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Potential and competitiveness of EU countries in terms of slaughter livestock production

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Abstract: Models and methods of spatial econometrics are gaining more and more popularity. Their advantage is the opportunity to examine the interrelationships between individual territorial units. These methods, apart from the own potential of the region, take into account the impact of neighbouring objects and location in space. The aim of the study is to examine the relationship between the potential and the level of competitiveness of individual European Union countries in the field of slaughter cattle production. In addition, the paper attempts to determine the specialisation of individual EU countries in the production of slaughter animals by sector. The analysis covered the years 2010–2016, using Eurostat data. The obtained results allow indicating countries in which there is a strong concentration of income potential (Sweden, Spain, Great Britain, France and Belgium). Countries in which the highest values of the potential quotients in the entire European Union are distinguished (Poland, Finland and Belgium).

Keywords: animal production; competitiveness; specialisation

The conditions in which agriculture operates are constantly changing due to the increasing interdependence of national economies and the opening of foreign markets. All this leads to a confrontation of agri-food products of one country with analogous products in another country. Increasing competition between entities operating in agriculture means that they must strive for more effective use of available production means. Competitiveness can be described in a certain simplification as the ability to effectively compete with other entities in pursuit of analogous objectives. In order to face competition and achieve a specific competitive position, understood as a result of such competition, it is necessary to build an appropriate potential (Gorton et al. 2000; Ferto and Hubbard 2003; Jambor and Babu 2016). This potential is treated as a source of competitive advantage of this sector. Adequate use of the agricultural production potential of a given region (country) may result in higher production results than the others. This potential of agriculture in the region is a derivative of the impact of various groups of conditions, both favourable and limiting, it is usually assessed in terms of the size of production factors, resources and mutual relations between them, as well as the way they are used (Frohberg and Hartman 1997; Josling et al. 1998; Tangermann and Banse 2000).

In the analyses of regional development level, the potential models are used, for which a correlation analysis is carried out that enables to study the relations between potential and other socio-economic phenomena. In the regional analysis, potential is a measure of the impact of regions included in a given system. Potential defines the intensity of impact between regions not only as a variable depending on the size of regions but also on their location

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(Niedercorn and Becholdt 1969; Bergstrand 1987). The favourable location of a region in the regional system of impacts may increase its small potential. In order to determine the changes in competitive position and specialisation, as well as their changes over time, methods are used which take into account the spatial connections of surveyed units. One of such methods is the Esteban-Marquillas' method of changes in the competitiveness, which consists in calculating individual elements of the analysis concerning components of the change in studied phenomenon, with particular emphasis on the regional component and the allocation effect included in it. The aforementioned allocation effect may be interpreted as a potential value of studied phenomenon in the sector and region *r*, if the structure of studied phenomenon of this region corresponds to the structure of phenomenon in the reference area (Head and Mayer 2011).

The aim of this study is to examine the relation between the potential and competitiveness level of individual European Union countries in the field of slaughter livestock production. In addition, this paper attempts to determine the specialisation of individual EU countries in the field of slaughter livestock production by sectors. The analysis covered the years 2010–2016, using Eurostat data (Eurostat Database 2019a,b,c).

MATERIAL AND METHODS

Potential models

The subject literature distinguishes three basic spatial potential models: population potential model, income potential model and localisation potential model (Head and Mayer 2011). 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 (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).

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

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

The advantage of the quotient of potential is a clear scale and interpretation of the obtained results. The obtained quotient of potential values indicate the differences in the potentials of the regions under consideration (Coffey 1978; Vickerman et al. 1999).

In the next step, the relation between the potential quotient P_i and the regional income per capita g_i is determined in the form of (Coffey 1978):

$$P_i = \left(1 + \frac{\sum_{j=1}^{n} z_j / d_j}{z_i}\right) / \left(1 + \frac{\sum_{j=1}^{n} l_j / d_j}{l_i}\right) \times g_i \quad (4)$$

where: g_i – regional income per capita.

The value of P_i/g_i in *i* region depends on:

– proportion between the potential generated by the environment of *i* region and own potential of *i* region in terms of income, as well as in terms of the number of inhabitants;
– relations of equality or inequality between these proportions.

In a situation where in the region is a greater degree of spatial concentration of income potential than the population's potential, there is the inequality. This means that the role of regional environment

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of a given i region and in generating the population potential of that region is greater than in generating its income potential (Coffey 1978).

Esteban-Marquillas' method

In the 1960s of the 20th century, Dunn (1960) and Perloff et al. (1960) presented the classical shift-share analysis (SSA), which was then used for the first time to assess changes in competitiveness and specialisation over time. In the following years, this method was modified many times, the works of Dunn (1960), Perloff et al. (1960), Houston (1967), Berzeg (1978), Fothergill and Gudgin (1979), Stevens and Moore (1980) and Arcelus (1984) are worthy of attention. In 1972, Esteban-Marquillas introduced a new element, the so-called homothetical variable $\widehat{x_{ri}}$ into the classical shift share equation (Esteban-Marquillas 1972):

$$\widehat{x_{ri}} = x_{ri} \times \frac{x_{r.}}{x_{..}} \quad (5)$$

where: x_{ri} – value of variable X for r region in i sector; $x_{..}$ – the sum of all observations of variable X; $x_{r.}$ – total value of the sum of observations by sector of variable X for r region.

The need for changes introduced by Esteban-Marquillas resulted from relations between the position of competitiveness and the effect of structural changes, i.e. the level of i variant of the phenomenon, which r facility would have if the structure of phenomenon in this facility was identical to the national structure (Baltagi and Arbia 2008; Edwards 2017).

The change of x_{ri} value by the value $\widehat{x_{ri}}$ causes the effect of changes in the position of competitiveness to be cleaned from the impact of local structural changes. The remaining, unexplained part of actual changes in the phenomenon is called the allocation effect (Sobczak 2012; Tłuczak 2016):

$$a_{ri} = \left(x_{ri} - \widehat{x_{ri}}\right) \times \left(tx_{ri} - tx_{.i}\right) \quad (6)$$

where: tx_{ri} – individual growth rate of variable X in the i^{th} sector and r^{th} region; $tx_{.i}$ – average growth rate of variable X in the i^{th} sector.

The component of allocation effect a_{ri} indicates whether r facility is specialised in the sense of concentration in those variants of the phenomenon $\left(x_{ri} - \widehat{x_{ri}}\right)$ in which it is the most competitive $(tx_{ri} - tx_{.i})$. The value $\widehat{x_{ri}} \times x \left(tx_{ri} - tx_{.i}\right)$ is considered an indicator of the competitive advantage (or gap) of i sector in r region in relation to the reference area (Esteban-Marquillas 1972; Baltagi and Arbia 2008).

The lack of regional specialisation in the starting year $\left(x_{ri} - \widehat{x_{ri}} < 0\right)$ and the subsequent occurrence of this specialisation in the final year of analysis is acceptable $\left(x^*_{ri} - \widehat{x^*_{ri}} > 0\right)$.

The allocation effect will be positive in those regions that specialize in those sectors where the growth rate is higher than the global regional growth rate (Table 1). Conversely, if the growth rate in regions is lower than global, then the allocation effect assumes negative values, and it can be said that this region has no specialisation of the studied phenomenon in a given sector. The higher value of the allocation effect for the whole region, the better studied phenomenon is distributed among the analysed sectors. If there is no specialisation in a given region, then the allocation effect takes the value of zero, and the region does not benefit from competitive advantages (Esteban-Marquillas 1972; Baltagi and Arbia 2008; Edwards 2017; Tłuczak 2017).

Table 1. Characteristics of allocation effects

	Sign of allocation effect (a_{ri})	Components of allocation effect (a_{ri})	
		specialisation $\left(x_{ri} - \widehat{x_{ri}}\right)$	competitiveness $\left(tx_{ri} - tx_{.i}\right)$
Facility specialisation (competitive disadvantage)	negative –	positive +	negative –
Lack of facility specialisation (competitive disadvantage)	positive +	negative –	negative –
Lack of facility specialisation (competitive disadvantage)	negative –	negative –	positive +
Facility specialisation (competitive disadvantage)	positive +	positive +	positive +

Source: Sobczak (2012)

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RESULTS AND DISCUSSION

Researchers began their investigation by identifying the population potential and income potential for each country. The population potential was calculated using employment in agriculture in a given country, while the income potential was calculated using GDP in EUR per capita of the rural population.

Comparison of population potential for the analysed spatial units (Table 2) – EU[1] countries shows a relatively stable situation in the years 2010–2016. The values of population potential in EU countries do not differ significantly from one year to the next. It is visible that in Poland and Romania the population potential assumes the highest values, in these countries the percentage of people employed in agriculture is many times higher than, e.g. in Estonia or Belgium, where the share of people working in agriculture is the lowest.

In the case of income potential, small changes in value between 2010 and 2016 can be observed. The spatial potential model indicates a strong concentration of income potential in Sweden, Spain, United Kingdom, France and Belgium (Figure 1). The lowest income potential intensity is observed in the countries of Central and Eastern Europe: Romania, Slovenia, Poland. Apart from Bulgaria, which moved from the group of countries for which $U_i < 0.5$

Table 2. Population potential and income potential in EU countries in 2010–2016

Country	2010		2016	
	population potential	income potential	population potential	income potential
Austria	1.95	0.98	2.02	0.97
Belgium	0.63	4.33	0.63	4.17
Bulgaria	1.93	0.48	2.11	0.50
Croatia	2.19	0.32	1.50	0.28
Czech Republic	1.43	0.83	1.42	0.80
Denmark	0.65	1.65	0.72	1.60
Estonia	0.28	0.37	0.30	0.40
Finland	1.00	0.98	1.05	0.94
France	6.61	1.11	6.92	1.04
Germany	5.65	2.29	5.56	2.31
Greece	4.83	0.67	4.66	0.48
Hungary	1.59	0.63	1.94	0.61
Ireland	0.80	0.66	1.10	0.92
Italy	7.52	2.91	7.85	2.60
Latvia	0.72	0.59	0.71	0.60
Lithuania	1.05	1.36	1.24	1.42
Netherlands	2.12	9.63	1.78	8.64
Poland	17.80	0.38	17.54	0.37
Portugal	4.86	0.60	3.78	0.54
Romania	23.79	0.18	23.51	0.19
Slovakia	0.78	0.45	0.92	0.45
Slovenia	0.83	0.39	0.93	0.37
Spain	6.95	6.85	7.11	6.14
Sweden	0.89	3.47	0.95	4.69
United Kingdom	3.15	7.90	3.74	8.95

Source: own calculations based on Eurostat Database (2019b) – Statistics on Rural Areas in the EU, Eurostat Database (2019c) – GDP per capita in PPS

[1]Malta, Luxembourg and Cyprus have been omitted for lack of data completeness.

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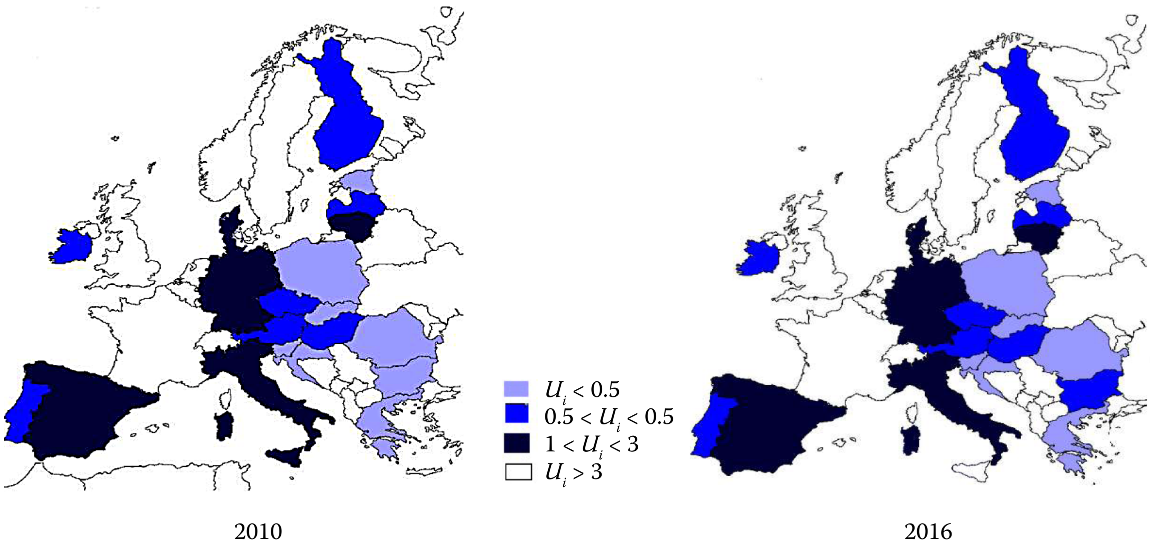

Figure 1. Income potential (U_i) in 2010 and 2016

Source: own calculations based on Eurostat Database (2019c) – GDP per capita in PPS

to the group where $U_i \in (0, 1)$, the areas with high-income potential values did not expand.

Spatial distribution of the potential quotient, as a measure of the development level, is the basis for distinguishing in the regional structure of the European Union countries on the basis of the core-periphery concept of core regions and peripheral areas. On the map of distribution of the potential quotient (Figure 2), the continuous systems of sub-regions with high values of this quotient correspond to the systems of their impact in a form of core regions.

Distribution of potentials quotient on the map of Europe has a three-pole character. Distinguished poles are Poland, Finland and Belgium, where the highest values of the potential quotient in the whole European Union are recorded. At the same time, Poland is a country with the highest income potential values and one of the lower population potential values (Figure 2). The impact of Poland, Finland and Belgium covers neighbouring countries: Germany and France. Areas with lower values of the potential quotient are in clear contrast with the countries mentioned above, for which the potential quotient assumes the highest values. The outlying countries are above all: Estonia and Lithuania. Each time, the values of potential quotient for these countries do not exceed 0.1.

In the EU system in 2010 and 2016 there was the same number of countries for which there is a relationship of $P_i < g_i$. These are Romania, Poland, Portugal, Greece, Croatia, France, Bulgaria, Italy, Hungary, Germany and Slovenia (Figure 3). This means that these countries show a higher degree of spatial concentration of income potential than the population potential. In addition, it means that the role of regional envi-

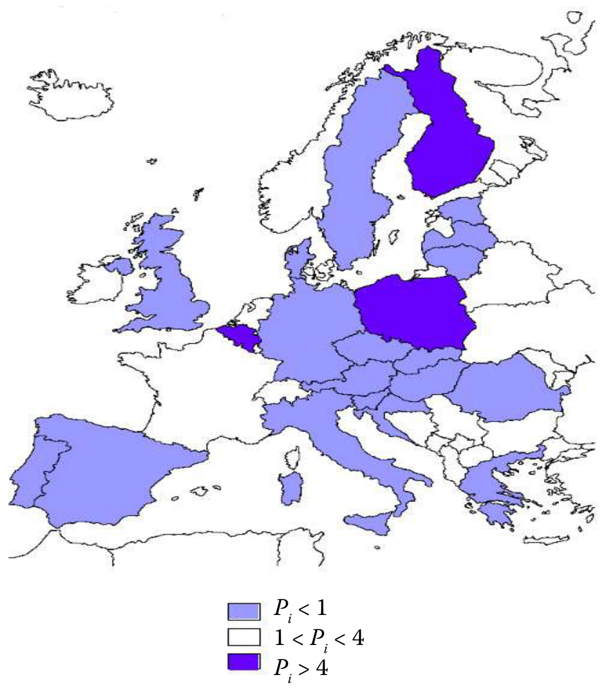

Figure 2. Quotients of income and population potentials (P_i) in 2010–2016

Source: own calculations based on Eurostat Database (2019b) – Statistics on Rural Areas in the EU, Eurostat Database (2019c) – GDP per capita in PPS

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Figure 3. Distribution of $P_i < g_i$ values in 2010 and 2016

g_i – regional income per capita; P_i – income and population potentials

Source: own calculations based on Eurostat Database (2019b) – Statistics on Rural Areas in the EU, Eurostat Database (2019c) – GDP per capita in PPS

ronment of these countries in generating population potential is greater than the role of generating income potential of the countries in this group.

Analysis of the structure of slaughter livestock production was carried out for the member states[2] of the European Union in relation to the development level of this phenomenon in the whole EU. The data included the volume of slaughter livestock production in individual countries (r = 1, ..., 25) and the structural division of this production by type of meat: beef, pork, poultry (i = 1, 2 , 3).

According to Eurostat data, in 2017 total meat production in volume terms decreased by 0.1% in the EU, but the dynamics of changes were varied geographically and in terms of type (Eurostat Database 2019a,b,c). In terms of meat production, the European Union is self-sufficient, with production covering on average 105% of internal demand. The value of EU meat products and meat production in 2016 was over 208 billion EUR in producer prices. Germany is the largest producer in the EU with a production value of 43.8 billion EUR. Germany and the Netherlands are the main exporters of meat and meat products in the EU, with total exports of 15 billion EUR.

The individual rate of change in slaughter livestock production between 2010 and 2016 varied depending on the subtype of meat production: beef, pork, poultry, as well as for each country individually. In the European Union, there was an increase in slaughter livestock production by nearly 6.5%, including an increase of 19.8% for poultry livestock production, a decrease of 3.3% for pork livestock and a decrease of 3.3% for beef livestock. Within the slaughter livestock production, the largest changes occurred in Po-

Table 3. Individual rates of changes in the volume of slaughter livestock production in EU countries in 2010–2016

Country	Beef and veal meat (%)	Pork meat (%)	Poultry meat (%)
Austria	0	–6	9
Belgium	6	–	–9
Bulgaria	–10	4	2
Croatia	3	–23	79
Czech Republic	–1	–21	–17
Denmark	–3	–5	–18
Estonia	15	–7	25
Finland	5	–6	30
France	–5	–3	3
Germany	–4	2	12
Greece	–32	–19	48
Hungary	4	1	37
Ireland	5	32	–2
Italy	–25	–8	1
Latvia	11	–3	30
Lithuania	–2	1	–
Netherlands	7	13	30
Poland	20	6	62
Portugal	–2	–2	20
Romania	–25	17	20
Slovakia	–38	–33	–7
Slovenia	0	–39	10
Spain	5	17	25
Sweden	–2	–11	37
United Kingdom	0	21	14

Source: own calculations based on Eurostat Database (2019a) – Agricultural Production – Livestock and Meat

[2]Malta, Luxembourg and Cyprus have been omitted for lack of data completeness.

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Table 4. Allocation effect for animal production in EU countries in 2010–2016

Specialisation	Competitiveness	Beef and veal meat	Pork meat	Poultry meat
Negative –	negative –	Finland, Hungary, Ireland, Lithuania, Netherland, Poland, Spain, United Kingdom	Hungary, Latvia, Lithuania, Netherlands, Poland, Spain	Ireland
Positive +	positive +	Austria, Belgium, Croatia, Czech Republic, Denmark, Slovenia	Belgium, Bulgaria, Denmark	Bulgaria, France, Italy, Slovakia, Slovenia
Positive +	negative –	Bulgaria, France, Germany, Greece, Italy, Portugal, Romania, Slovakia, Sweden	Austria, Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Italy, Portugal, Slovakia, Slovenia, Sweden	Belgium, Czech Republic, Denmark
Negative –	positive +	Estonia, Latvia	Ireland, Romania, United Kingdom	Austria, Croatia, Estonia, Finland, Germany, Greece, Hungary, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Spain, Sweden, United Kingdom

Source: own calculations based on Eurostat Database (2019b) – Agricultural Production – Livestock and Meat

land and Slovakia. In Poland, there was an increase in livestock production by nearly 29%. In Slovakia, it was a decrease by 23%. Further noticeable changes in the production of slaughter animals for slaughter relate to the Netherlands, Czech Republic, Hungary, Lithuania and Spain where the value of production increased by 17–18% .The highest increase in poultry livestock production is observed in Croatia (79%), Poland (62%) and Lithuania (44%). In the audited period, negative values of the rate of change were also noted. A decrease in production by nearly 32% can be observed in case of Greece (beef and veal meat), Slovakia – a decrease in production of beef and veal meat by 38% and pork meat by 33%. In other countries these changes were not as significant (Table 3).

A separate structure of slaughter livestock production enabled to carry out an analysis of specialisation and regional competitiveness of meat production in EU countries in 2010–2016. Obtained results show that the specialisation and competitiveness level of countries in terms of production in the analysed period was on average diversified (Table 3).

Table 4 presents countries where the allocation effect in the slaughter livestock sector was positive and negative. Countries for which both components of the allocation effect were positive, are characterised by specialisation in slaughter livestock production and, at the same time, a competitive advantage in relation to other countries in the production of particular meat species.

In countries where is a positive value of the specialisation component and a negative value of the competitiveness component, there is a competitive gap in the analysed sectors of animal production. Such a situation occurs e.g. in case of Belgium, the Czech Republic and Denmark and poultry production. In case of beef livestock production, the majority of countries achieve a positive allocation effect (14 countries), while the negative allocation effect is recorded in case of poultry livestock production.

CONCLUSION

Potential models and Esteban-Marquillas' method for changing competitiveness are used in spatial socio-economic analyses. They are used in research on e.g. industrial location, economic development, international trade, and environmental protection. The advantage of these models is a possibility to examine the interrelations between particular territorial units. These methods, apart from the region's own potential, take into account the impact of interactions of neighbouring facilities and their location in space.

A characteristic feature of agriculture is its regional differentiation. This concerns both the agrarian struc-

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ture, as well as natural and non-natural conditions. Issues related to the study of the agrarian structure are in the focus of attention almost always, they have become particularly important in the context of farms adaptation in individual EU countries to the ability to compete on the Community (EU) markets. The results of similar studies were presented by Leeuwen et al. (2010), the authors divided the regions into urban and rural areas. The results of research indicated that the concentration and specialisation of agricultural production can occur in an area recognised as non-rural area. The issues of changes in agricultural patterns and of the restructuring of livestock production have been examined by numerous authors. The main methodological approaches include mathematical programming models and multiple criteria analysis, maximisation of an objective function, shift-share analysis (Dooley et al. 2009; Manos et al. 2010; Zerger et al. 2011; Ragkos et al. 2016; Tłuczak 2017).

One of the aspects of expected changes in the EU agriculture is a reduction in the number of farms, an increase in their area and an increase in the economic efficiency of the agricultural activity. The aim of this paper was to study the diversity of agricultural potential, to identify core and peripheral regions on the basis of the applied potential model. Conducted research confirms the hypothesis of agricultural diversification at the level of EU countries in 2010–2016. The division of countries into the so-called agricultural and non-agricultural is visible; it has its sources of historically shaped diversification of the economic development level. The right direction of agricultural production with the existing potential of region may bring high incomes to agricultural producers. A change in the direction of production, which is often expensive, may protect against incurring additional costs.

The core regions identified in the study are regions with relatively high agricultural potential in relation to other countries. They are characterised by a low-income potential, with a high population potential of agriculture at the same time. This may have positive effects on the development of this agricultural activity, in which the share of human labour should be higher than average.

Additionally, the study focuses on a selected aspect of changes in the structure of slaughter livestock production. Each analysed region has its own specific features, which influence the rate and directions of its economic and social development. Based on the Esteban-Marquillas' method, it is possible to:

– identify competitive advantages (gaps) of countries;
– assess the degree of specialisation of countries in a given sector of slaughter livestock production;
– assess the impact on a given sector of the condition of all agriculture;
– assess the impact of changes in a given sector on agriculture as a whole.

Research results were certainly influenced by the selection of analysed variables. Presented analysis should be extended to other sectors of slaughter livestock production, which become more and more important in animal production in general. Depending on the period in question, the degree of competition position of countries and the specialisation level of countries in given sector changes. Looking at the long term, the worst situation is in the case of beef and pork livestock, as in this sector the allocation effect and its components (specialisation component and competitiveness component) were negative. At the same time, the situation in case of these sectors seems to be the most diversified. There is a group of countries, in which, competitive gaps in the production of slaughter animals occurred in 2010 and 2016.

It is important to note that the analysis of slaughter livestock production is non-exhaustive. Most popular measures of competitiveness include either a technical component (productivity or efficiency) or a relative price component (prices of inputs and outputs or private versus social prices) or both (Bureau and Butault 1992), although they also vary considerably (with regard to methodology, as well as manpower and data requirements) (Zawalinska 2004). Research on the regional diversity of agricultural development is multithreaded research and should take into account many factors, both economic and natural conditions.

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