

APPLICATION OF THE LINEAR ORDERING METHODS TO ANALYSIS OF THE AGRICULTURAL MARKET IN POLAND

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Abstract: The agricultural market is an integral component of the entire market, and its aim is the production of food and essential raw materials. The subject of research was the analysis of the agricultural market in Poland. For this purpose, several rankings for each year were developed using selected methods of linear ordering. To choose the best one ranking, the method of rankings comparison was applied. This allowed to present changes that took place during analyzed years in Poland.

Keywords: agricultural market, methods of linear ordering, ranking, synthetic variables

JEL classification: C44, C61

INTRODUCTION

The agricultural market, in a broad sense, is all exchange relations between producers, sellers and buyers. It is an integral part of the entire market, and its economic situation is highly dependent on the overall condition of the economy.

The agricultural market, like other markets, is governed by identical economic laws [Chabiera et al. 1988]. One of the many factors affecting the volume of production and the price level is the weather. In the low season, there is a noticeable increase in prices, especially in the vegetable and fruit market. Also

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during the season, prices may be high due to adverse weather conditions (drought, frost, floods). The prices of products on which this market depends, e.g. prices of feed or fertilizers, also play an important role. Due to the short-lived products of this market, it is required to create the right infrastructure for storage to extend their freshness. It is important to provide the right means of transport as well as to adjust the transport time. Otherwise, additional costs are generated.

Agriculture in Poland is very fragmented because there are many small farms. Over half (in 2016 - 53.9%, in 2010 - 54.1%) has an area of up to 5 ha, which means that these farms use traditional methods that do not require high fertilization and consumption of plant protection products, as well as feed industrial in animal feed. The percentage of large-scale farms over 50 ha increases from year to year, the largest of which is in the WP Province. According to the data from the National Agricultural Census conducted in 2010, more than 50% of Polish farms mainly produce to meet their own needs. As a result, they reduce food expenses and family maintenance costs.

The subject of the research was an attempt to analyze the regional diversity of agricultural development in Poland in terms of selected characteristics in the period from 2006 to 2016. To this end, the linear ordering method of a set of objects based on a synthetic variable was used to describe the studied phenomenon. A synthetic measure allowed to organize individual provinces by the level of agricultural market development. The condition of Polish agriculture is a frequent topic of reflection among many authors [Binderman 2005a,b, 2006a,b, 2007, 2008, 2009, 2013; Kukuła 2014; Majchrzak, Wysocki 2007; Ossowska, Janiszewska 2013; Kisielińska 2016].

In the article for the name of the province replaced by following codes: DŚ-Lower Silesia Province, KP-Kujawy-Pomerania Province, LB-Lublin Province, LS-Lubusz Province, ŁD-Łódź Province, MP-Małopolska Province, MZ-Mazovia Province, OP-Opole Province, PK-Podkarpacie Province, PL-Podlasie Province, PM-Pomerania Province, ŚL-Silesia Province, ŚK-Świętokrzyskie Province, WM-Warmia-Masuria Province, WP-Wielkopolska Province, ZP- West Pomerania Province.

EMPIRICAL DATA

The analysis was conducted on the basis of data from the Statistical Yearbooks of Agriculture issued by the Central Statistical Office of Poland (CSO) for 2006, 2009, 2013 and 2016. The applied methods of linear ordering were selected based on the following literature items: [Hellwig 1968; Nowak 1977, Strahl 1978; Hwang, Yoon 1981; Kukuła 1986, 2000, 2012]. The study assumes that each diagnostic variable brings the same amount of information to evaluate the objects tested [Kukuła, Luty 2015]. Diagnostic variables adopted for analysis are as follows:

X₁ - income of budgets of local government units due to agricultural tax [PLN million],

X₂ - share of certified organic farms in total utilized agricultural area [%],

X₃ - consumption of mineral or chemical fertilizers calculated on the pure component and per 1 ha of agricultural land [kg],

X₄ - purchase value of agricultural products per 1 ha of arable land (current prices) [PLN],

X₅ - persons employed in agriculture per 1 ha of agricultural land [os],

X₆ - share of arable land in the administrative area of the province [%].

All variables were classified into the stimulant set. The values of numerical characteristics of diagnostic variables are presented in Table 1.

Table 1. Selected characteristics of adopted diagnostic variables

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
2006						
Mean	50.58	0.51	121.31	1825.63	13.11	50.07
Median	46.6	0.33	114.55	1750	12	50.02
Minimum	19.3	0.04	61.3	798	4	35.86
Maximum	90.1	1.19	182.3	3269	26.2	61.10
Standard deviation	19.94	0.40	31.16	598.69	6.65	7.78
Skewness	0.64	0.60	0.33	0.69	0.56	-0.29
2009						
Mean	77.41	1.47	117.38	2174.19	12.92	50.42
Median	72.75	1.20	120.25	2294	11.5	49.82
Minimum	35.1	0.25	55.4	900	4.1	36.24
Maximum	121.6	4.76	186.8	3738	26.2	63.18
Standard deviation	25.63	1.12	36.48	648.90	6.61	8.79
Skewness	0.25	1.64	0.24	0.36	0.61	-0.14
2013						
Mean	104.06	3.62	135.53	3663.19	17.74	45.37
Median	96	2.64	135.2	3608	11.75	44.46
Minimum	48	0.49	68.2	1508	5.2	29.16
Maximum	155.9	11.77	223.5	6103	48.5	58.61
Standard deviation	34.60	3.02	41.16	1154.13	12.75	9.89
Skewness	0.11	1.57	0.24	0.16	1.40	-0.18
2016						
Mean	94.59	3.12	127.56	3644.63	17.83	45.03
Median	84.11	1.96	127.45	3614.5	11.7	43.75
Minimum	40.71	0.46	70.2	1591	5.2	28.59
Maximum	154.17	9.56	203.2	6367	48.4	57.35
Standard deviation	34.71	2.83	35.67	1217.03	12.71	9.87
Skewness	0.35	1.46	0.41	0.47	1.37	-0.22

Source: own elaboration

METHODS

The linear ordering is based on the creation of a ranking of compared objects, i.e. this is based on juxtaposition of the objects from the best one to the worst one in the analyzed research context (Kaczmarczyk 2018). Variables to be ordered should be measured on an interval scale. When they are measured on a range or quotient scale, they need to be normalized).

Four linear ordering procedures were selected to determine the synthetic variable (Table 2). Lebles in Table 2: Q_i - synthetic variable value, Z_{ij} - normalized value of the j -th variable for the i -th object.

Table 2. Selected methods of linear ordering

Method	Formula
Hellwig	$Q_i = 1 - \frac{d_i^+}{d_0}, \quad d_i^+ = \sqrt{\sum_{j=1}^m (z_{ij} - z_j^+)^2}, \quad z_j^+ := \max_i \{ z_{ij} \}$ $d_0 = \bar{d} + 2S_d, \quad d = [d_1^+ \quad d_2^+ \quad \dots \quad d_n^+]$
TOPSIS	$Q_i = \frac{d_i^-}{d_i^- + d_i^+}, \quad d_i^+ = \sqrt{\sum_{j=1}^m (z_{ij} - z_j^+)^2}, \quad d_i^- = \sqrt{\sum_{j=1}^m (z_{ij} - z_j^-)^2}$ $z_j^+ := \max_i \{ z_{ij} \}, \quad z_j^- := \min_i \{ z_{ij} \}$
Median ordering	$Q_i = 1 - \frac{d_i^+}{d_0}, \quad d_i^+ = \text{med}_j z_{ij} - z_j^+ , \quad z_j^+ := \max_i \{ z_{ij} \}$ $d_0 = \text{med}_i(d) + 2,5\text{mad}(d), \quad \text{mad}(d) = \text{med}_i d_i - \text{med}(d) ,$ $d = [d_1^+ \quad d_2^+ \quad \dots \quad d_n^+]$
Non-pattern	$Q_i = \frac{1}{m} \sum_{j=1}^m z_{ij} \quad m - \text{number of diagnostic variables}$

Source: own study based on [Kukuła, Luty 2015]

Each procedure requires diagnostic variables to be normalized. The main purpose of normalization is to reduce the examined features to a similar order of magnitude. It consists in the unification of their measuring units, as well as constructing a constant range of variability. Table 3 presents the most commonly used standardization formulas.

If multiple rankings have been created using different sorting methods, select the one that is most similar to the others. For this purpose, one can use the method of comparing rankings proposed by Karol Kukuła [Kukuła 1986]. To determine the ranking that is most similar to the others, select the one for which this measure is the largest. Comparison of selected rankings allows you to evaluate changes in the object that occur at a given time. This method is the basis for the preparation and

interpretation of the ranking of the examined objects [Kukuła, Luty 2015] and is determined as follows:

$$\bar{u}_p = \frac{1}{v-1} \sum_{\substack{q=1 \\ q \neq p}}^v m_{pq}, \quad p, q = 1, 2, \dots, v, \quad (1)$$

where:

v – number of rankings;

$$m_{pq} = 1 - \frac{2 \sum_{i=1}^n |c_{ip} - c_{iq}|}{n^2 - z}, \quad (2)$$

such that:

c_{ip} – position of the i -th object in the ranking with the number p ;

c_{iq} – position of the i -th object in the ranking with the number q ;

$$z = \begin{cases} 0, & n \in P \\ 1, & n \notin P \end{cases}, \text{ where } P - \text{set of even natural numbers.}$$

Labels to the Table 3: x_{ij} - value of the j -th variable, z_{ij} - normalized value of the j -th variable for the i -th object; \bar{x}_j, S_j is the arithmetic mean and standard deviation of the j -th variable, respectively; θ_{0j} - value of the j -th coordinate of Weber's median for the feature system; $m\tilde{a}d(X_j) = med_i |x_{ij} - \theta_{0j}|$.

Table 3. Selected normalization formula

Method	Normalizing formula
standardization	$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}, \quad S_j \neq 0$
unitarization	$z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, \quad \max_i x_{ij} \neq \min_i x_{ij}$
ratio transformation	$z_{ij} = \frac{x_{ij}}{\bar{x}_j}$
Strahl transformation	$z_{ij} = \frac{x_{ij}}{\max_i x_{ij}}, \quad \max_i x_{ij} \neq 0$
positional standardization	$z_{ij} = \frac{x_{ij} - \theta_{0j}}{1,4826m\tilde{a}d(X_j)}, \quad m\tilde{a}d(X_j) \neq 0$

Source: own elaboration on the basis of [Perkal 1953; Wesołowski 1975; Kukuła 2000; Strahl 1978; Lira et al. 2002]

RESEARCH RESULTS

The following methods of linear ordering were used for multivariate analysis:

- Method non-based on the pattern of development using unitarization (R1);
- Method non-based on the pattern of development using Strahl transformation (R2);

- Method non-based on the pattern of development using ratio transformation (R3);
- Hellwig method using standarization (R4);
- TOPSIS method using ratio transformation (R5);
- Median ordering using standardization (R6);
- Non-based on the pattern of development using standardization (R7).

In each of the surveyed years, the positions of the voivodehips occupied in individual rankings may differ. In order to select the ranking which will be the most similar to all others, a method proposed by Karol Kukuła and Lidia Luty (2015) was used.

$$\begin{aligned}
 M_{2006} = [m_{pq}]_{p,q=1,2,\dots,7} = & \begin{bmatrix} 1 & 0.875 & 0.703 & 0.844 & 0.594 & 0.781 & 0.938 \\ & 1 & 0.828 & 0.766 & 0.719 & 0.781 & 0.828 \\ & & 1 & 0.609 & 0.891 & 0.625 & 0.672 \\ & & & 1 & 0.500 & 0.813 & 0.859 \\ & & & & 1 & 0.516 & 0.563 \\ & & & & & 1 & 0.781 \\ & & & & & & 1 \end{bmatrix} \\
 M_{2009} = [m_{pq}]_{p,q=1,2,\dots,7} = & \begin{bmatrix} 1 & 0.922 & 0.656 & 0.766 & 0.406 & 0.672 & 0.969 \\ & 1 & 0.719 & 0.781 & 0.469 & 0.719 & 0.938 \\ & & 1 & 0.625 & 0.750 & 0.703 & 0.672 \\ & & & 1 & 0.422 & 0.703 & 0.797 \\ & & & & 1 & 0.531 & 0.422 \\ & & & & & 1 & 0.672 \\ & & & & & & 1 \end{bmatrix} \\
 M_{2013} = [m_{pq}]_{p,q=1,2,\dots,7} = & \begin{bmatrix} 1 & 0.813 & 0.484 & 0.859 & 0.281 & 0.703 & 0.953 \\ & 1 & 0.641 & 0.766 & 0.422 & 0.594 & 0.828 \\ & & 1 & 0.500 & 0.766 & 0.359 & 0.516 \\ & & & 1 & 0.281 & 0.719 & 0.859 \\ & & & & 1 & 0.266 & 0.313 \\ & & & & & 1 & 0.719 \\ & & & & & & 1 \end{bmatrix} \\
 M_{2016} = [m_{pq}]_{p,q=1,2,\dots,7} = & \begin{bmatrix} 1 & 0.344 & 0.547 & 0.828 & 0.328 & 0.703 & 0.938 \\ & 1 & 0.531 & 0.266 & 0.578 & 0.266 & 0.313 \\ & & 1 & 0.453 & 0.750 & 0.547 & 0.500 \\ & & & 1 & 0.266 & 0.766 & 0.891 \\ & & & & 1 & 0.375 & 0.313 \\ & & & & & 1 & 0.719 \\ & & & & & & 1 \end{bmatrix}
 \end{aligned}$$

Based on the data presented, it can be concluded that the pair of rankings R7 and R1 have the highest $e_{m_{pq}}$ value in individual years. To choose the best ranking, it should be compared the values of the \bar{u}_p measure. The values for each surveyed year are presented in Table 4.

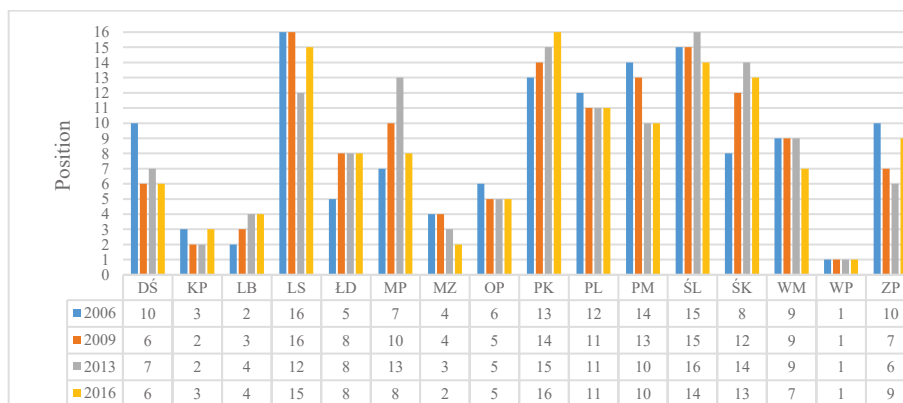
Table 4. Measures of similarity of the rankings selected for survey in the years 2006, 2009, 2013, 2016

	\bar{u}_p for given ranking						
	R1	R2	R3	R4	R5	R6	R7
2006	0.789	0.799	0.721	0.732	0.630	0.716	0.773
2009	0.732	0.758	0.688	0.682	0.500	0.667	0.745
2013	0.682	0.677	0.544	0.664	0.388	0.560	0.698
2016	0.615	0.383	0.555	0.578	0.435	0.563	0.612

Source: own elaboration

After sorting the rankings by decreasing measure \bar{u}_p , it is noticeable that their positions are slightly different. The least similar to the others is R5 created by the TOPSIS method, which in 2006, 2009, 2013 was in last place and in 2016 in sixth. The seventh place in 2016 was taken by the R2 ranking, which in 2006 and 2009 came first and in 2013 third. Since R1 and R7 were the most similar in the M matrix in the studied years, their positions should be considered by measure \bar{u}_p . In 2006, R1 came in second, with R7 in third. In 2009, R7 was in second place and R1 in third. In 2013, R7 took first place, while R1 came second, but in 2016 their positions reversed and R7 was in second place, and R1 in first place. It should be noted that the rankings obtained differ significantly from each other, most of the similarity measures are roughly 0.7, but there are also values below 0.4 (for R2 in 2016 and for R5 in 2013). To compare all the analyzed years with each other, one method of ranking should be chosen. Based on the available data, the R7 ranking was selected.

Figure 1. Positions of provinces obtained by the R7 method in the analyzed years



Source: own elaboration

The WP Province occupies the first position in all the surveyed years, so it is the leader on the agricultural market among other provinces. In this area, only the share of arable land in its administrative area decreases slightly, and the values of other variables used in the study are systematically increasing. Positive changes are

also taking place in MZ Province, because in 2006 and 2009 it was in fourth place mainly due to the small number of organic farms, the number of which began to increase in subsequent years, which is why its position began to grow, and in 2013 it took the third, and in 2016 the second place. The provinces with high agricultural potential also include KP Province, which took second or third place in the analyzed period.

Positive changes in agriculture can be seen in the OP Province, which in 2006 was in sixth place, and in the following years it is invariably in the fifth position. Its low position was caused by the lowest area of organic farms in relation to the total area of arable land among all provinces, but in subsequent years their area increased, as did the values of other variables. WM Province was in ninth place for the years 2006, 2009 and 2013, while its position in 2016 increased by 2 and is now 7th, which shows that changes in this area favorable for agriculture occur due to, among others an increase in the share of the area of organic farms and an increase in the purchase value of agricultural products. The group of provinces in which fruitful agricultural market development processes take place also includes the PL Province, which occupies the twelfth place in 2006, and in the eleventh in the following years, which shows, for example, an increase in local government budget income from agricultural taxes, as well as an increase in the share of certified farms ecological, and PM Province, where there was a significant increase from the fourteenth in 2006, through the thirteenth in 2009, tenth in 2013 and 2016.

A significant deterioration in the agricultural market, as compared to other provinces, occurred in ŁD Province and PK Province. In 2006, ŁD Province took the fifth position, while in subsequent years it was consistently in eighth place. This was caused by a decrease of 8.3 percentage points in the share of arable land in its administrative area, comparing the years 2006 and 2016. A much larger decrease in the value of this variable occurred in the PK Province, whose position fell in each analyzed year. In 2006 it was on the thirteenth place, in 2009 on the fourteenth, in 2013 on the fifteenth, and in 2016 it reached the sixteenth. Adverse changes in agriculture occurred in the MP Province, which from the seventh position in 2006 fell to the tenth in 2009, and then to the thirteenth in 2013.

Comparing Polish provinces, it can be noticed that in some of them there are very fast changes, which increase their position in the ranking. In others - the values of the studied variables are close to each other during these years, so they can remain in a similar position, but most often they drop by a significant number of places.

CONCLUSION

Agriculture is one of the basic sectors of the economy, which main task is to provide food, as well as the necessary raw materials (e.g. vegetable and animal fiber). It includes animal husbandry and plant production. Other types of industry are associated with it, which produce means of production for it (artificial fertilizers, agricultural machinery). The agricultural market began to develop more dynamically with Poland's accession to the European Union. Thanks to the subsidies received, the Polish village is no longer associated with the lack of adequate infrastructure. In terms of the number of people working in agriculture, Poland is one of the leading countries among the Member States. Changes in the structure of farm areas are also visible. The number of large and medium-sized farms significantly affects the country's share in the international agricultural market. The number of medium-sized farms in Poland has not changed much, while since 2006 the number of small farms below 5 ha has decreased by 58%, while the number of farms with an area over 50 ha has increased by 54%.

Thanks to Poland's accession to the European Union, a one-time non-returnable subsidy system was introduced for young farmers who started running their own farms. In addition, EU training is also conducted. In addition, Poland has obtained the possibility of exporting, as well as participation in the international market.

As a result of the research carried out in 2016, provinces: WP, MZ and KP were in the top positions. LB, OP, DŚ, WM, ŁD and ZP provinces were classified below the third place. In positions lower than nine are provinces: PM, PL, MP, ŚK, ŚL, LB and PK.

Comparing the changes that have occurred since 2006, an increase in all diagnostic variables used for the study is visible. In some provinces, this increase is not as great as in others, so they occupy the final positions. Analyzing the share of ecological farms in total utilized agricultural area, the regularity is visible that a high percentage of these farms is located in provinces that occupy final positions in the overall ranking. The same is true for the number of people working in agriculture. In provinces such as ŚK or PK provinces, the number of people working in agriculture is one of the highest in Poland, which does not translate into the position of these provinces in the ranking.

The agricultural market in Poland is constantly developing. Numerous government and EU programs are emerging that support farmers in their activities. Agricultural machinery facilitating work is constructed using technological progress, thanks to which running a farm is no longer associated with very heavy physical effort. Poland's accession to the European Union also meant that products of Polish origin, mainly regional, are valued by consumers of other European countries, thanks to which the share of exports of agri-food products increases and Poland's importance in the international arena increases.

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