects,
wij—elements of the spatial weight matrix (weights matrix standardized with rows to one),

$$\sigma^2 = \frac{\sum_{j=1}^{n}(x_i - \overline{x})^2}{n-1},$$

—wariancja.

High values of the coefficient indicate the presence of clusters of similar values, low—the occurrence of the so-called hot spots, and values close to the expected value E (Ii) for a random distribution of the studied variable in space. Local Moran statistics take negative values when a given area is surrounded by regions with significantly different values of the studied variable (negative autocorrelation). The positive values of the statistics should be interpreted as follows: the region is surrounded by similar regions (positive autocorrelation). Thanks to this, it is possible to determine clusters with low or high values of the studied variable [63,64].

To illustrate the spatial dependence of the distribution of agricultural potential in voivodships and their development, the I Moran statistics were calculated, using the Queen matrix standardized by rows to one (using the PQStat program for this purpose).

Regression analysis is the study of the relationship between the variables of interest to us, aimed at the construction of the model. It allows us to indicate the relationship between the dependent variable (Y) and independent variables (X). Linear regression analysis aims to calculate regression coefficients such that the model predicts the value of the dependent variable as well as possible, so that the estimation error is as small as possible. We describe a linear regression model by the following formula:

$$yi = bxi + a,\ i = 1, 2, \ldots,\ n, \tag{11}$$

For the multiple regression model, we use the following formula for the regression line:

$$y = b1\ x1 + b2\ x2 + \ldots + \ bi\ xi\ +\ a,\ i\ =\ 1,\ 2,\ \ldots,\ n, \tag{12}$$

where:

b— is the regression coefficient calculated for individual predictors in the model,
x— independent (explanatory) variable,
y— dependent variable (explained) by the model,
a— is an intercept.

The regression analysis permits checking whether the built model allows for significant predictions of the value of the explained variable. In the process of building a regression model, autocorrelation of variables should be excluded. Next, determine the percentage of the variance explained by reading the (preferably corrected) R^2 statistic. Its values range from 0 to 1. The closer to 1, the better the regression function fits the empirical data [65–69].

4. Results

In order to make a comparative analysis of voivodships in terms of the achieved level of socio-economic development and agricultural potential, the TOPSIS method of building a synthetic measure and spatial analysis (global and local statistics of I Moran) were used. The results of ordering the voivodships from the best to the worst for the selected years of the 2008–2018 period are presented in Table 3, while Table 4 provides descriptive characteristics of the synthetic measure of development and agricultural potential for the extreme years of the research period, i.e., for 2008 and 2018.

Table 3. Classification of voivodships in Poland according to the value of the synthetic measure of agricultural development and potential (in 2008, 2018).

Gr.	qi Agriculture Potential		qi Development	
	2008	2018	2008	2018
	voivodships	voivodships	voivodships	voivodships
I	opolskie 0.4 wielkopolskie 0.4 kujawsko-pomorskie 0.38 łódzkie 0.38	opolskie 0.45 wielkopolskie 0.43 kujawsko-pomorskie 0.41	śląskie 0.48 pomorskie 0.45 lubuskie 0.43 mazowieckie 0.43	mazowieckie 0.53 pomorskie 0.52 śląskie 0.49 wielkopolskie 0.49
II	lubelskie 0.36 podlaskie 0.36	Łódzkie 0.38 podlaskie 0.38 lubelskie 0.37 dolnośląskie 0.36 mazowieckie 0.36	dolnośląskie 0.42 warmińsko-mazurskie 0.42 wielkopolskie 0.41 zachodniopomorskie 0.41	dolnośląskie 0.48 lubuskie 0.47 małopolskie 0.46 zachodniopomorskie 0.46
III	dolnośląskie 0.34 małopolskie 0.34 świętokrzyskie 0.34 mazowieckie 0.33 podkarpackie 0.3 śląskie 0.28	małopolskie 0.32 świętokrzyskie 0.32 podkarpackie 0.29 śląskie 0.27	małopolskie 0.39 podlaskie 0.37 kujawsko-pomorskie 0.36 podkarpackie 0.35	warmińsko-mazurskie 0.42 podkarpackie 0.41 podlaskie 0.4
IV	pomorskie 0.23 warmińsko-mazurskie 0.2 zachodniopomorskie 0.19 lubuskie 0.14	pomorskie 0.26 zachodniopomorskie 0.24 warmińsko-mazurskie 0.21 lubuskie 0.16	Łódzkie 0.33 Opolskie 0.31 świętokrzyskie 0.31 lubelskie 0.28	Łódzkie 0.38 Opolskie 0.38 kujawsko-pomorskie 0.35 świętokrzyskie 0.34 lubelskie 0.3

1st tallest, 2nd good, 3rd medium. IV low. Source: study based on the BDL CSO data.

Table 4. Values of indicators describing the situation of the agricultural potential and development of Polish voivodships in 2008 and 2018 (according to the average value for quartile groups).

Detailed	2008				2018			
	I	II	III	IV	I	II	III	IV
q agricultural potential	0.38	0.34	0.3	0.19	0.41	0.36	0.29	0.2
number of units	6	3	3	4	5	3	5	3
q development potential	0.34	0.37	0.42	0.43	0.4	0.44	0.44	0.45
q the potential of demographics and the labor market	0.37	0.42	0.5	0.46	0.34	0.39	0.42	0.29
q economic potential	0.33	0.37	0.42	0.36	0.46	0.56	0.48	0.44
q the potential of the natural environment	0.28	0.34	0.31	0.43	0.32	0.3	0.39	0.5
q infrastructure potential	0.4	0.37	0.44	0.47	0.49	0.51	0.48	0.57
the share of agricultural land (UAA) in% of the total area of the voivodeship	0.67	0.62	0.59	0.49	0.65	0.66	0.56	0.48
the share of arable land in% of the total area of the voivodeship	0.51	0.45	0.41	0.36	0.5	0.47	0.39	0.34
working in (agriculture, forestry, hunting and fishing) in general	0.28	0.23	0.17	0.13	0.22	0.23	0.23	0.15
unemployed living in rural areas in total unemployed	0.44	0.49	0.43	0.47	0.42	0.47	0.48	0.47
Number of tractors in units per 100 ha of UAA.	8	8.67	8.67	4.25	9.6	9.67	11.6	4.67
Cattle stock per 100 ha of UAA.	36.8	18.3	24.3	18	47.6	26	18	19.3
Number of livestock Pigs (pigs) per 100 ha of UAA.	105	37.3	44.7	49.5	94.4	30.7	32.8	30.7
Production of livestock for slaughter per 100 ha of UAA.	32	16	22.7	20.3	44.2	31	29.4	27.7

Table 4. *Cont.*

Detailed	2008				2018			
	I	II	III	IV	I	II	III	IV
Milk production per 1 ha of UAA.	0.78	0.37	0.6	0.35	1.09	0.62	0.33	0.4
Egg production per 1 ha of UAA.	0.58	0.5	0.65	0.28	1	0.3	0.45	1.59
Ground vegetables yield from 1 ha of UAA	2.76	14.7	1.59	4.01	2.85	13.2	1.86	4.7
Fruit harvest from trees from 1 ha of UAA.	4.16	10.9	0.34	2.82	6.79	13	1.37	6
Yields Basic cereals of cereals per 1 ha of UAA.	18.2	13.4	11.3	12.4	18	16.1	11.3	10.7
Potato yields per 1 ha of UAA.	5.13	6.84	6.73	4.21	4.15	3.7	5.37	2.02
Sugar beet yields per 1 ha of UAA.	7.13	3.8	1.91	2.32	11.8	9.77	3.37	3.19
grain maize per 1 ha of UAA.	1.39	1.5	0.95	0.48	3.2	2.29	1.41	0.94
green maize per 1 ha of UAA.	13.4	2.51	6.35	5.22	22.3	10.9	4.57	5.66
rape and turnip rape per 1 ha of UAA.	1.44	0.94	0.44	1.57	1.46	1.78	0.79	1.17
balance of migration per 1000 inhabitants	−1.3	−0.5	−0.13	−0.78	−0.92	0.63	−0.12	−1.33
population per 1 km^2	104	157	214	81.5	106	127	189	68.7
Unemployed persons (total) per 1000 inhabitants	39.8	43.7	38.3	46.8	26.2	27.3	26.8	28.7
Working per 1000 inhabitants	204	212	244	208	236	256	236	216
entities entered in the register per 1000 population	89.2	95.7	95.3	104	101	122	104	111
natural persons running a business per 1000 population	69.7	72.7	71.3	78.3	75	82.7	76.6	79.7
Own income/total income (financial independence ratio)	0.48	0.57	0.62	0.44	0.44	0.6	0.44	0.33
Transfer revenues/total revenues (financial state interference rate)	0.52	0.42	0.36	0.56	0.23	0.19	0.2	0.33
Investment expenditures/total expenditures (investment attractiveness index)	0.35	0.35	0.36	0.33	0.35	0.29	0.41	0.34

Source: study based on BDL CSO data.

Table 3 shows the division of voivodships into four groups with a similar level of development or agricultural potential. The groups were determined based on the value of quartiles (1, 2, 3). There is a spatial differentiation in the level of development and potential of agriculture in voivodships of eastern Poland. The synthetic qi of the agricultural potential ranged from 0.14 (Lubuskie, the weakest unit) to 0.40 (Opolskie, Wielkopolskie, the best units) in 2008 and from 0.16 (Lubuskie) to 0.45 (Opolskie) in 2018. The increase in the range measure (from 0.26 to 0.29) indicates a slight increase in the differentiation of units in terms of agricultural potential. In 2008, the synthetic measure of development ranged from 0.28 (Lubelskie) to 0.48 (Śląskie), and in 2018 from 0.30 (Lubelskie) to 0.53 (Mazowieckie). The range of the range value in 2018 was higher (0.23) than in 2009 (0.20), which indicates an increase in the diversity of units in the studied area.

The Figure 1 shows the classification of voivodships in Poland according to the synthetic measure of development and agricultural potential (dark color of the best unit, the lighter color of the weaker units). The classification of communes was carried out on the basis of quartiles, which were threshold values for subsequent groups. In terms of development, the best units in 2008 were Śląskie, Pomorskie, Mazowieckie, and Lubuskie. In 2018, Mazowieckie, Pomorskie, and Śląskie were the strongest, while the weakest ones were Lubelskie and Świętokrzyskie, respectively. The best regions were characterized by high development potential, thanks to which further development was possible. The weaker economic situation of the regions does not allow for such a quick catching up and may be one of the reasons for the lower level of economic development in these regions in the coming years, due to the lower development opportunities.

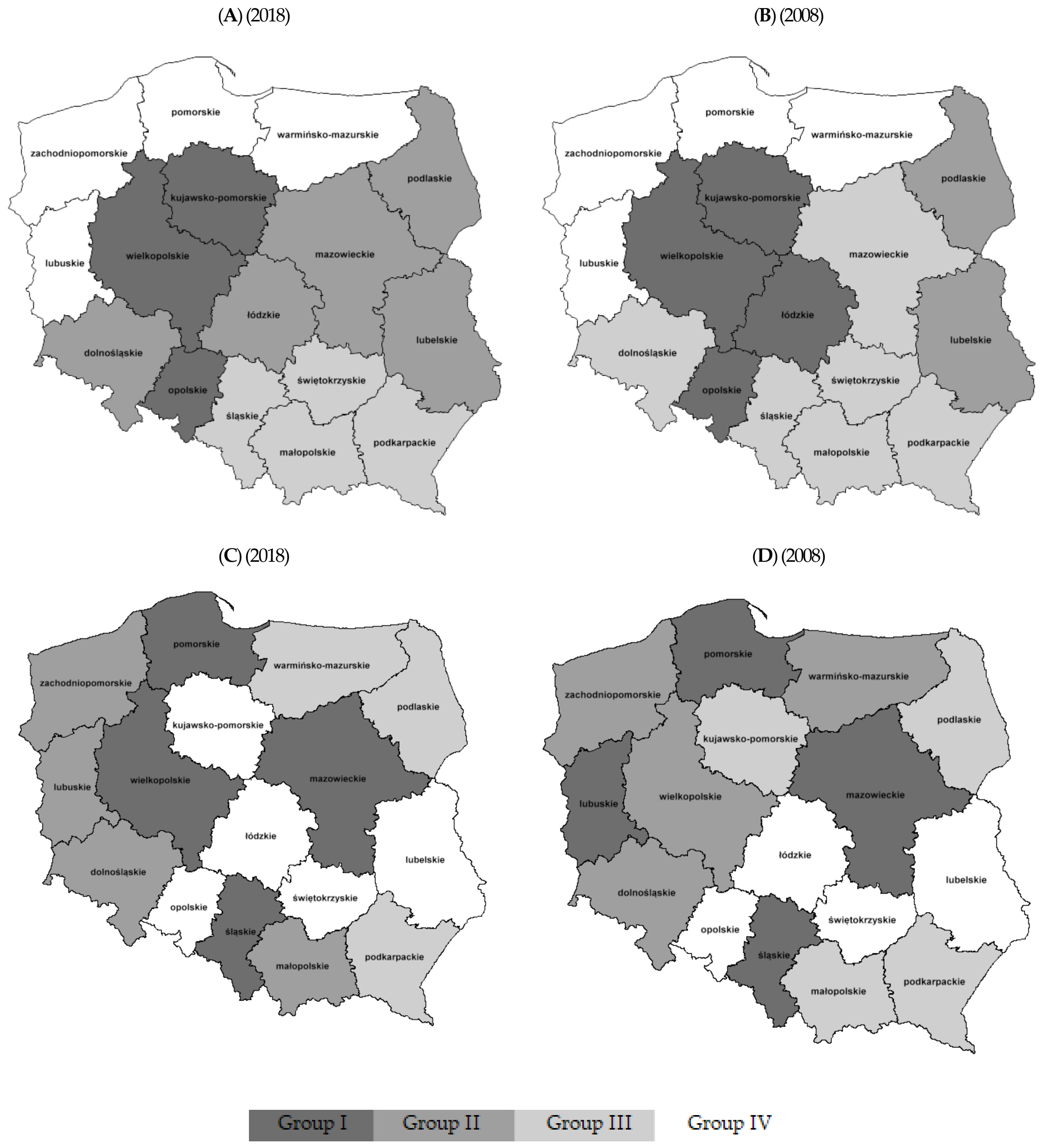

Figure 1. Quartile groups for measures of synthetic agricultural potential of Polish voivodeships in 2008 and 2018. (**A**,**B**) (agriculture) (**C**,**D**) (development). Source: own study based on the BDL CSO data.

The agricultural potential in voivodships in Poland was influenced by the fact that a given area belonged to one of the three former partitions: the Prussian partition (the most dynamically developing, fairly good situation; modern agricultural production, the existence of an absorbent market), the Austrian partition (slower development, farms more and more fragmented), the Russian partition (the weakest development, farms fragmented, poorly equipped with technical devices).

In the case of the measure of agricultural potential, the Wielkopolskie, Oposkie, Kujawsko-Pomorskie provinces turned out to be the best in 2018 (and 2008), the weakest Lubuskie, Warminsko-Mazurskie (2008) and Zachodniopomorskie, Lubuskie (2018)

(Figure 1). Apart from natural factors, agricultural activity is influenced by the relief, soil quality and climate, as well as by non-natural factors. These factors include, among others basic soil cultivation, soil fertilization—fertilization, melioration, chemical plant protection, crop care. The socio-economic factors of agricultural development are also of great importance, including: the size of farms, specialization of agricultural production, marketability of agricultural production, mechanization of work, employment in agriculture and the agricultural policy of the authorities.

Having a large area of agricultural land and appropriate equipment with agricultural machinery and equipment, high yields and crops are obtained at lower unit costs of cultivating the land. There are still too many small semi-subsistence farms in Poland. The production in them is usually small and expensive (poorly specialized and mechanized). It is also more difficult to sell small crops from small farms at favorable prices for the farmer. The solution is good quality, attracting the customer with quality, distinguishing himself on the market, direct sales, short supply chains, i.e., getting the producer closer to the end-user (omitting intermediaries), customer trust in the producer, local markets, direct sales, good quality and taste, own processing, etc. It is thanks to small farms that employment in agriculture reaches over a dozen percent. The greatest fragmentation of farms occurs in South-Eastern Poland, where small farms account for over 70% of all farms. There is also the lowest level of agricultural production marketability (Świętokrzyskie, Małopolska, Podkarpacie). The highest marketability is recorded in the west of Poland, especially in areas with good soils (Kujawsko-Pomorskie, Zachodniopomorskie, Pomorskie, Wielkopolskie). In the indicated provinces, the largest number of large farms specializing in a specific type of agricultural production, e.g., in the cultivation of cereals or other mono-season plants (sugar beet, rape), or in the breeding of pigs or poultry.

Rural communes of eastern Poland are characterized by significant disproportions in terms of the financial situation and demographic potential. Communes distinguished by a higher level of the financial situation have a higher demographic potential index. The synthetic measure of the agricultural potential in group I ranged from 0.38 to 0.4, while in group IV from 0.14 to 0.23 (in 2008), in group I—0.41–0.45 and group IV—0.16–0.26 (in 2018). The range in these groups was 0.02 and 0.04 (group I), and 0.09 and 0.10 (group IV), respectively, which indicates a slight variation in the studied range. In the case of the development measure in group I from 0.43 to 0.88 and IV 0.28 to 0.33 (2008) and 0.49 to 0.53 (gr I) and 0.30 to 0.38 (gr IV), with a range of 0.05 and 0.04 (gr I) and 0.04 and 0.08 (gr IV; Table 4).

The communes of the first (the best) group in relation to the communes of the fourth (weakest) group were characterized by a higher value of the agricultural potential, a weaker situation in terms of demography, development, environment and infrastructure. In the case of variables describing the potential of agriculture, in the case of most of the variables, they were higher in group I than in group IV both in 2008 and 2018. A similar situation took place with regard to most of the development potential variables. Units with a better agricultural potential are not characterized by a better level of development.

Regions located peripheral to the central center are characterized by, e.g., the effect of capital leaching (siphoning capital from the periphery to the central center). According to Rosner's research [70], there is a close relationship between the processes related to population (population, age and occupational structure, birth rate, migration balance, population density) and the level of socio-economic development. The age structure of the population shapes the situation on the labor market, and this indirectly influences the infrastructural potential and local finances. The decrease in the number of the unemployed in all groups, the increase in the number of the employed and the number of entities and natural persons conducting business activity should be assessed positively.

Statistical characteristics of the synthetic measure of the financial situation of rural communes in eastern Poland in 2008 compared to 2018 show the stability of the analyzed phenomenon. The standard deviation was 0.08–0.08 in terms of agricultural potential and 0.06–0.07 in terms of development (Table 5). It indicates a slight differentiation of units in the examined aspect. An increase in the standard deviation value indicates that the values of the variable are more scattered around the mean. The classical coefficient of variation (0.26–0.25 for agricultural potential, i.e., a decrease in diversity; 0.15–0.16 for development, i.e., a slight increase in diversity) shows slight disproportions. The coefficient of variation is used to test the degree of variation in the value of a variable. An increase in the value of the coefficient means an increase in the diversity of variables and indicates the heterogeneity of the studied population. The range (0.26–0.29 for the agricultural potential; 0.20–0.23 for development) indicates how large is the spread between the smallest and the largest value of the variable in the studied area, it indicates a slight increase in the diversity of the phenomenon in the studied area.

Table 5. Statistical characteristics of the synthetic measure of development and agricultural potential of voivodships in Poland in 2008 and 2018.

Detailed	qi Potential of Agriculture		qi Development	
	2008	2018	2008	2018
min	0.14	0.16	0.28	0.30
max	0.40	0.45	0.48	0.53
gap	0.26	0.29	0.20	0.23
average	0.31	0.33	0.38	0.43
median	0.34	0.34	0.40	0.44
standard deviation	0.08	0.08	0.06	0.07
quarterly deviation	0.05	0.06	0.04	0.05
coefficient variability	0.26	0.25	0.15	0.16
positional coefficient of variation	0.14	0.17	0.10	0.12
quartile stretch	0.10	0.12	0.08	0.10
skew (asymmetry)	−0.91	−0.40	−0.26	−0.31
kurtosis (measure of concentration)	−0.31	−0.49	−0.84	−0.9

Source: study based on the BDL CSO data using the Statistica program.

The value of agriculture, as one of the three main branches of the Polish economy, is determined by: the possibility of feeding the country's population and exporting it outside Poland, the level of employment, agricultural products have a high position in foreign trade; ability to generate part of GDP. Pearson's correlation coefficient between the value of the synthetic measure in 2008 was −0.335, and in 2018 −0.561 (an increase in the value of the development potential will mean that the potential of agriculture is likely to do the opposite and will decrease (and vice versa), Figure 2).

The region's economic efficiency is created, among others, by professional activity of inhabitants, local labor market, entrepreneurship, infrastructure, and the condition of the natural environment. Its proper level influences the growth of the living standard, increasing production and causes favorable social situation [71,72]. Migration causes important changes in the level of population, spatial distribution and in various population structures [73]. The number of economic entities shows the level of entrepreneurship in the region. The more entities, the greater, positive pro-development impulses that entrepreneurship exerts on the economy.

The level of the synthetic measure of agricultural potential in voivodships in Poland was correlated with the measure of the natural environment (−0.6918), the measure of infrastructure (−0.3965) and, to a small extent, the number of the unemployed (−0.2081) and working people (0.1396) or the share of income from transfers from the state budget in total income (−0.2461) and forest land area (−0.7563). In the aspect of variables describing agriculture, the synthetic measure of agricultural potential was to the greatest extent correlated with the area of agricultural land (0.8241), arable land (0.8209) working in agriculture (0.3189), number of tractors (0.4633), cattle population (0.4593), pigs (0.5113) and production of milk (0.4081), basic cereals (0.4979), sugar beet (0.5758), and grain maize (0.5335).

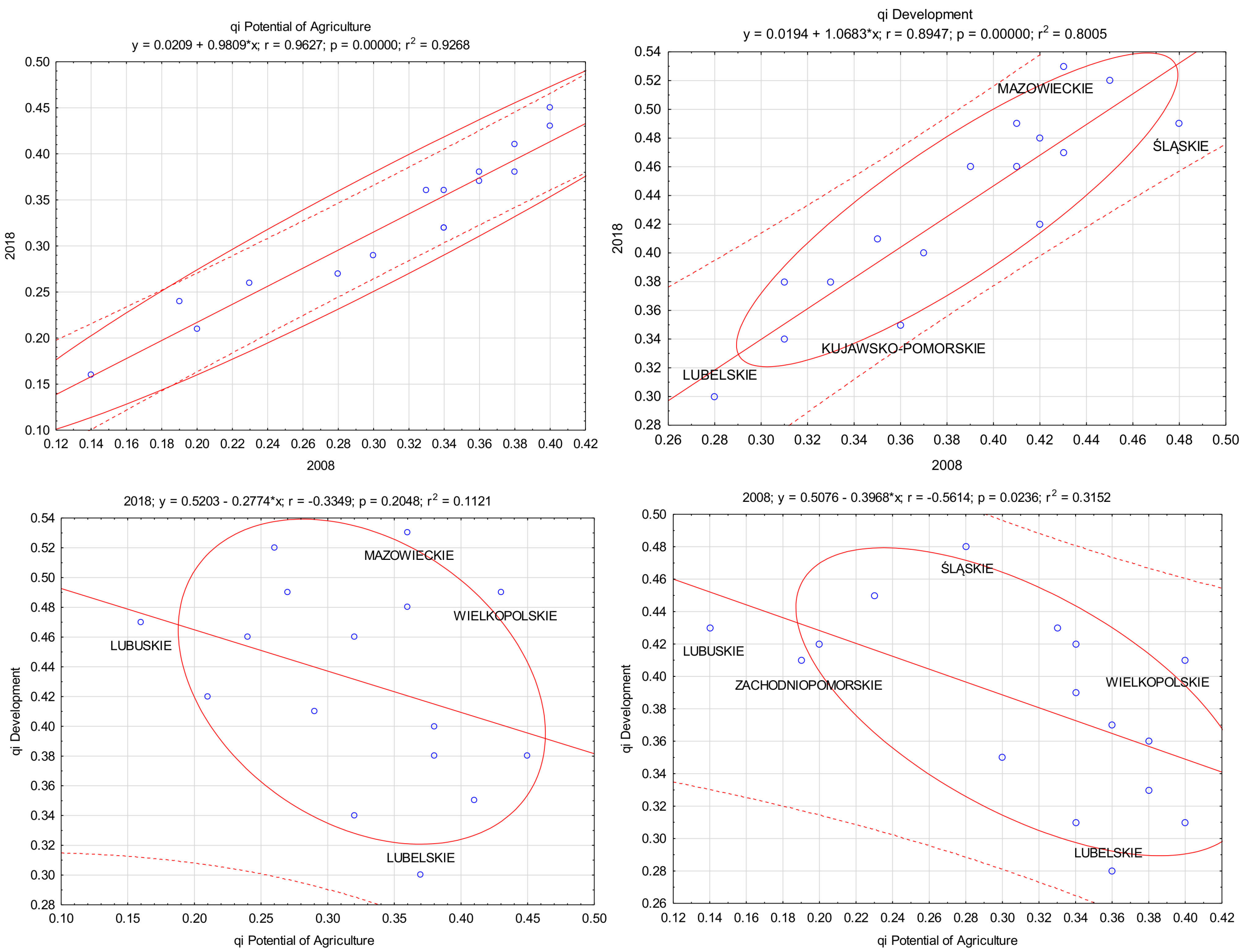

Figure 2. Dispersion of the synthetic measure of development and agricultural potential of voivodships in Poland in 2008 and 2018. Source: own study based on BDL CSO data using the Statistica program

The measure of voivodship development is correlated with the synthetic measure of the potential of agriculture (−0.4743), the natural environment (0.3479), the measure of the demographic and labor market potential (0.7067), the measure of economy (0.7299) and infrastructure (0.6581). The development was most influenced by the level of migration (0.5582), the number of employed (0.6573) and economic entities (0.6891) and natural persons running a business (0.629), own income in total income (0.4941), people benefiting from treatment (0.6705). The variables describing the potential of agriculture had the greatest negative impact on the development process, i.e., the area of agricultural land (−0.5928), arable land (−0.5491) and the number of people working in agriculture (−0.7573) (Table 6).

Table 6. Correlation between measures of development potential and agriculture, and socio-economic variables in voivodships of Poland (Pearson's coefficient).

Detailed	Agriculture	Development
q agricultural potential	1	−0.4743
q development potential	−0.4743	1
q the potential of demographics and the labor market	−0.1294	0.7067

Table 6. *Cont.*

Detailed	Agriculture	Development
q economic potential	0.0097	0.7299
q the potential of the natural environment	−0.6918	0.3479
q infrastructure potential	−0.3965	0.6581
the share of agricultural land (UAA) in% of the total area of 8the voivodeship	0.8241	−0.5928
the share of arable land in% of the total area of the voivodeship	0.8209	−0.5491
working in (agriculture, forestry, hunting and fishing) in general	0.3189	−0.7573
unemployed living in rural areas in total unemployed	0.0075	−0.3969
Number of tractors in units per 100 ha of UAA.	0.4633	−0.4264
Cattle stock per 100 ha of UAA.	0.4593	−0.0845
Number of livestock Pigs (pigs) per 100 ha	0.5113	−0.0303
Production of livestock for slaughter per 100 ha of UAA.	0.3117	0.2776
Milk production per 1 ha of UAA.	0.4081	−0.0789
Egg production per 1 ha of UAA.	0.1788	0.1901
Ground vegetables yield from 1 ha of UAA	0.07	0.1471
Fruit harvest from trees from 1 ha of UAA.	0.1752	0.0273
Yields Basic cereals of cereals per 1 ha of UAA.	0.4979	−0.1308
Potato yields per 1 ha of UAA.	0.3363	−0.2399
Sugar beet yields per 1 ha of UAA.	0.5758	−0.2653
grain maize per 1 ha of UAA.	0.5335	−0.0331
green maize per 1 ha of UAA.	0.4912	−0.0371
rape and turnip rape per 1 ha of UAA	0.0841	0.1029
balance of migration per 1000 inhabitants	0.0111	0.5582
Unemployed persons (total) per 1000 inhabitants	−0.2081	−0.3967
Working per 1000 inhabitants	0.1396	0.6573
entities entered in the register per 1000 population	−0.1294	0.6891
natural persons running a business per 1000 population	−0.1215	0.629
Own income/total income (financial independence ratio)	0.198	0.4941
Transfer revenues/total revenues (financial state interference rate)	−0.2461	−0.4794
The area of forest land in the total area	−0.7563	0.4531
% Of the population using sewage treatment plants	−0.3455	0.6705
% Of the population using the water supply network	−0.0003	0.3678

Linear correlation coefficients for observations from sample 1–176. Critical value (with two-sided 5% critical area) = 0.1480 for n = 176.
Source: Own calculations using Gretl software.

The regression analysis of the agricultural potential and development variables indicates that the presented regression model allows us to explain 0.734062 of model variability, i.e., that it is explained by the variability of independent variables. It can be concluded that the model is fit enough. The model shows an important role for population km^2, the number of unemployed and working people per 1000 inhabitants, entities entered in the register per 1000 inhabitants, share of financial income in total income, forest land area and housing resources per 1000 inhabitants. In shaping the agricultural potential of voivodships in Poland. These are the variables that build the endogenous economic base of the region, which has an impact on the development process. The endogenous potential of the region is built, among others, by professional activity, local labor market, entrepreneurship, infrastructure, and the condition of the natural environment. Its appropriate level affects, among others raising the standard of living, increasing production, better social situation. The region's potential is the result of a combination of local conditions, it defines its possibilities and directions of development. Their impact on economic development is diversified; nevertheless, each of these factors contributes, and the occurrence of development processes is not possible without any of them. The substitution of components that are deficient in a certain territory by others that are in relative excess is limited. The fit of the model is measured with the corrected R^2 (0.722981). The adjusted coefficient of the determination reached 72%. Further increasing the multidimensionality of the model would result in a slight increase in value, and the model could include statistically insignificant variables. The model could include statistically insignificant variables. This error is eliminated by the corrected R^2. It shows the actual fit of the model, independent of the number of added variables that have no significant influence on the model. The F statistic is F (7, 168) 66.24644 and is statistically significant (*p*) (Table 7).

Table 7. Results of the regression analysis between the agricultural potential and the variables of the voivodeship development in Poland.

Detailed	Factor	Standard Error	t-Student	*p* Value
const	0.838128	0.0631715	13.27	<0.0001
Population per km^2	−0.000276930	5.51887×10^{-5}	−5.018	<0.0001
Unemployed persons (total) per 1000 inhabitants	−0.00184698	0.000279864	−6.600	<0.0001
Working per 1000 inhabitants	0.00138197	0.000246205	5.613	<0.0001
entities entered in the register per 1000 population	−0.000906043	0.000293730	−3.085	0.0024
Own income/total income (financial independence ratio)	−0.159192	0.0433446	−3.673	0.0003
The area of forest land in the total area	−0.00923137	0.000519380	−17.77	<0.0001
Housing resources per 1000 inhabitants	−0.000733598	0.000152982	−4.795	<0.0001
Arithmetic Mean of the Dependent Variable	0.321648	Standard Deviation Of Dependent Change		0.078530
Sum of squared residuals	0.287007	Standard error of residuals		0.041332
Factor. R-squared determination	0.734062	Corrected R-square		0.722981
F(7, 168)	66.24644	The *p*-value for the F-test		4.59×10^{-45}
Likelihood logarithm	315.1154	Akaike's information criterion		−614.2308
Schwartz's Bayesian information criterion	−588.8669	criterion Hannana-Quinna		−603.9433

Observations 1–176 used; Dependent variable (Y): q agriculture. Source: Own calculations using Gretl software.

The values captured by the global statistics of Moran's I mean the occurrence of a diversified level of the studied phenomenon in distant units in relation to the neighboring ones. On the basis of the obtained values, it can be noticed that in the period in question there is a slight negative autocorrelation and a decrease in its value (in relation to 2018 to 2008; Table 8) for the measure synthetyczny rozowju. There is also a slight autocorrelation in the development area, but the significance levels of these measures are quite high, which suggests insignificant statistical values, therefore no spatial autocorrelation ($p > 0.05$; values are distributed randomly). This means that any observed level of agricultural potential can emerge in any location with equal probability. It can be stated that the agricultural potential in terms of voivodeships does not, therefore, show spatial autocorrelation. The decreasing value of the considered statistics means a decreasing spatial dependence. This means there is a tendency to concentrate similar values (i.e., high and low) in the area of the studied variable in a given region.

Table 8. Values of Moran's global statistics in 2008–2018 for the potential of agriculture and development in Poland by voivodship.

Year	Moran's I	Expected I	Variance I	Z-Statistic	*p*-Value	Significance Level (*p*)
for a measure of development potential						
2008	0.112188	−0.066667	0.022125	1.202429	0.229198	0.233014
2018	0.032208	−0.066667	0.022125	0.664725	0.506226	0.512636
for a measure of development						
2008	−0.0017	−0.066667	0.022125	0.436765	0.662281	0.669658
2018	−0.089365	−0.066667	0.022125	−0.1526	0.878714	0.881722

Source: Own calculations using the PQStat program.

In the next step of the analysis, local Moran statistics were determined for each voivodship. The obtained values of these statistics are presented in Table 9. Significant and high positive and negative values of local statistics of Moran I were obtained in Zachodniopomorskie, Opolskie, Łódzkie, Podlaskie, Wielkopolskie, Warmińsko-Mazurskie, Śląskie (in 2008) and Opolskie, Zachodniopomorskie, Łódzkie, Śląskie, Lubuskie, Warmińsko-Mazurskie (2018) in aspect of the sythetic potential of agriculture. In the case of the development measure, the following answers were: Voivodeships with positive values of local statistics can be treated as outliers. These voivodships are surrounded by units with significantly similar levels of potential within the studied area. A high *p*-value suggests insignificant values of the Moran statistic, therefore no autoco-spatial relation. At the same time, the decreasing tendency of the value of the considered statistics in the period under consideration means a weakening spatial relationship.

Table 9. Values of local statistics and Moran for the potential of agriculture and development in Poland in terms of voivodships.

2008	Ii	e (Ii)	Z (Ii)	Value *p* (Ii)	2018	Ii	e (Ii)	Z (Ii)	Value *p* (Ii)
According to the measure of agricultural potential									
zachodniopomorskie	1.008	−0.067	2.092	0.036	opolskie	0.638	−0.067	1.639	0.101
opolskie	0.545	−0.067	1.429	0.153	zachodniopomorskie	0.54	−0.067	1.176	0.24
łódzkie	0.477	−0.067	1.697	0.09	łódzkie	0.387	−0.067	1.413	0.158
pomorskie	0.226	−0.067	0.684	0.494	dolnośląskie	0.108	−0.067	0.338	0.735
lubelskie	0.167	−0.067	0.546	0.585	mazowieckie	0.099	−0.067	0.517	0.605
świętokrzyskie	0.096	−0.067	0.507	0.612	lubelskie	0.079	−0.067	0.338	0.735
mazowieckie	0.078	−0.067	0.452	0.651	pomorskie	0.031	−0.067	0.226	0.821
lubuskie	0.017	−0.067	0.162	0.871	kujawsko-pomorskie	0.03	−0.067	0.262	0.793
dolnośląskie	0.012	−0.067	0.154	0.878	małopolskie	0.027	−0.067	0.182	0.856
małopolskie	−0.018	−0.067	0.095	0.925	świętokrzyskie	−0.005	−0.067	0.192	0.848
kujawsko-pomorskie	−0.028	−0.067	0.105	0.917	wielkopolskie	−0.043	−0.067	0.084	0.933
podkarpackie	−0.059	−0.067	0.014	0.989	podkarpackie	−0.059	−0.067	0.016	0.988
podlaskie	−0.107	−0.067	−0.078	0.938	podlaskie	−0.1	−0.067	−0.064	0.949
wielkopolskie	−0.226	−0.067	−0.565	0.572	śląskie	−0.347	−0.067	−0.653	0.514
warmińsko-mazurskie	−0.246	−0.067	−0.419	0.675	lubuskie	−0.437	−0.067	−0.718	0.473
śląskie	−0.258	−0.067	−0.447	0.655	warmińsko-mazurskie	−0.463	−0.067	−0.923	0.356
by development measure									
2008	**Ii**	**e (Ii)**	**Z (Ii)**	**value *p* (Ii)**	**2018**	**Ii**	**e (Ii)**	**Z (Ii)**	**value *p* (Ii)**
lubelskie	0.627	−0.067	1.606	0.108	zachodniopomorskie	0.413	−0.067	0.923	0.356
podkarpackie	0.615	−0.067	1.313	0.189	lubuskie	0.406	−0.067	0.909	0.363
lubuskie	0.41	−0.067	0.918	0.359	lubelskie	0.283	−0.067	0.808	0.419

Table 9. *Cont.*

2008	Ii	e (Ii)	Z (Ii)	Value *p* (Ii)	2018	Ii	e (Ii)	Z (Ii)	Value *p* (Ii)
zachodniopomorskie	0.362	−0.067	0.827	0.408	podkarpackie	0.275	−0.067	0.658	0.51
pomorskie	0.318	−0.067	0.89	0.373	dolnośląskie	0.181	−0.067	0.477	0.633
warmińsko-mazurskie	0.2	−0.067	0.618	0.537	podlaskie	0.087	−0.067	0.296	0.767
świętokrzyskie	0.178	−0.067	0.759	0.448	wielkopolskie	0.056	−0.067	0.433	0.665
podlaskie	0.034	−0.067	0.195	0.846	świętokrzyskie	0.033	−0.067	0.308	0.758
wielkopolskie	0.022	−0.067	0.313	0.754	pomorskie	0	−0.067	0.154	0.877
łódzkie	0.018	−0.067	0.262	0.794	łódzkie	0	−0.067	0.207	0.836
małopolskie	−0.008	−0.067	0.114	0.909	warmińsko-mazurskie	−0.043	−0.067	0.054	0.957
dolnośląskie	−0.012	−0.067	0.106	0.915	małopolskie	−0.109	−0.067	−0.081	0.936
kujawsko-pomorskie	−0.178	−0.067	−0.302	0.762	opolskie	−0.326	−0.067	−0.6	0.548
mazowieckie	−0.557	−0.067	−1.523	0.128	śląskie	−0.522	−0.067	−1.053	0.292
opolskie	−0.591	−0.067	−1.214	0.225	kujawsko-pomorskie	−0.661	−0.067	−1.605	0.108
śląskie	−1.463	−0.067	−3.235	0.001	mazowieckie	−1.413	−0.067	−4.18	0

Source: Own calculations using the PQStat program.

Spatial interactions between the development potential and the division of voivodeships in Poland are shown in Figure 3. The local statistics of I Moran were determined for each trait. The manner of spatial connections between communes was determined using the neighborhood matrix.

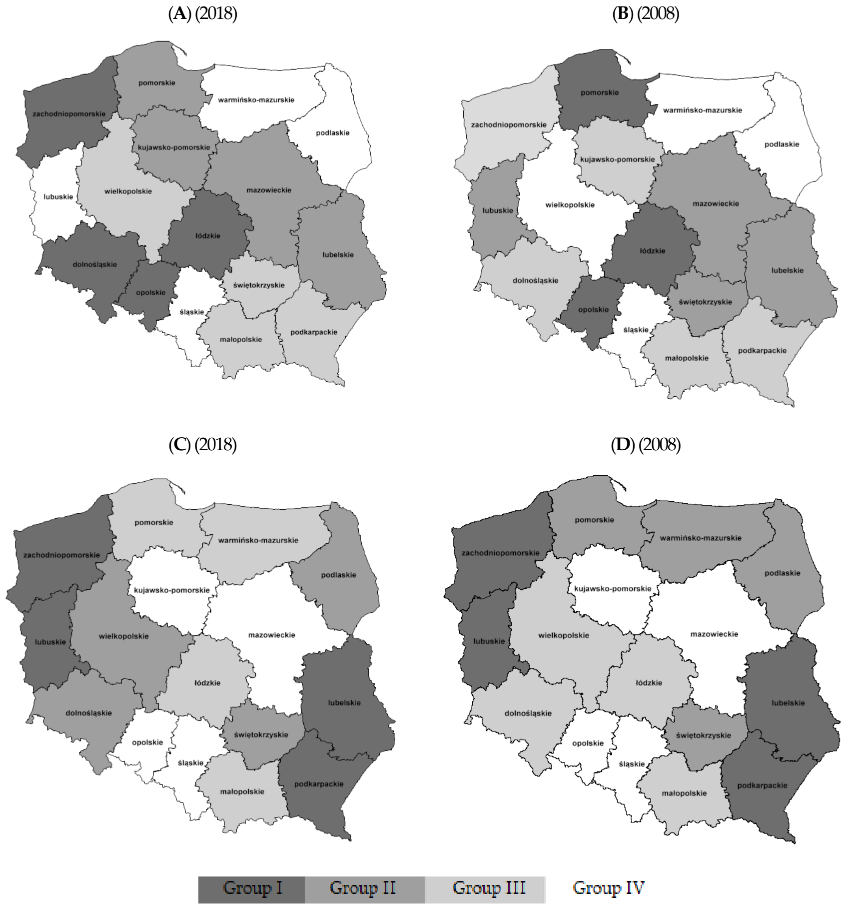

Figure 3. Quartile groups for measures of synthetic agricultural potential of Polish voivodships in 2009 and 2018 according to the value of local statistics of I Moran. (**A**,**B**) (agriculture) (**C**,**D**) (development). Source: own study based on the BDL CSO data

5. Discussion

Better-developing voivodships were found in western and central Poland (Mazowieckie, Wielkopolskie). Due to geographic and natural conditions and the influence of socio-economic factors, individual regions of the country are characterized by a different economic situation. The processes take place within regions and translate directly into the living conditions, as well as the well-being of the inhabitants [74]. Agriculture is a branch of the economy dependent on many factors. The multidimensionality of both the development aspect and the agricultural potential should be emphasized. The discussed potentials determine numerous variables included in Table 1, which also determine the strength of the region. The multidimensionality and multifaceted nature of the connections taking place in the local (regional) economy requires building a network of relations simultaneously at all levels of operation, i.e., micro, meso and macro. Additionally, the multidimensionality is noticeable in the context of the functioning of regions in the economic, social, cultural and environmental spheres.

Its development is influenced by natural, social and economic conditions (including human capital, agrarian structure, the level of mechanization and technical infrastructure). These variables are interdependent and occur at the same time. They should therefore be considered together. The potential of agriculture in Poland is a complex and spatially diversified phenomenon. It results from differences in: natural conditions, type of agricultural production, agrarian fragmentation or the level of economic development of voivodships [75].

One-dimensional analysis of its level may not be sufficient. It should be strengthened by a multidimensional (synthetic) approach. Examples of the use of linear ordering methods in agricultural economics were presented by the potential of agriculture by Anna Majchrzak and Feliks Wysocki [12], Feliks Wysocki and Agnieszka Kozera [13], Walenty Poczta and Natalia Bartkowiak [10], Luiza Osowska and Dorota Janiszewska [14]. Individual authors used different sets of features characterizing the potential of agriculture. Difficulties in the description and measurement of phenomena occurring in agriculture result from the complexity of the production process in agriculture. This is due to from regional differentiation of production conditions, demographic and social processes. The selection of the features was made after reading the professional literature and the necessary statistical calculations. Many economists studying the potential of agriculture have focused on assessing the level of potential compared to other countries. Less attention was paid to regional analysis (e.g., by voivodship) [76,77]. The authors, through the prism of the multitude of synthetic mairy, present the diversification of the potential of agriculture in voivodships in Poland (Figure 1). The topic of the potential of agriculture is present not only in Poland but all over the world. This is evidenced by numerous scientific studies. Gudrun Loose points out that the natural conditions influenced by climate, water, soil and vegetation strongly affect the basic agricultural potential in Central and Eastern Europe [78].

Clawson M., Landsberg H.H., Alexander L.T. analyze the agricultural potential of the Middle East, including countries such as Egypt, Israel, Jordan, Lebanon, Syria, Iraq and Saudi Arabia. They indicate that the development potential should be considered in such areas as natural resources, land and water management, inputs, labor, farms, crops, livestock, production, marketing and trade [79]. X Deng, J Huang, S Rozelle, E Uchida pointed out that the potential development and productivity of agriculture has an impact on China's food security [80]. Research conducted in the USA by AJ Planting, RN Lubowski, and RN Stavins indicates the relationship between irreversible and uncertain land development and the value of agricultural land [81]. An issue that relates to this issue is the market position of farms in market networks. It can be considered in two perspectives—as the position of some farms against others, and as the market power of farms against other economic entities, e.g., producers of means of production or trading companies [82,83].

Contemporary agriculture is going through a period of intense changes. They are related to the search for management methods that guarantee the achievement of economic, social and environmental goals. The level of development (including agricultural development) is characterized by large spatial differentiation, both in terms of the potential and the degree of its use. The decline in the number of agricultural workers results from the progressing technological, economic, structural and organizational changes as well as migration processes.

The conducted analyzes of the synthetic measure of the potential of agriculture show that Polish agriculture is characterized by a large spatial differentiation. Its level was influenced by the measure of the natural environment, the measure of infrastructure, the number of unemployed (especially in rural areas) and working people, or the share of income from transfers from the state budget in total income, and the area of forest land. The indicated ones also shaped the development process, it was also shaped by the variables of the agricultural potential (Table 6). The indicated elements constitute the local economic base of the region. Skillful use of the potential of agriculture together with structural changes may decide the development (competitiveness) of the region. Significant and growing spatial disproportions in the level of socio-economic development may shape the processes taking place in agriculture.

R. Grabowski and S. Self emphasized the special importance of technological changes in agriculture. They indicated that changes in agricultural technology had a positive impact on the region's growth [84]. The same dependence in the field of technology development is also indicated in the latest study by Vesna Vesna MrdaljHamid El Bilali [85]. Other authors indicate that specialization is a way to better use the potential of agriculture. Its increase may lead to increased profitability and may also increase the risk of farming and environmental hazards [86]. The analysis of numerous studies has shown that the potential of agriculture is correlated with climate change as a result of an increase in the concentration of greenhouse gases. This is indicated, inter alia, by C Rosenzweig and FN Tubiello, who believe that it is necessary to implement an environmental protection strategy with simultaneous socio-economic pressure [87]. Martin L. Parry, Timothy R. Carter, Nicolaas T. Konijn, also link the influence of climate to various aspects of agriculture, referring in their research to Iceland [88]. It should be emphasized that this is a global problem, but nevertheless, solutions should be adapted to regions, due to appropriate natural, social and economic factors.

6. Conclusions

Agriculture is one of the three main sectors of the economy. It produces food. The basic natural factors influencing the development of agriculture are soil quality, climate and topography. Non-natural factors of agriculture development include the level of agrotechnics, farm size, commodity and specialization of agricultural production, employment in agriculture, agricultural policy of the authorities. There are still too many small semi-subsistence farms in Poland—they dominate the east of the country.

The subject of the research was to compare the potential of agriculture in voivodships in Poland. A synthetic measure was chosen as the research method, which allows for their ranking. On the basis of the synthetic variable, voivodeships were divided into typological groups. A division into quartile groups was proposed, assuming one, two, three quartiles as threshold values. The analyzes were carried out for the years 2008 and 2018. This slowly assessed the changes in the potential of agriculture in the analyzed period. The values of single simple (diagnostic) variables in individual groups can be characterized by a fairly large dispersion. The total measure (synthetic variable) shows the actual position of the voivodship. The goodness of the variables for the study may affect the position of the individual in the examined aspect. The position of the unit may also result from the construction of the synthetic measure. The obtained results should be treated with caution, as the use of a different measure or the selection of a different area of the test may have a significant impact on the test result. The synthetic measure of the agricultural potential ranged from 0.14 (Lubuskie) to 0.40 (Opolskie, Wielkopolskie) in 2008 and from 0.16 (Lubuskie) to 0.45 (Opolskie) in 2018. An increase in the range measure (from 0.26 to 0.29) indicates a greater differentiation of units in terms of agricultural potential. In the case of the measure of agricultural potential, the best voivodships were Wielkopolskie (0.48), Mazowieckie (0.46), and Podlaskie (0.45). In 2008, the synthetic measure of development ranged from 0.28 (Lubelskie) to 0.48 (Śląskie), and in 2018 from 0.30 (Lubelskie) to 0.53 (Mazowieckie). The value of the range was higher in 2018 (0.23) than in 2008 (0.20), which indicates an increase in the differentiation of units in the studied area.

The level of the synthetic measure of agricultural potential in voivodships in Poland was negatively correlated with the measure of the natural environment, the measure of infrastructure, the number of unemployed and the area of forest land. In the aspect of variables describing agriculture, the measure of agricultural potential was correlated with the area of arable land, number of tractors, cattle population, pigs, and the production of milk, basic crops, sugar beet, and grain maize. The development was influenced by the level of migration, the number of employees (as well as economic entities and natural persons running a business, own income in total income, people using treatment, the measure of demographic potential and the labor market, the measure of economy and infrastructure.

In the case of the leading voivodships, in terms of the agricultural potential, we are dealing with a high level of their operational efficiency and their large area. Agriculture is fragmented in four voivodeships of south-eastern Poland. The decline in the number of agricultural employees resulted from the migration of workers, interest in expanding non-agricultural types of economic activity, and enabled better use of the remaining labor force and improvement of the agrarian structure of farms.

Expanding the aspect of non-agricultural activities, as part of multifunctional rural development, while maintaining the principles of the sustainable development concept, which means obtaining complementarity of individual functions of rural areas, while meeting the criteria of economic, social and environmental order. Developing a diverse offer of non-agricultural activities services, both on farms and in the environment, will generate higher farm incomes and create additional jobs in their surroundings. This will contribute to the development of both farms themselves and the economic strengthening of rural areas. The non-agricultural professional activity of the agricultural population will significantly and in the long term raise the standard of living of farming families by generating additional sources of income. The multi-functional development of rural areas is primarily aimed at counteracting economic and social marginalization and depopulation of rural areas.

Strengthening and development of infrastructure in rural areas should be the result of activities undertaken by local authorities as part of the implementation of multi-annual strategic plans developed at the local level. In the institutional aspect, one should also take into account not only the number and structure of public institutions, but also non-governmental organizations and the efficiency of their activities, and thus the development of civic activity, which will consequently constitute the basis for the development of the rural social economy.

Local authorities should first of all take care to improve the economic potential, which may increase the attractiveness of the areas and attract new entrepreneurs, create new jobs (including in non-agricultural sectors) and improve the quality of life of rural residents, thanks to activities aimed at accelerating multifunctional development of areas rural. It may also allow for a partial departure of the labor force from the agricultural sector and will positively reduce the so-called hidden unemployment in agriculture. Moreover, the possibility of finding a job outside agriculture may result in the liquidation of some small and ineffective farms and their takeover by larger, dynamically developing farms, thus positively influencing the change in the agrarian structure. In many regions of Poland you can still observe the so-called "land hunger", that is, owners of larger farms want to expand them, but find it difficult to find people willing to sell their land. Many small farms have a social function (place of residence and food production for self-supply). The acceleration of the transformation of the economic and social structure should also contribute to the improvement of the income structure, strengthening of financial independence, and improvement of the economic base in rural areas.

The presented methods make it possible to identify areas with a higher or lower level of agricultural and development potential, and then to program their support, e.g., from public funds under the regional policy. It can be used as a useful tool for local authorities in assessing the accuracy of past decisions, as well as the effectiveness of the regional management instruments used in the past. The low availability of statistical data on the agricultural potential makes it difficult to analyze the operation or programming, conduct and evaluation of the local government development policy. The lack of properly selected indicators increases the risk of their selective selection and the possibility of making wrong decisions in the future.

Author Contributions: Conceptualization, P.D., P.P., M.B.; methodology, P.D., P.P.; software, P.D., P.P., M.B.; validation, P.D., P.P., M.B.; formal analysis, P.D., P.P.; investigation, P.D., P.P., M.B., M.S.; resources, P.D., P.P., M.B.; data curation, P.D., P.P., M.B.; writing—original draft preparation, P.D., P.P., M.B., M.S.; writing—review and editing, P.D., P.P., M.B., M.S.; visualization, P.D., P.P., M.B.; supervision, P.D., P.P., M.B., M.S.; project administration, P.D., P.P.; funding acquisition, P.D., P.P., M.B., M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Beba, P.; Poczta, W. Miejsce rolnictwa w gospodarce polskich regionów. *J. Agribus. Rural Dev.* **2015**, *1*, 17–26.
2. Stanny, M. Zróżnicowanie poziomu rozwoju obszarów wiejskich w Polsce a problem realizacji polityki spójności. *Zesz. Nauk. SGGW Warszawie Polityki Eur. Finans. Mark.* **2009**, *1*, 47–56.
3. Sawa, J. Próba oceny zrównoważenia procesów produkcji rolniczej. *Inżynieria Rol.* **2008**, *2*, 257–262.
4. Kiełbasa, M. Przyszłość sektora rolno-spożywczego w Polsce w odniesieniu do stanu obecnego. *Prog. Econ. Sci.* **2015**, *2*, 227–238.
5. Chądzyński, J.; Nowakowska, A.; Przygodzki, Z. *Region i Jego Rozwój w Warunkach Globalizacji*; Wydawnictwo CeDeWu: Warszawa, Poland, 2007.
6. Szulc, E. *Ekonometryczna Analiza Wielowymiarowych Procesów Gospodarczych*; Wydawnictwo Uniwersytetu Mikołaja Kopernika: Toruń, Poland, 2007.
7. Kopczewska, K. *Ekonometria i Statystyka Przestrzenna z Wykorzystaniem Programu R CRAN*; Wydawnictwo CeDeWu: Warszawa, Poland, 2006.
8. Krasowicz, S.; Igras, J. Regionalne zróżnicowanie wykorzystania potencjału rolnictwa w Polsce. *Pamiętnik Puławski* **2003**, *132*, 233–251.
9. Poczta, W.; Mrówczyńska, A. Regionalne zróżnicowanie polskiego rolnictwa. In *Zróżnicowanie Regionalne Gospodarki Żywnościowej w Polsce w Procesie Integracji z Unią Europejską*; Poczta, W., Wysocki, F., Eds.; Wydawnictwo Akademii Rolniczej im. Augusta Cieszkowskiego w Poznaniu: Poznań, Poland, 2002.
10. Poczta, W.; Bartkowiak, N. Regionalne zróżnicowanie rolnictwa w Polsce. *J. Agribus. Rural Dev.* **2012**, *1*, 95–109.
11. Kisielinska, J. Ranking województw ze względu na potencjał rolnictwa. *Rocz. Nauk. Ekon. Rol. Rozw. Obsz. Wiej.* **2017**, *104*, 56–71. [CrossRef]
12. Majchrzak, A.; Feliks, W. Potencjał produkcyjny rolnictwa w województwie wielkopolskim. *Rocz. Nauk. Ser.* **2007**, *9*, 217–221.
13. Wysocki, F.; Kozera, A. Potencjał produkcyjny rolnictwa i efektywność wykorzystania czynników produkcji. *Wiadomości Stat.* **2012**, *4*, 49–64.
14. Osowska, L.; Janiszewska, D. Potencjał produkcyjny i uwarunkowania rozwoju rolnictwa w województwie zachodniopomorskim. *Zesz. Nauk. Sggw W Warszawie. Probl. Rol. Swiat.* **2013**, *13*, 68–78.
15. Poczta, W.; Średzińska, J.; Standar, A. Sytuacja finansowa gospodarstw rolnych krajów UE według potencjału produkcyjnego. *J. Agribus. Rural Dev.* **2008**, *10*, 83–94.

16. Słodowa-Hełpa, M. Wieś i rolnictwo w regionalnych i lokalnych strategiach rozwoju. In *Wieś i Rolnictwo w Procesie Integracji z Unią Europejską: Przyjmowanie Zachodnioniemieckich Dróg Rozwoju, Utrzymywanie Własnej Tożsamości czy Poszukiwanie Innych Rozwiązań*; Kośmicki, E., Januszek, H., Janik, W., Eds.; Wydawnictwo AR w Poznaniu: Poznań, Poland, 1998; pp. 359–379.
17. Nazarczuk, J. *Potencjał Rozwojowy a Aktywność Inwestycyjna Województw i Podregionów Polski*; Wydawnictwo UWM w Olsztynie: Olsztyn, Poland, 2013.
18. Klepacki, B.; Grontkowska, A. *Ekonomika i Zarzadzanie Przedsiębiorstwem w Agrobiznesie*; Format-AB: Warszawa, Poland, 2006; Volume 14–15, pp. 22–24.
19. Baer-Nawrocka, A.; Poczta, W. Przemiany w rolnictwie. In *Polska Wieś 2014 Raport o stanie wsi Agricultural transformation*; Nurzyńska, I., Poczta, W., Eds.; (Polish Village in 2014 Report on the State of the Village); Wydawnictwo naukowe SCHOLAR: Warszawa, Poland, 2014; pp. 85–115.
20. Tomczak, F. Potencjał i możliwości produkcyjne rolnictwa. In *Encyklopedia Agrobiznesu*; Woś, A., Ed.; Fundacja Innowacja: Warszawa, Poland, 1998; p. 713.
21. Rzeszutko, A. *Regionalne Zróżnicowanie Przemian Struktury Rolnictwa w Polsce w Warunkach Integracji z Unią Europejską*; Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu: Poznań, Poland, 2014; p. 231.
22. Toth, D.; Smutka, L.; Maitah, K.; Jarolínová, V. Income Differentiation as a Factor of Unsustainability in Forestry. *Sustainability* **2020**, *12*, 4749. [CrossRef]
23. Stanny, M.; Czarnecki, A. *Zrównoważony rozwój obszarów wiejskich Zielonych Płuc Polski. Próba Analizy Empirycznej*; Wyd. IRWiR PAN: Warszawa, Poland, 2011.
24. Vermeulen, B.; Pyka, A. The role of network topology and the spatial distribution and structure of knowledge in regional innovation policy. A calibrated agent-based model study. *Comput. Econ.* **2018**, *52*, 773–808. [CrossRef]
25. Szymla, Z. *Determinanty Rozwoju Regionalnego*; Ossolineum: Wrocław, Poland, 2000; p. 59.
26. Ngo Dang, T.; Tran Thuy, C.; Tran Van, Y.; Nguyen Thanh, T. Sets of Sustainable Development Indicators in Vietnam: Status and Solutions. *Economies* **2018**, *6*, 1. [CrossRef]
27. Tang, L.; Wang, D. Optimization of County-Level Land Resource Allocation through the Improvement of Allocation Efficiency from the Perspective of Sustainable Development. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2638. [CrossRef]
28. Jutengren, G.; Jaldestad, E.; Dellve, L.; Eriksson, A. The Potential Importance of Social Capital and Job Crafting for Work Engagement and Job Satisfaction among Health-Care Employees. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4272. [CrossRef]
29. Hellwig, Z. Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom rozwoju oraz zasoby i strukturę wykwalifikowanych kadr. *Przegląd Stat.* **1968**, *4*, 307–326.
30. Dziekański, P.; Prus, P. Financial Diversity and the Development Process: Case study of Rural Communes of Eastern Poland in 2009–2018. *Sustainability* **2020**, *12*, 6446. [CrossRef]
31. Pawlik, A.; Dziekański, P. *Atrakcyjność Miast i Gmin Województwa świętokrzyskiego*; Uniwersytet Jana Kochanowskiego: Kielce, Poland, 2020; ISBN 978-83-7133-858.
32. Dziekanski, P.; Pawlik, A.; Wronska, M.; Karpinska, U. Demographic Potential as the Basis for Spatial Differentiation of the Financial Situation Communes of Eastern Poland in 2009–2018. *Eur. Res. Stud. J.* **2020**, *XXIII*, 872–892. [CrossRef]
33. Grabiński, T. Metody określania charakteru zmiennych w wielowymiarowej analizie porównawczej. *Zesz. Nauk. Akad. Ekon. W Krakowie* **1985**, *213*, 35–63.
34. Malina, A. *Wielowymiarowa Analiza Przestrzennego Zróżnicowania Struktury Gospodarki Polski Według Województw*; Wyd. Akademii Ekonomicznej w Krakowie: Kraków, Poland, 2004; pp. 96–97.
35. Malina, A.; Zieliaś, A. Taksonomiczna Analiza Przestrzennego Zróżnicowania Jakości Życia Ludności w Polsce w 1994 r. In *Ekonometryczne Modelowanie Danych Finansowo-Księgowych*; Nowak, E., Urbaniak, M., Eds.; UMCS: Lublin, Poland, 1996; pp. 85–89.
36. Kolenda, M. Zamiana cechy na stymulantę. *Pr. Nauk. Akad. Ekon. We WrocławiuEkonom.* **2003**, *11*, 110–127.
37. Młodak, A. *Analiza Taksonomiczna w Statystyce Regionalnej*; Centrum Doradztwa i Informacji Difin: Warszawa, Poland, 2006.
38. Kukuła, K. *Metoda Unitaryzacji Zerowanej*; PWN: Warszawa, Poland, 2000.
39. Lenormand, M.; Deffuant, G. Generating a Synthetic Population of Individuals in Households: Sample-Free vs. Sample-Based Methods. *J. Artif. Soc. Soc. Simul.* **2013**, *16*, 1–12. [CrossRef]
40. Jahanshahloo, G.R.; Lotfi, F.H.; Izadikhah, M. An Algorithmic Method to Extend {TOPSIS} for Decision-Making Problems with Interval Data. *Appl. Math. Comput.* **2006**, *2*, 1375–1384. [CrossRef]
41. Hwang, C.L.; Yoon, K. *Multiple Attribut Decision Making: Methods and Applications*; Springer: Berlin/Heidelberg, Germany, 1981.
42. Velasquez, M.; Hester, P.T. An Analysis of Multi-Criteria Decision Making Methods. *Int. J. Oper. Res.* **2013**, *2*, 56–66.
43. Özcan, T.; Çelebi, N.; Esnaf, S. Comparative Analysis of Multi-Criteria Decision Making Methodologies and Implementation of a Warehouse Location Selection Problem. *Expert Syst. Appl.* **2011**, *8*, 9773–9779. [CrossRef]
44. Zavadskas, E.K.; Zakarevicius, A.; Antucheviciene, J. Evaluation of ranking accuracy in multi-criteria decisions. *Informatica* **2006**, *17*, 601–618. [CrossRef]
45. Huang, I.B.; Keisler, J.; Linkov, I. Multi-criteria decision analysis in environmental science: Ten years of applications and trends. *Sci. Total Environ.* **2011**, *409*, 3578–3594. [CrossRef]
46. Behzadian, M.; Khanmohammadi Otaghsara, S.; Yazdani, M.; Ignatius, J. A state-of-the-art survey of TOPSIS applications. *Expert Syst. Appl.* **2012**, *39*, 13051–13069. [CrossRef]

47. Zalewski, W. Zastosowanie metody TOPSIS do oceny kondycji finansowej spółek dystrybucyjnych energii elektrycznej. *Ekon. I Zarządzanie* **2012**, *4*, 137–145.
48. Bieniasz, A.; Gołaś, Z.; Łuczak, A. Zróżnicowanie kondycji finansowej gospodarstw rolnych wyspecjalizowanych w chowie owiec i kóz w krajach Unii Europejskiej. *Rocz. Ekon. Rol. I Rozw. Obsz. Wiej.* **2013**, *100*, 168–181.
49. Nowak, E. *Metody Taksonomiczne w Klasyfikacji Obiektów Społeczno-Gospodarczyc*; PWE: Warszawa, Poland, 1990; p. 190.
50. Zeliaś, A.; Malina, A. O budowie taksonomicznej miary jakości życia. Syntetyczna miara rozwoju jest narzędziem statystycznej analizy porównawczej. *Taksonomia* **1997**, *4*, 238–262.
51. Bivand, R. Autokorelacja przestrzenna a metody analizy statystycznej w geografii. In *Analiza Regresji w Geografii*; Chojnicki, Z., Ed.; PWN: Poznań, Poland, 1980; pp. 23–38.
52. Getis, A. A History of the Concept of Spatial Autocorrelation: A Geographer's Perspective. *Geogr. Anal.* **2008**, *40*, 297–309. [CrossRef]
53. Suchecki, B. (Ed.) *Ekonometria Przestrzenna. Metody i Modele Analizy Danych Przestrzennych*; Wydawnictwo, C.H. Beck: Warszawa, Poland, 2010.
54. Sikora, J. Określenie siły i charakteru autokorelacji przestrzennej na podstawie globalnej statystyki I Morana infrastruktury rolniczej Polski południowej i południowo-wschodniej. *Infrastruct. Ecol. Rural Areas* **2009**, *9*, 217–227.
55. Longley, P.; Goodchild, M.F.; Maguire, D.J.; Rhind, D.W. *GIS. Teoria i praktyka (GIS. Theory and Practice)*; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2006.
56. Anselin, L. Local Indicators of Spatial Association—LISA. *Geogr. Anal.* **1995**, *27*, 93–115. [CrossRef]
57. Cliff, A.D.; Ord, J.K. *Spatial Autocorrelation*; Pion: London, UK, 1973.
58. Janc, K. Zjawisko autokorelacji przestrzennej na przykładzie statystyki I Morana oraz lokalnych wskaźników zależności przestrzennej (LISA)–wybrane zagadnienia metodyczne. *IDEE I Prakt. Uniwersalizm Geogr.* **2006**, *33*, 76–83.
59. Zeliaś, A. (Ed.) *Ekonometria Przestrzenna*; PWE: Warszawa, Poland, 1991.
60. Kopczewska, K. *Ekonometria i Statystyka Przestrzenna z Wykorzystaniem Programu R Cran (Econometry and Spatial Statistics Using Software R Cran)*; CEDEWU.PL: Warszawa, Poland, 2011.
61. Upton, G.; Fingleton, B. *Spatial Data Analysis by Example*; Wiley: New York, NY, USA, 1985.
62. Martinho, V. Spatial Analysis of the Tourism Supply. 2013. Available online: http://hdl.handle.net/10419/71762 (accessed on 10 December 2020).
63. Anselin, L.; Bera, A. Statystyka Globalna MORANA. Available online: http://manuals.pqstat.pl/przestrzenpl:autocorpl:gmoranpl (accessed on 10 December 2020).
64. Moran, P.A.P. Notes on Continuous Stochastic Phenomena. *Biometrika* **1950**, *37*, 17–23. [CrossRef]
65. Maddala, G.S. *Ekonometria*; PWN: Warszawa, Poland, 2007.
66. Górecki, T. *Podstawy Statystyki z Przykładami w R*; Wydawnictwo BTC: Warszawa, Poland, 2011.
67. Welfe, A. *Ekonometria*; Metody i ich zastosowanie, PWE: Warszawa, Poland, 2009.
68. Gigerenzer, G. Mindless statistics. *J. Socio-Econ.* **2004**, *33*, 587–606. [CrossRef]
69. Conover, W.J.; Iman, R.L. Rank transformations as a bridge between parametric and nonparametric statistics. *Am. Stat.* **1981**, *35*, 124–129. [CrossRef]
70. Rosner, A. *Zmiany Rozkładu Przestrzennego Zaludnienia Obszarów Wiejskich. Wiejskie obszary Zmniejszające Zaludnienie i Koncentrujące Ludność Wiejską*; IRWiR PAN: Warszawa, Poland, 2012.
71. Satoła, Ł. Municipal infrastructure and the Level of Fiscalism in Local Taxes. In Proceedings of the International Scientific Conference "Economic Sciences for Agribusiness and Rural Economy" (No. 1), Warsaw, Poland, 7–8 June 2018; pp. 370–375. [CrossRef]
72. Kudłacz, T. Rozwój społeczno-gospodarczy Polski południowo-wschodniej w układzie jednostek nowego podziału terytorialnego kraju. *Zesz. Nauk. /Akad. Ekon. W Krakowie* **2000**, *545*, 15–30.
73. Okólski, M. Demografia. In *Podstawowe Pojęcia, Procesy i Teorie w Encyklopedycznym Zarysie*; Wydawnictwo Naukowe SCHOLAR: Warszawa, Poland, 2005.
74. Malina, A. Analiza przestrzennego zróżnicowania poziomu rozwoju społeczno-gospodarczego województw Polski w latach 2005–20172. *Soc. Inequalities Econ. Growth* **2020**, *61*, 138–155.
75. Lukiewska, K.; Chrobocińska, K. Przestrzenne zróżnicowanie potencjału produkcyjnego rolnictwa w Polsce. *Rocz. Nauk. Ekon. Rol. I Rozw. Obsz. Wiej.* **2015**, *102*, 56–65.
76. Poczta, W. Potencjał i pozycja konkurencyjna polskiego sektora rolno-żywnościowego na rynku europejskim. *Postępy Nauk Rol.* **2010**, *2*, 35–56.
77. Grochowska, R.; Mańko, S. Produktywność gospodarstw rolnych w Polsce na tle innych krajów. *Probl. Rol. Światowego* **2014**, *14*, 25–33.
78. Loose, G. Climate, Soils and Agricultural Potential. In *Agricultural Transformation and Land Use in Central and Eastern Europe*; Routledge: London, UK, 2018; pp. 23–56.
79. Clawson, M.; Landsberg, H.H.; Alexander, L.T. The Agricultural Potential of the Middle East. *Soil Sci.* **1972**, *114*, 499. [CrossRef]
80. Deng, X.; Huang, J.; Rozelle, S.; Uchida, E. Cultivated land conversion and potential agricultural productivity in China. *Land Use Policy* **2006**, *23*, 372–384. [CrossRef]

81. Plantinga, A.J.; Lubowski, R.N.; Stavins, R.N. The effects of potential land development on agricultural and prices. *J. Urban Econ.* **2002**, *52*, 561–581. [CrossRef]
82. Gazdecki, M.; Goryńska-Goldmann, E. The system of interorganizational linkages in agri-markets. Relationship, Interactions and networks in Competitive Environments. In Proceedings of the 35th Annual IMP Conference, IÉSEG School of Management, Paris, France, 20–27 August 2019. Available online: https://www.impgroup.org/paper_view.php?viewPaper=11050 (accessed on 20 December 2020).
83. Gazdecki, M.; Goryńska-Goldmann, E. *Relationships on Food Markets. Consumer Perspective*, 1st ed.; Poznan University of Life Science: Poznan, Poland, 2018. Available online: https://www.academia.edu/40708090/RELATIONSHIPS_ON_FOOD_MARKETS_CONSUMERS_PERSPECTIVE_MICHA%C5%81_GAZDECKI_EL%C5%BBBIETA_GORY%C5%83SKA_GOLDMANN (accessed on 20 December 2020).
84. Grabowski, R.; Self, S. Economic Development and the Role of Agricultural Technology. *Discuss. Pap.* **2007**, *40*. Available online: https://opensiuc.lib.siu.edu/econ_dp/40/ (accessed on 20 December 2020).
85. Mrdalj, V.; El Bilali, H. Information and Communication Technologies in Bosnian Agriculture: Potential and Challenges. In Proceedings of the International Scientific Conference Agrarian Perspectives XXIX "Trends and Challenges of Agrarian Sector", Prague, Czech Republic, 16–17 September 2020; pp. 231–246. Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwif7cGRzPPtAhXLpIsKHVGuAyUQFjAAegQIBBAC&url=https%3A%2F%2Fap.pef.czu.cz%2Fdl%2F88730%3Flang%3Den&usg=AOvVaw07wELXPJOA01V11rqme6Do (accessed on 20 December 2020).
86. Józwiak, W.; Juźwiak, J. Rolnictwo wielostronne czy wyspecjalizowane? *Wieś I Rol.* **2007**, *4*, 9–20.
87. Rosenzweig, C.; Tubiello, F.N. Adaptation and mitigation strategies in agriculture: An analysis of potential synergies. *Mitig. Adapt. Strateg. Glob. Chang.* **2007**, *12*, 855–873. [CrossRef]
88. Parry, M.L.; Carter, T.R.; Konijn, N.T. (Eds.) *The Impact of Climatic Variations on Agriculture: Volume 1: Assessment in Cool Temperate and Cold Regions*; Springer Science & Business Media: New York, NY, USA, 2013.