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Diversity of the selected elements of agricultural potential in the European Union countries

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Abstract: Agricultural importance in determining the directions of respective regions results from its production potential. The agricultural potential of a given country is determined by natural resources, ways of using them, natural conditions, workforce resources, technical resources and basic economic conditions. In this paper, only income and rural population are taken under consideration to describe the agricultural potential. Currently, European Union countries are functioning under the assumptions of the Common Agricultural Policy, assuming, among other things, increasing agricultural productivity, ensuring an adequate standard of living for the rural population and stabilising markets. The European Union (EU) is one of the world's leading exporters and importers of agricultural products. The obtained results allowed the identification in 2010 and 2018 of countries with high and low values of income and population potential. It is characteristic that within both potentials, population and income, the countries with the lowest potentials are the most numerous group. Poland and Romania stand out against the background of all countries, where due to the high share of people working in agriculture, the population's potential has the highest values. Denmark is also an outstanding country for which income potential has the highest value. This study aims to examine the diversity of selected elements of agricultural potential in the European Union countries. The research was conducted using, among other potential models and global and local spatial autocorrelation statistics. The analysis covered the years 2010 and 2018 by applying statistical data (Eurostat, Statistical Yearbook of Agriculture).

Keywords: agricultural; potential; spatial autocorrelation

Many external and internal factors determine the development possibilities and potential of a region. In the case of agriculture, particular attention should be paid to natural and non-natural conditions. The first mentioned group of factors includes soil conditions, climatic conditions and terrain. On the other hand, non-natural conditions may include, among others, the level of social and economic development, agrarian culture and the type of applied technologies. Agriculture and its development level are increasingly affected by non-natural conditions, in particular labour resources, technical means and primary economic conditions.

Specific features and external conditions of individual regions determine their development opportunities. The importance of agriculture in determining development directions of individual regions results from its production potential (Martino and Marchini 1996). In agricultural sciences, the production potential of agriculture is usually assessed through the prism of the resources of production factors and their mutual relations, as well as the way they are used (Zasada et al. 2013). The size, quality and structure of production resources as well as the efficiency of their use, apart from the socio-economic system and economic policy,

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are also among the most important factors determining the competitiveness of a given economy and its sectors. Knowledge of the possibilities of agricultural production potential in a given region allows setting directions in the development strategy of the agricultural sector of this territorial unit. The efficiency of agricultural production is determined by a combination of the natural environment, economic conditions, technical measures and human labour (Bowler 1986; Bilbao-Osorio and Rodríguez-Pose 2004).

European agriculture is characterised by a smaller scale of the advancement of concentration processes (compare North and South America, Australia, New Zeland, North and West Asia), as well as a relatively high share of the workload of the owner and his family, and part-time work. Besides, individual countries of the European Union have their characteristics which may inhibit or stimulate various branches of agriculture, thus shaping the production level and structure.

Weak natural conditions can be compensated by the use of appropriate production technologies, which in turn is related to the need to have more capital. Therefore, it should be expected that the countries characterised by a high level of social and economic development, due to better technologies and a more absorbent market (higher demand), will be more productive than the countries with high agricultural potential, but at a lower level of economic development.

Knowledge of potential possibilities enables to determine directions in the development strategy of the agricultural sector of a given region. Therefore, the analysis of potential, as well as its diversification and influence of particular determinants, is an essential direction of economic and agricultural research. These studies more often use advanced statistical methods that enable to distinguish relatively homogeneous groups of regions with similar analysis (Chaplin 2000). Spatial analysis in economics is becoming increasingly important as more spatial data, and innovative data mining technologies are developed. The problem of potential in agriculture was described in the paper by Bryden (2002), Terluin (2003), and D'Amico et al. (2013).

This paper is focused on the diversification of selected elements of agricultural potential in the European Union countries with use spatial econometrics methods (spatial autocorrelation, models of potential). The analysis covers the period between 2010 and 2018 and is based on Eurostat data (Eurostat Database 2019, Statistical Yearbook of Agriculture 2019). In the analysis of spatial differentiation, the distance between territorial units or their neighbourhood is a crucial element. The location of a given country may affect the economic situation of its agriculture industry and in particular, the income from agricultural production. More distant countries may have difficulties accessing the market, and incur additional costs related to the import of means of production. As a result, companies in these countries can afford to pay relatively low wages – even if their technological development is similar to that of other countries. The study also verified the hypothesis about the lack of differentiation in population potential and agricultural income despite different climatic conditions. The presented research is an introduction to broader analyses, including the study of the relationship between the spatial diversity of agricultural potential and natural conditions. Finally, the study verifies the hypothesis about the relationship between natural and economic conditions and the productivity and efficiency of agricultural production.

MATERIAL AND METHODS

Potential models. The subject literature distinguishes three basic spatial potential models: population potential model (Head and Mayer 2011), income potential model, localisation potential model. In 1970, Dutton introduced the concept of potential quotient to geographical research (Dutton 1970). The author assumed that income potential is proportional to demand, and population potential is an indicator of real demand. Applying the potential quotient in empirical research was presented by Coffey in 1978, defining the potential quotient as a measure of the ability to satisfy demand. The potential quotient takes into account the influence of interregional relations on the development level of regions. It is a systemic measure and a variable of continuous spatial distribution (Friedmann 1967; Coffey 1978; Rich 1980; Tłuczak 2019).

Potential models are widely used in researching the level of socio-economic development. The precursors of spatial analysis in Europe were Clark et al. (1969), Dicken and Lloyd (1977), Keeble et al. (1982). Hanson (1998), Overman et al. (2003), Redding and Venables (2004) deal with this topic. They used the potential model to analyse the identification of central and peripheral areas of the then European Economic Community and to examine changes in its value as a result of progressive economic integration caused by the reduction of trade barriers (Tłuczak 2019).

The use of potential quotient in the study of regional differentiation involves several stages. In the first stage,

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the values of population potential V_i and U_i income potential are calculated according to formulas:

$$V_i = \frac{l_i}{d_{ii}} + \sum_{j=1}^{n} \frac{l_j}{d_{ij}}, i = 1, 2, \ldots, n \quad (1)$$

$$U_i = \frac{z_i}{d_{ii}} + \sum_{j=1}^{n} \frac{z_j}{d_{ij}}, i = 1, 2, \ldots, n \quad (2)$$

where: z_i – income in i region, d_{ij} – distance between region i and j; l_i – population in i region.

Comparison of two potential areas with each other enables to identify areas with a surplus or deficit of availability. It is assumed that the sum of potentials of the studied system is 100%. This gives a possibility to express the potential in point and as a percentage of the total potential of the whole system. Result one (V_j = 1) means the same availability, values from zero to one an availability advantage in one system and above one in another (Rich 1980; Vickerman et al. 1999). For each region, the quotient of P_i potentials is calculated in order (Tłuczak 2019):

$$P_i = \frac{U_i}{V_i} \quad (3)$$

The advantage of the potential quotient is a precise scale and interpretation of obtained results, for example, V_j = 0.25 always means that the percentage of potential in the first set was four times smaller than in the second and the value V_j = 4 that was four times greater[1] (Coffey 1978; Vickerman et al. 1999). The quotient of the income potential and the population potential in the region is the equivalent of the per capita income indicator and in terms of conditions is not different from that indicator. Its superiority as a measure of the level of development of regions consists in the fact that: (*i*) takes into account the impact of interregional relations on the formation of this level, (*ii*) is a systemic measure, (*iii*) is a variable with continuous spatial distribution (Dutton 1970; Tłuczak 2019).

Spatial autocorrelation. The phenomenon of spatial autocorrelation occurs when the level of a specific phenomenon in one spatial unit affects the change of probability for the occurrence of this phenomenon in adjacent units (Cliff and Ord 1981; Goodchild 1986; Anselin 1988; Isaaks and Shrivastava 1989; Haining 1990; Chou 1997; Perry et al. 2002; Griffith 2003; Getis 2007; Su-Wei and Hsieh 2010; Edwards 2017). Today, the concepts and methods of spatial autocorrelation have been applied to many fields, which have resulted in several interesting findings (Beck and Sieber 2010; Benedetti-Cecchi et al. 2010; Bonnot et al. 2010; Mateo-Tomás and Olea 2010; Impoinvil et al. 2011; Braun et al. 2012; Chen 2012; Deblauwe et al. 2012; Kumar et al. 2012; Stark et al. 2012).

One of the most commonly used statistics in the study of spatial autocorrelation is the global I Moran's statistic is given by the equation (Moran 1950; Cliff and Ord 1973):

$$I = \frac{n}{S_0} \frac{\sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \quad (4)$$

where: n – number of objects, w_{ij} – weight of links between object i and object j as determined by the distance between objects or by the neighbourhood,

$$w_{ij} = \begin{cases} 0, \text{if the objects share a common boundary} \\ 1, \quad \text{otherwise} \end{cases};$$

$S_0 = \sum_i \sum_j w_{ij}$, $x_i(x_j)$ – the value of the feature of a given object in location i(j).

If the value of global I Moran's statistic is more significant than $-1/(n - 1)$ then we refer to a positive spatial autocorrelation, otherwise to a negative spatial autocorrelation. For values close to $-1/(n - 1)$, it is assumed that the distribution of the value of the variable x in space is random. For large large n, this value does not differ significantly from zero thus, often the value $I = 0$ is also identified with the lack of spatial autocorrelation.

Testing the significance of global I Moran's statistic is carried out using the following test:

$$Z(I) = \frac{I - E(I)}{\sqrt{Var(I)}} \quad (5)$$

where: $E(I) = -\frac{1}{n-1}$.

Assuming the accuracy of zero hypotheses $I = E(I)$, the statistic $Z(I)$ has an asymptotically normal standardised distribution (Cliff and Ord 1973).

The use of the global I Moran's statistic spatial autocorrelation enables to detect the strength and character of spatial dependence in the studied area. Its value determines the character of the averaged pattern of spatial autocorrelation in the studied area. However, it is insensitive to local deviations from the averaged spatial autocorrelation model and does not contain informa-

[1]The value of 4 is given here as an example after Coffey (1978) and Vickerman (1999).

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tion on the degree of instability of this model. Therefore, it is not possible to identify areas with locally stronger (positive) spatial dependence, as well as outlier observations, i.e. related to locally negative spatial autocorrelation (Fortin et al. 1989; Henebry 1995; Torgersen et al. 1995; Koenig 1998; Radeloff et al. 2000).

In order to determine whether neighbours surround the region with high or low values of the studied variable, local LISA (Local Indicators of Spatial Autocorrelation/Association) statistics are used, which allow more detailed insight into the structure of spatial distribution of the value of the studied feature. Local Moran statistics are as follows (Anselin 1995; Mathur 2015):

$$I(w) = \frac{(x_i - \bar{x}) \sum_i w_{ij} (x_i - \bar{x})}{\sum_{i=j} (x_i - \bar{x})^2} \quad (6)$$

Local Moran statistics adopt negative values when regions surround a given areas with significantly different values of the studied variable (negative autocorrelation). Positive values of statistics should be interpreted as follows: the region is surrounded by similar regions (positive autocorrelation). Local Moran statistics have an approximately normal distribution, but there are often problems in determining its exact distribution. Units with statistically significant I_i values enable to determine clusters with low (LL) or high (HH) values of the studied variable, i.e. assigning them to hot or cold spots (Ord and Getis 1995). Two types of outlier observations can also be determined – low-high (LH) and high-low (HL) (Goovaerts and Jacques 2004). The final result of LISA analysis is to map clusters and outlier observations, which were carried out in this paper.

RESULTS AND DISCUSSION

Firstly, the population and income potential of all EU countries was calculated. In order to calculate the population potential, employment in agriculture per hectare of arable land in a given country was used. To calculate the income potential, the agricultural GDP in euro per capita was used.

Between 2010 and 2018, no significant changes in the average values of population potential and income potential were observed (Figure 1). There was also little change in the variability between 2010 and 2018.

Based on the obtained values of population and income potentials, countries were divided into three relatively homogeneous groups according to the potential values. The group were constructed as follow:

$$\text{Group 1: } \left(\min; \min + \frac{\max - \min}{3}\right);$$

$$\text{Group 2: } \left(\min + \frac{\max - \min}{3}; \min + 2 \times \frac{\max - \min}{3}\right);$$

$$\text{Group 3: } \left(\min + 2 \times \frac{\max - \min}{3}; \max\right).$$

The group of countries with the lowest potential values is the largest in each case. A comparison of the population potential in 2010 and 2018 (Figure 2) for the analysed spatial units – EU countries – shows a relatively stable situation. The values of population potential in the EU countries in particular years do not differ significantly from each other. In Poland and Romania, the population potential assumes the highest

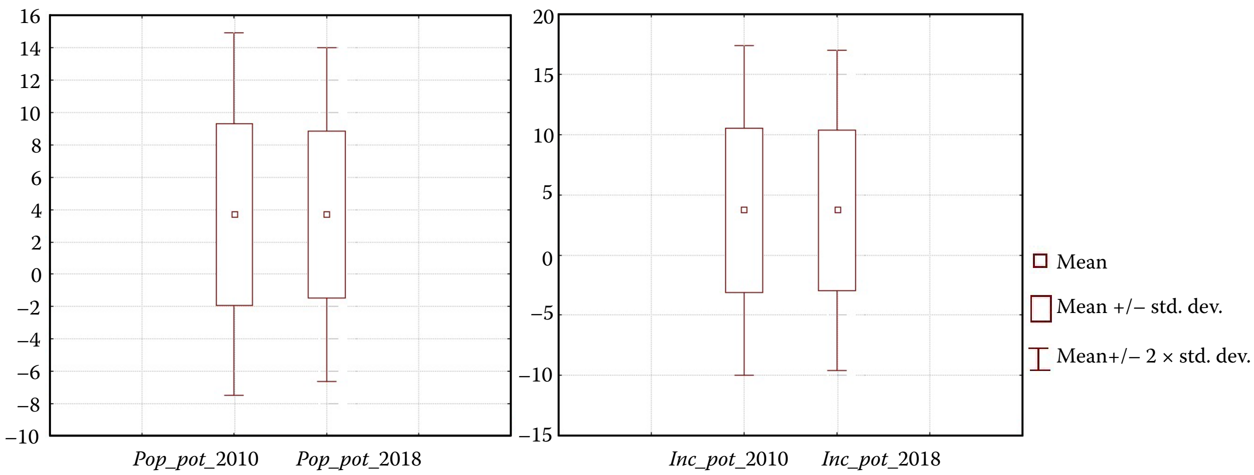

Figure 1. Boxplot for population potential (*pop_pot*) and income potential (*inc_pot*) in 2010 and 2018

Source: Own calculations based on Eurostat Database (2019)

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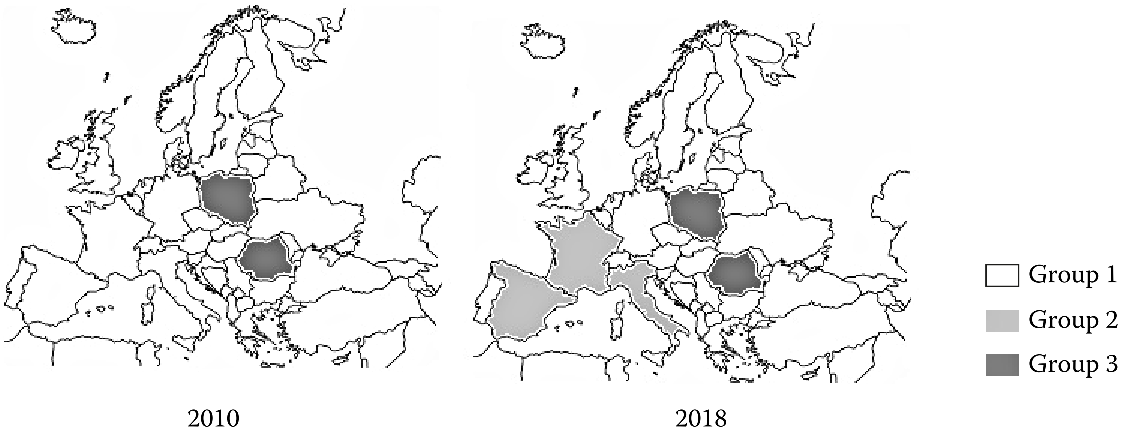

Figure 2. Population potential in 2010 and 2018

Source: Own calculations based on Eurostat Database (2019)

values, which results from the fact that in these countries the percentage of people employed in agriculture is much higher than, e.g. in France or Spain, where the share of people employed in agriculture is the lowest. In 2010, France, Spain and Italy were in group 1, along with other countries with the lowest population potential, while in 2018 they were in group 2.

Due to the value of income potential, EU countries form a cohesive group in terms of potential value. In 2010 Denmark belonged to group 3, Greece to group 2, while other countries formed the most numerous group 1. In 2018, only Denmark belonged to group 3, and the remaining countries belonged to group 1 (the group of countries with the lowest income potential).

When we take into account the population potential and income potential, it results that four countries stand out. Denmark is a country with a low population and high-income potential. Poland and Romania are countries with high population potential and low-income potential (Figure 3). Greece, on the other hand, is a country with an average population potential and a higher than average income potential. The characteristic feature of the distribution of values of income and population potentials is that apart from the four countries mentioned above, the remaining countries form a cohesive homogeneous group.

The spatial distribution of the quotient of potentials (the quotient of income potential and population) presented as a measure of the development level is the basis for distinguishing in the regional structure of the EU Member States in terms of the concept of core-peripheries of core regions and peripheral areas. On the potential quotient distribution map (Figure 4), the continuous systems of subregions with high values of this quotient correspond to the systems of their impact in the form of core regions.

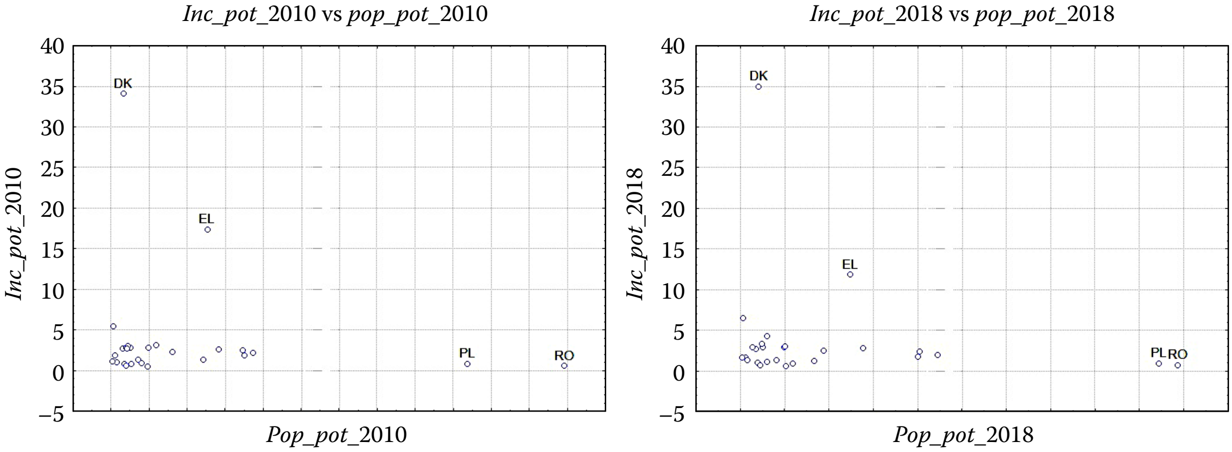

Figure 3. Population potential versus income potential in 2010 and 2018

DK – Denmark; EL – Greece; PL – Poland; RO – Romania

Source: Own calculations based on Eurostat Database (2019)

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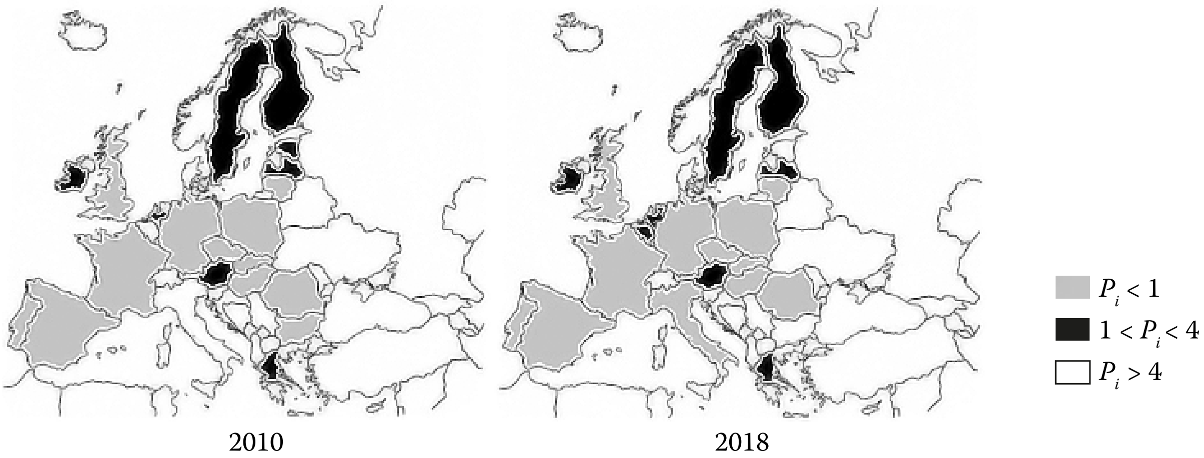

Figure 4. Quotients of income and population potentials in 2010 and 2018

P_i – potential quotient
Source: Own calculations based on Eurostat Database (2019)

A large group (13 countries) consists of countries with the value of potential quotient below unity, another group (9 countries in 2010 and 8 countries in 2018) consists of countries with the value of potential between 1 and 4. Countries such as Greece, Ireland, Malta, Cyprus, Belgium, Luxembourg are countries with the highest value of potential quotient (above 4). From the spatial distribution of the quotient values on the map, these countries can be considered as so-called cores, which means that agriculture in these countries affects neighbouring countries. However, this conclusion should be treated with caution in the case of Malta and Cyprus, as these are countries which do not have a land border with any other country.

The fact that spatial autocorrelation exists means that geographically closer areas are similar. Spatial statistics (global and local) enable this relationship to be verified. These statistics help to detect spatial dependencies of the considered characteristics within the whole surveyed area and concerning a specific location and neighbouring areas.

The significance of obtained values can be assessed based on of *P*-value[2] values. Analysing the results contained in Table 1, it can be observed that over the whole considered period, the statistics relating to population potential (*pop_pot*) and income potential (*inc_pot*) are statistically significant. Therefore, it can be concluded that there is a negative (moderate to weak) spatial autocorrelation for *pop_pot* and *inc_pot* variables, which means that areas with high and low potential values are neighbouring. In terms of both potentials, the European Union countries differ to a small extent. The quotient of potentials shows a small insignificant positive autocorrelation.

Table 2 presents the analysis results of the values of local Moran statistics. This analysis enabled to distinguish clusters of countries for particular variables. Groups

Table 1. Global *I* Moran's statistics for EU countries in 2010 and 2018

Year	Global *I* Moran's statistic (*inc_pot*)		Global *I* Moran's statistic (*pop_pot*)		Global *I* Moran's statistic (*pot_quot*)	
	I	*P*-value	*I*	*P*-value	*I*	*P*-value
2010	–0.0702	0.3560	–0.0231	0.3790	0.0194	0.2030
2018	–0.0415	0.4440	–0.0385	0.4520	0.0004	0.2600

Inc_pot – income potential; *pop_pot* – population potential; *pot_quot* – potential quotient

Source: Own calculations based on Eurostat Database (2019)

[2]Assuming a significance level of 0.05, it is accepted that positive values of *I* statistics are significant when the *P*-value is less than 0.05, while negative values of this statistics are significant when the *P*-value is higher than 0.95.

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Table 2. Countries with significant value of local Moran's statistics

Variable	Year	Low-low	Low-high	High-low
Pop_pot	2010	Finland	Romania	Italy
	2018	Finland	Romania	Italy
Inc_pot	2010	Lithuania	–	Greece
	2018	–	–	Greece
P_quot	2010	France, Slovakia, Romania, Hungary	Belgium	–
	2018	Portugal, Slovakia, Romania, Hungary	Belgium	–

Pop_pot – population potential; *inc_pot* – income potential; *p_quot* – potential quotient
Source: Own calculations based on Eurostat Database (2019)

of similar countries form clusters called "low-low", "low-high", "high-low" and "high-high[3]". Observation of the obtained results shows that in case of population potential, Finland is a country with low values of this potential and at the same time is surrounded by countries with low values of population potential (low-low). In Romania, there is a low population potential, but it is a country surrounded by countries with high potential values. Italy is a country with high population potential in 2010 and 2018, with countries with low potential as neighbours. Due to the income potential, Greece stands out as a country with high-income potential values, surrounded by countries with low potential values.

CONCLUSION

Undoubtedly, agriculture in the European Union countries is differentiated in many respects. This differentiation, apart from nature, was influenced, among others, by historical conditions. Changes in the European economy, which began over two centuries ago, were also reflected by changes in agriculture. Land consolidation, agricultural reforms, as well as mechanisation and chemisation of agriculture caused a decrease in employment in agriculture and an increase in agricultural production in Western European countries. The situation in the Eastern and Central European countries was different.

Currently, the European Union countries implement the Common Agricultural Policy, assuming, among others, an increase in agricultural productivity, ensuring a proper standard of living for the population and stabilising markets. The European Union continues to be one of the leading exporters and importers of agricultural products in the world. However, this results not only from the global position of the entire EU, but also from the high share of individual Member States in international trade. Among the top 20 world exporters and importers of agricultural products are the Netherlands, France, Germany, Great Britain, Belgium, Italy and Spain (FAO 2010).

The method of the quotient of income and population potentials used in the analysis of the regional structure has the following advantages: (*i*) it is a system measure of the social and economic development level of regions, (*ii*) in comparison with the development level indicator in the form of regional income per capita is characterised by a "retraction" of the value scale, (*iii*) reduces extreme regional contrasts on the scale of development level by taking into account the compensatory impact of the interregional influence included in the potential.

The obtained values of population potential and income enabled to distinguish countries with its high and low values in 2010 and 2018. The characteristic feature of the EU Member States is that within the population potential and income potential, the most numerous group are the countries with the lowest potential values. In comparison with all countries, within the population potential, Poland and Romania stand out, where due to the large share of people working in agriculture, the potential assumes the highest values. Denmark is also a distinctive country, for which the income potential is the highest.

The analyses carried out in the field of spatial autocorrelation showed the existence of global and local spatial autocorrelation for selected characteristics

[3]High-high – high-value objects surrounded by high-value objects; low-low – low-value objects surrounded by low value objects; low-high – low-value objects surrounded by high-value objects; high-low – high-value objects surrounded by low-value objects.

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representing the agricultural potential of the European Union countries.

A negative autocorrelation was noted for the income and population potential. However, it was not very strong and was either at a similarly low level during the whole period under consideration. The only considered variable for which positive spatial autocorrelation was recorded was the quotient of potentials, which allows for the conclusion that the distribution of countries in terms of the quotient of potentials is spatially differentiated. The analysis of local Moran's statistics in particular years for the variables included in the study distinct clusters of countries and non-typical countries.

Therefore, the analysis of phenomena using of spatial statistics can help to identify areas which are characterised by similar or different values of the studied variables, thus enabling monitoring and control of the phenomenon. Moreover, such analysis may support the implementation of programmes aimed at counteracting undesirable phenomena and sustaining positive trends.

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