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Size Structure Transformation of Polish Agricultural Farms in 2010–2020 by Typological Groups of Voivodeships

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Abstract: Changes in the agrarian structure are among the indicators of Polish agriculture's adaptation to competition with the EU agriculture and therefore require a thorough examination. The purpose of this paper is to determine the scale, direction and level of diversification of Polish agricultural farm size structures in 2010–2020 by typological groups of voivodeships. The research was carried out on the basis of Statistics Poland (GUS) data on the number of farms by size groups for the years 2010 and 2020. The following farm size groups were analysed: up to 2 ha of agricultural land (AL), 2–5 ha, 5–10 ha, 10–20 ha, 20–50 ha and over 50 ha. Based on fuzzy classification, four typological groups were distinguished, comprising voivodeships with similar farm size structure. Then, changes in the structure of the typological groups and changes in the number of farms in absolute terms were presented. The structure of the typological groups changed only marginally, while changes in the number of farms in absolute terms were very significant. In all groups, a decrease in the total number of farms was observed, notably farms of up to 10 ha in size, as well as an increase in the number of farms larger than 20 ha, with the rate and scale of those changes varying regionally. The largest decrease in the number of farms was recorded for voivodeships with the most fragmented agrarian structure.

Keywords: agroeconomy; farm area structure; voivodeships; fuzzy classification; typological groups

1. Introduction

The Polish agricultural farm size distribution is an effect of natural factors, such as soil conditions or relief and non-natural factors, e.g., political and legal (legal conditions of land trade), economic (influencing decisions on the purchase, lease or other form of land management) or demographic (depopulation of rural areas) factors, as well as certain historical developments (the consequences of the partitioning country's policy on their subordinated territories are still there to see).

The unfavourable size structure of farms impacts farming efficiency [1]. It is also mentioned as one of the key factors influencing the level of agriculture competitiveness. According to Ziętara, an increase in the average size of farms and an increase in the shares of large farms are good indicators of the competitiveness of Polish agriculture versus the agriculture of European countries [2]. The agrarian structure plays a key role in developing specific properties of the agricultural sector. The experience of various highly developed countries in the world shows that the agrarian transformation focused primarily on the improvement of agricultural productivity, which is closely related to the improvement of the farm size structure [3]. Therefore, experts exploring ways to modernise agricultural production to improve farm competitiveness and their income point out that it is necessary to improve the Polish agrarian structure. It then begs the question what "ideal scenario" should be pursued? Research by L. Wicki [4] indicates that farms of around 10 ha demonstrated low efficiency. Farms of around 50 ha performed much better in this respect. It follows research conducted on farms participating in the Polish FADN (Farm

Accountancy Data Network) in the period 2004–2018; the highest production per hectare of agricultural land was recorded in the group of large entities operating on about 100 ha [5]. On those farms, production in 2018 was up by 6.03% on the 2004 figure. Very small farms (8.22 hectares of AL on average) and small farms (14.6 ha of AL) not only had the lowest production figure per hectare, but also recorded the largest drop in production between 2004 and 2018.

Land concentration in agriculture is therefore essential to: (1) increase labour efficiency, (2) efficiently use technology (overinvestment of small farms), (3) alleviate the pressure to reduce unit costs, which is important for economic competitiveness and (4) create conditions for the income growth for agricultural population [6].

European legislation too emphasises the fact that structural policy should aim to change farming conditions in and around agriculture, for example by improving the size structure of farms [7].

Growing competitive pressure on the agricultural market is forcing farms to expand their size (small size farms can also be economically viable, as exemplified by poultry farms, whose number has increased significantly in recent years). It is mainly large farms that invest in the purchase of land for a size increase, implement innovative solutions and purchase modern machinery and equipment. Therefore, changes in the size structure of farms are among indicators of Polish agriculture's adaptation to the agriculture of EU countries; hence, they are closely monitored and analysed [8–16].

Szymańska devotes her research to the changes in the agrarian structure of Polish agriculture and its transformation in a broad historical context [17]. According to the author, the last century saw significant transformations in the agrarian structure of Polish agriculture. They were determined in different historical periods (the author singles out and analyses four time slots from the history of Poland) by various factors of a political, economic and social nature. However, the agrarian fragmentation of Polish agriculture has not been eliminated. In 2018, more than half of farms had less than 5 hectares of UR, and only 2.4%. state-owned farms of at least 50 hectares. Kłopot [18], on the other hand, argues that the agrarian structure in Poland, with the characteristic dominance of small farms, which was formed after the enfranchisement of peasants, has remained essentially unchanged up to the present day. In each of the analysed periods, the author points to other factors that caused the petrification of the agrarian structure of individual agriculture. In his opinion, the 20 year transition period with the introduction of the market economy did not accelerate changes in the agrarian structure, nor did it initiate processes of land concentration.

Szymańska and Maj analysed changes in the number and structure of farms in the period 2010–2017 [8]. The authors point out that these changes are too slow and small units still dominate among farms. The average area of farms and the percentage of large, economically strong units is increasing too slowly.

Michna devoted a section of his broader research to analysing changes in the size structure of farms in Poland against the background of the EU-15 and EU-27 countries in the first decade of the 21st century [19]. Due to the fact that the share of farms with an area of more than 20 hectares is half as large in Poland as in the European Union on average, according to the author, the negative consequences of this fact for the entire agriculture and national economy will be visible. More than half of the agricultural land in Poland remains in the hands of small farms, which are unable to even just reproduce their production potential, let alone create conditions for the realization of agricultural progress and the introduction of innovations.

The functioning of family farms, including the trends of changes in agrarian structure in the period 2000–2010, was analysed by Zegar based on data from representative surveys of the Central Statistical Office in 2005 and 2007 [20]. Bożek and others dedicated their research to the analysis of changes in the agrarian structure of Polish farms in various time frames, including the broader context, relating the dynamics of changes on a national scale to other EU countries [21,22]. The observed changes in the number of farms in the EU

in 2010–2016 were quite large, but they did not significantly reduce the gap between the countries with the most fragmented agrarian structure and the leading countries.

Comparative studies on the competitiveness of agriculture, including the agrarian structure, of European countries and the US were conducted by Pawlak and others [23]. In light of these comparisons, one person working in agriculture in the EU-28 cultivated an average of about 18 hectares of farmland, with the country-specific average ranging from 6–9 hectares in Romania, Poland and Slovenia to 42–44 hectares in Luxembourg, Denmark, Estonia, Ireland and the UK. In contrast, in the United States in 2017, there were approximately 166.5 hectares per person employed in agriculture. Thus, the incomparably higher concentration of farmland in the US promotes greater labour productivity in the country's agricultural sector.

Comparative research on changes in the forms of agricultural land use and the trade of agricultural land, and thus, consequently, the formation of the agrarian structure in Poland and Hungary in the first years after accession to the Union, was conducted by Takacs-Gyorgy and others [24]. According to them, in Poland, the polarization of the agrarian structure of agricultural farms and significant regional variations in their land size continue to be characteristic. Meanwhile, in Hungary, a substantial portion of land is cultivated by tenants (over 60%), resulting in larger average farm sizes, indicating a slow process of concentration, particularly among farms with areas exceeding 50 hectares. The authors note that although the percentage of medium-sized farms remains low and the process of land acquisition by larger farms is gradual, concentration of land has begun in these two countries.

Akimowicz and others focused on analysing the factors influencing the size of agricultural farms and the dynamics of changes in their size in the years 2000–2007 in southwestern France [25]. The results of the estimated econometric models highlight the significant impact of the initial size, type of agricultural farm, its specialization, and location (urban or non-urban area) on farm size growth.

Polish agriculture has a large potential, which mainly results from the total area of agricultural land and the share of Poland in the total EU agricultural production (5.9%) (https://ec.europa.eu/eurostat/databrowser/view/AACT_EAA01/default/table?lang=en (accessed on 12 July 2023)). However, the potential is not used to it's fullest, due to, among others, the relatively high fragmentation level of agricultural farms in Poland, which is among the highest in the European Union [26–28]. However, it should be emphasised that the increase in the farm size area is strongly dependent on other farms' being discontinued or selling some of their land. That interdependence relating to a strictly limited resource (land) is what sets agriculture apart from virtually any other sector. The exception to this rule is voivodeships, where agricultural land is not fully utilised [29].

Since joining the EU, however, major changes have been taking place in Polish agriculture. They are taking place thanks to the use of aid instruments of the Common Agricultural Policy (CAP), but their pace is also influenced by macro-economic conditions, especially the state of the general economic situation and the situation in agriculture [30]. In the period 2010–2020, the number of farms in Poland decreased by 13%. This was mainly due to a decline in the number of the smallest farms, up to 5 hectares and 5–10 hectares. According to the authors' previous research, in the period 2010–2016 in most of the new member states, the rate of decline in the total number of farms was higher than in Poland [14], and this decline was mainly due to the disappearance of the smallest farms, up to 2 hectares. Changes in the area structure of EU countries are constantly monitored, especially in the context of development and cohesion policy implementation goals [11,21,31–33]. In Poland, the direction and intensity of these transformations varies from voivodeship to voivodeship and is closely related to the regional differentiation of farm structure. This differentiation is a permanent phenomenon, the genesis of which dates back to the period of partitions [34–36]. Thus, the picture of agrarian structure in Poland in national terms does not fully reflect reality—a full picture is given by analysis in spatial (regional) terms.

This work follows up on the authors' research on agrarian structure in Poland and the EU [14,15,21,22,28]. The aim of the paper is to present the direction and scale of changes in the size structure of agricultural farms in Poland over the period 2010–2020, which is the time interval separating two consecutive General Agricultural Censuses (GAS). Taking into account the strong regional differentiation of agriculture in Poland, the analysis was carried out for Poland on a national and spatial basis. The basis of the analysis is the grouping of voivodeships into sets of objects similar in terms of the distribution of the number of farms in AL area groups. The grouping was carried out on the basis of the fuzzy classification method. Due to the specific nature of Polish agriculture, in which small farms predominate, the following area groups of farms were included in the study: up to 2 hectares of arable land, 2–5 hectares, 5–10 hectares, 10–20 hectares, 20–50 hectares, 50 hectares or more.

2. Materials and Methods

The research was carried out on the basis of data from Statistics Poland (GUS) presenting the number of farms by size groups and by voivodeships for the years 2010 and 2020. The data come from the 2010 and 2020 General Agricultural Censuses.

In order to group voivodeships by similar farm size structure, a fuzzy classification based on the concept of fuzzy sets [37] was used, which was then transformed into a conventional classification.

Fuzzy classification is one of the methods used to divide a set of multidimensional objects into homogeneous groups. There are many methods of grouping and, while applied to the same statistical material, they can give results that differ in the number of groups and their composition. This problem has been repeatedly addressed by many authors [38–44]. Clustering results depend primarily on the degree of statistical variation, but also on the choice of the classification method. Some methods are not very stable, i.e., a small change in the initial conditions (e.g., data, value of the differentiation threshold) can cause significant changes in the clustering results [45] which makes spatial-temporal analyses difficult. In the present study, the fuzzy classification method was used as the authors' previous studies have confirmed the usefulness of this method in studying agrarian structure in dynamic terms [16,22,45]. This method makes it possible to objectively separate groups of objects homogeneous in terms of the studied structure and to synthetically represent the studied phenomenon over time, with relatively little loss of input information.

The issue of fuzzy classification can be formulated as follows:

It is assumed that a set Ω is given, consisting of n objects (voivodeships in this case): $P_1, P_2, ..., P_n$. These objects are described by r values of variables: $X_1, X_2, ... X_r$ (in this paper, X_l means the share of the number of farms from the l-th size group in the total number of farms in a given voivodeship). A family of fuzzy classes $S_1, S_2, ... S_K$ $(1 < K < n)$ should be defined for the set Ω and, for each object P_i, the degree of its membership of class S_j should be determined, i.e., the membership function $f_{S_j}(P_i)$, satisfying the following conditions:

1. $0 \le f_{S_j}(P_i) \le 1 (i = 1, ..., n; j = 1, ..., K)$, where $f_{S_j}(P_i)$—the degree of P_i membership of class S_j,
2. $\sum_{j=1}^{K} f_{S_j}(P_i) = 1 (i = 1, ..., n)$,
3. Objects for which the degrees of membership of the same class reach a high value are very similar, while objects for which the degrees of membership of different classes reach a high value are dissimilar.

There are several methods to create a fuzzy classification [39]. In this paper, an iterative method is used based on the Centre of Gravity concept. In successive iterations, changes are made to the values of the degrees of membership of objects in each class. This procedure is repeated until these values no longer change significantly.

The fuzzy classification so obtained was transformed into a conventional classification, assuming that the object P_i belongs to a class (typological group) S_j when

$$f_{S_j}(P_i) = \max_l f_{S_l}(P_i) \tag{1}$$

The methodology of statistical analysis of structures [38,46,47] was used to further study the separated typological groups of voivodeships. For each typological group of voivodeships, the average values of the components (indicators) of the area structure of farms, i.e., the centre of gravity of the group and the intergroup distances, were determined according to the following formulas:

Let us assume that the *i*-th group consists of n_i objects (voivodeships) so it can be represented as a matrix:

$$S_i = [a_{lk}](l = 1, \ldots, n_i; k = 1, \ldots r) \tag{2}$$

where a_{lk} denotes the value of the *k*-th component in the *l*-th object (the share of the number of farms in the *k*-th area group in the total number of farms in the *l*-th voivodeship). Thus, the *l*-th row of the matrix represents the size structure of farms in the *l*-th voivodeship.

Then, the *k*-th component of the centre of gravity of the *i*-th group is the arithmetic mean of the *k*-th components of the objects belonging to the *i*-th group:

$$a_{ik}^* = \frac{\sum_{l=1}^{n_i} a_{lk}}{n_i} \tag{3}$$

In order to assess the differences between the structures of the groups so formed, intergroup distances were determined. The distance between the groups' centres of gravity, calculated according to the formula [48], was used to measure the intergroup distance:

$$v_{i,j} = \frac{\sum_{k=1}^{r} \left| a_{ik}^* - a_{jk}^* \right|}{2} \tag{4}$$

where a_{ik}^*, a_{jk}^*—the *k*-th component of the centre of gravity for the *i*-th and *j*-th group, respectively.

This measure takes values from the range [0;1]. The higher its value, the more the group structures differ. Determining the distance between the groups at the beginning and end of the tested period allows to capture trends as they occur—increasing or decreasing differences between groups.

Equation (2) was also used to assess the degree of change that occurred in the structure over the analysed period [48]:

If α is a shareholding structure studied over time $t = 0, 1, \ldots, n$, composed of *r* components, then matrix is given $[\alpha_{tk}]_{(t=0,1,\ldots,n,\ k=1,\ldots,r)}$, where

$\sum_{k=1}^{r} \alpha_{tk} = 1$ and $0 \leq \alpha_{tk} \leq 1$ $t = 0, 1, \ldots, n, k = 1, 2, \ldots, r$,

then

$$v_{t,t-\tau} = \frac{\sum_{k=1}^{r} \left| \alpha_{tk} - \alpha_{(t-\tau)k} \right|}{2} \tag{5}$$

determines the extent to which the structure changed over the period from $t - \tau$ to t. This measure takes values from the range [0;1]. Its high value indicates that there were major changes in the structure (in the period from $t - \tau$ to t). In particular, v_{n0} makes it possible to compare the structure in the initial period $t = 0$ with the structure of the final period $t = n$.

3. Results

3.1. Changes in the Size Structure of Farms on a National Level

The number of agricultural farms in Poland decreased in the period 2010–2020 by 191.7 thousand, a decrease of 13%. The reduction covers all size groups below 20 ha AL, with the decrease in number ranging from 10 to 27% in the respective groups (Table 1). The exception is the group of single-hectare farms, which increased in number by 0.4 thousand, or 2%. This increase may be related to a higher interest in organic farming or agro-tourism, or possibly the purchase of small land parcels for recreational purposes.

Table 1. Agricultural farms in Poland by agricultural land size groups − rate of changes in 2010–2020.

Specification	Total	Area Groups of Agricultural Land in Hectares							
		Up to 5	1	(1, 2)	<2, 5)	<5, 10)	<10, 20)	<20, 50)	50 and More
		Number of farms in thousands							
2010	1509.1	815.3	24.9	300.6	489.8	346.3	223.5	97.0	27.0
2020	1317.4	685.6	25.3	220.3	440.1	289.0	195.5	106.6	40.7
Changes 2020 − 2010	−191.70	−129.7	0.4	−80.3	−49.70	−57.30	−28.00	9.60	13.70
Index $\frac{2020}{2010}$	0.87	0.84	1.02	0.73	0.90	0.83	0.87	1.10	1.51
		Structure of farms in %							
2010	100.0	54.0	1.6	19.9	32.5	22.9	14.8	6.4	1.8
2020	100.0	52.0	1.9	16.7	33.4	21.9	14.8	8.1	3.1
		Area of agricultural land in farms (thousands of hectares)							
2010	14,860	2 059	18	441	1600	2468	3080	2829	4424
2020	14,682	1 734	17	360	1357	2050	2708	3160	5029
Changes 2020 − 2010	−178	−325	−1	-81	−243	−418	−372	331	605
Index $\frac{2020}{2010}$	0.99	0.84	0.94	0.82	0.85	0.83	0.88	1.12	1.14
		Area of agricultural land in farms in %							
2010	100.0	13.9	0.1	3.0	10.8	16.6	20.7	19.0	29.8
2020	100.0	11.8	0.1	2.5	9.2	14.0	18.4	21.5	34.3

Source: authors' own calculations based on: https://bdl.stat.gov.pl accessed on 12 May 2023.

On the other hand, there was an increase in the numbers of the two largest-size groups, in particular over 50 ha farms, whose number increased by as much as 51%. That happened at the expense of smaller-size farms, which is a favourable trend.

What follows from the change in the number of farms in the respective size groups is that there are only minor changes to their share in the structure. The changes are the largest for the 1–2 ha group, where there was a decrease by 3.2 percentage points (p.p.), and the 20–50 ha group, growing by 1.7 p.p.

Conclusions from the analysis of changes in the number of farms are corroborated by the analysis of changes in the agricultural land size in the respective groups. In general, the agricultural land size in Poland dropped by 1%, covering primarily land from smaller farms of less than 20 ha AL. In each less-than-20 ha AL group, the total size decreased relatively by 6–18% for the respective groups. A favourable trend is the increase in size in the two largest-farm groups, by 12 and 14%, respectively, probably caused by the absorption of land from smaller farms.

Changes in land size correspond to changes in the agrarian structure. The share of land held by up-to-20 ha farms decreased in the analysed period in each of the groups, but the changes are not significant, at around two percentage points. The increase in the share of farms between 20 and 50 ha was 2.5 p.p., and 4.5 p.p. for farms larger than 50 ha.

A general conclusion is that changes in the agrarian structure are slowly moving in the desired direction: the number of the largest farms is increasing, as well as the size of their AL. These changes drive a slight structure improvement, which has not, however, brought Poland significantly closer to the leading EU countries, such as Germany or France. The earlier research conducted by the authors regarding the agrarian structure of EU countries has led to the identification of groups of countries with a similar size structure of agricultural farms [14]. Poland is in the group of countries with a highly fragmented farm structure, together with Croatia, Greece, Spain, Portugal, Slovakia, Slovenia and Italy.

3.2. Changes in the Size Structure of Farms According to Typological Groups of Voivodeships

The picture is slightly more favourable in regional terms. The farm size in Poland is extremely varied. That is a permanent feature, with roots going back far in time when Poland was partitioned by the neighbouring powers [17,34]. Polish land, then belonging to the three great empires, was peripheral in their territory and covered by different state administrations, with different economic systems and legal orders. That, in turn,

resulted in different rates of economic development, agricultural progress and launch times of the first agricultural revolution. Traces of those dissimilarities, weaker as they become, are still manifested by the distribution of agricultural land or by the degree of agrarian fragmentation [49]. Regional differences of Polish agriculture, in particular the size structure of farms, are covered by many authors [38,50–52]. In the paper [15], relying on data from GAC 2010, the authors distinguished four groups of voivodeships with a similar farm structure and high inter-group variation. From then until 2020, the farm size structure in the respective voivodeships changed, in some cases significantly (Table 2). For example, in the Lubuskie voivodeship, the share of farms up to 2 ha dropped from 23.6% in 2010 to 18.6% in 2020, while the share of the largest farms of more than 50 ha grew in this period from 6.4% to 10.0%. The case is similar for the same size groups in the Zachodniopomorskie voivodeship: from 17.0 to 13.6% (up to 2 ha) and from 10.2 to 15.5% (over 50 ha), respectively. Significant structural transformations also took place in the Małopolskie, Podkarpackie and Śląskie voivodeships. In effect, the gaps, i.e., the differences between the largest and the smallest shares of individual size groups, also changed (Table 2). The changes did not go in one direction, however. In 2010, the largest difference was in the share of the smallest farms, up to 2 ha, as the gap was 29.1 p.p., decreasing in 2020 to 24.9 p.p. In 2020, the highest proportion of such farms is present in the Małopolskie voivodeship, at 33.2%, and the lowest in the Podlaskie voivodeship, at 8.3%. In 2020, the largest difference was recorded in the share of small farms, from 2 to 5 ha, coming to 29.1 p.p. (in 2010—27.9 p.p.). The highest proportion of such farms was in the Małopolskie voivodeship—47.6%, and the lowest in the Warmińsko-Mazurskie voivodeship—18.5%. The smallest difference of 15 p.p. was recorded for the largest farms, above 50 ha: from 0.5% in Małopolskie to 15.5% in Zachodniopomorskie.

Based on the fuzzy classification described above, voivodeships with similar structures were clustered using the 2020 data. The calculations were performed using proprietary software (software in C++ calculates the values of the fuzzy class membership functions of objects according to the algorithm provided in the paper [16]), which determines the clusters' centres of gravity for a given set of multidimensional objects and calculates the values of cluster membership functions of individual objects.

Based on the calculations, four (the number of groups was determined on the principle of minimizing intra-group variation while maximizing inter-group variation. The practical application of this method of optimizing partitioning in the study of agrarian structure is presented in the study [45]. For an overview of various methods of optimizing partitioning, see, among others, the work of Kisielińska and others [40]) typological groups of voivodeships were distinguished. The composition of the groups is shown in Table 3. For each of them, the average shares of farms in particular size groups were calculated, as well as measures of intra-group variation: standard deviation—s(x) and coefficient of variation—V(x). For comparison, the table also includes the structure of the groups from 2010 [15]. The groups so created have the same composition as in 2010, which proves that the split is permanent, and changes in the number of farms are similar for the voivodeships in the same group.

Group I, with the most unfavourable, fragmented farm structure, is formed by southeastern voivodeships: Małopolskie, Podkarpackie and Śląskie (Figure 1). Voivodeships in this group are dominated by farms of up to 5 ha, which accounted, on average, for 76.1% of the total number of farms in 2020, with 31.8% of farms of up to 2 ha and 44.3% of farms between 2 and 5 ha. Farms over 10 ha accounted for only 9.2% of the total. Between 2010 and 2020, there was a significant change in the share of the smallest farms, up to 2 ha, dropping by 5.6 p.p. in this regional group. The shares of the other size groups increased. The structural change index is 0.056 and the average change in shares per size group is 1.9 p.p.

Table 2. Farms by AL size groups and voivodeships in 2010 and 2020.

Voivodeships	Year	Area Groups of Agricultural Land in Hectares					
		Up to 2 [1]	<2, 5)	<5, 10)	<10, 20)	<20, 50)	50 and More
		In %					
Poland	2010	21.6	32.5	22.9	14.8	6.4	1.8
	2020	18.6	33.4	21.9	14.8	8.1	3.1
Dolnośląskie	2010	22.9	28.7	21.4	14.6	7.9	4.5
	2020	18.7	31.2	20.5	13.5	9.4	6.7
Kujawsko-Pomorskie	2010	13.2	19.4	24.1	25.0	14.8	3.5
	2020	12.6	20.7	21.5	22.8	16.6	5.8
Lubelskie	2010	18.4	35.4	27.9	13.3	4.2	0.8
	2020	15.7	36.6	25.8	14.1	6.3	1.6
Lubuskie	2010	23.6	27.0	18.5	15.2	9.3	6.4
	2020	18.6	28.1	18.0	13.9	11.3	10.0
Łódzkie	2010	15.6	32.3	31.1	16.2	4.2	0.5
	2020	15.0	33.4	28.4	16.1	6.0	1.2
Małopolskie	2010	38.1	45.4	12.7	2.8	0.7	0.2
	2020	33.2	47.6	13.3	3.8	1.6	0.5
Mazowieckie	2010	15.2	30.5	29.0	18.3	6.1	0.8
	2020	14.0	31.5	27.2	18.2	7.4	1.6
Opolskie	2010	19.2	26.7	20.5	17.1	11.6	5.0
	2020	17.1	28.6	18.7	15.3	12.7	7.6
Podkarpackie	2010	37.0	44.9	13.6	3.1	1.0	0.5
	2020	32.3	46.9	13.8	4.1	2.0	0.9
Podlaskie	2010	9.1	20.0	25.8	29.5	14.2	1.5
	2020	8.3	20.4	24.2	27.2	16.4	3.4
Pomorskie	2010	14.4	21.7	22.5	23.7	12.8	4.9
	2020	13.4	23.0	21.8	21.4	13.4	7.1
Śląskie	2010	37.1	36.9	15.8	6.5	2.6	1.0
	2020	29.9	38.4	17.0	8.0	4.5	2.2
Świętokrzyskie	2010	22.2	42.7	25.1	7.9	1.8	0.3
	2020	18.7	44.1	24.1	9.0	3.3	0.8
Warmińsko-Mazurskie	2010	13.1	17.5	17.0	25.7	19.6	7.1
	2020	11.9	18.5	17.4	22.3	19.8	10.0
Wielkopolskie	2010	16.8	22.6	24.0	23.1	10.6	2.8
	2020	16.3	23.6	22.2	21.2	12.4	4.2
Zachodniopomorskie	2010	17.0	22.7	17.8	18.9	13.4	10.2
	2020	13.6	23.5	17.1	16.5	13.9	15.5
Gap	2010	29.1	27.9	18.4	26.7	18.9	8.0
Gap	2020	24.9	29.1	15.1	23.4	18.2	15.0

Source: Author's own calculations based on: https://bdl.stat.gov.pl, accessed on 12 May 2023. [1]: The percentage of one-hectare farms is marginal, so this group was combined with the 1–2 ha group in further analysis.

Group II comprises four voivodeships of central and eastern Poland: Łódzkie, Mazowieckie, Świętokrzyskie and Lubelskie. They are less fragmented than the group I voivodeships. Although small farms, up to 5 ha, account for more than half of the total number (53.1%), there is a significant share of farms above 10 ha; in 2020, they accounted for 21.3%. There are slight changes in this group: a decrease in the share of farms up to 2 ha and 5–10 ha and an increase in the share of other farms. The structure of this group changed the least compared to the other typological groups: the index of structural change is 0.039 and the average change in shares is 1.3 pp.

Table 3. Average values and dispersion of farm size structure indicators for the created groups of voivodeships.

| Specification	Area Groups of Agricultural Land in Hectares					
	Up to 2	<2, 5)	<5, 10)	<10, 20)	<20, 50)	50 and More
	In %					
I (Małopolskie, Podkarpackie, Śląskie)						
2010 mean	37.4	42.4	14.1	4.1	1.4	0.6
2020 mean	31.8	44.3	14.7	5.3	2.7	1.2
s(x)	1.4	4.2	1.6	1.9	1.3	0.7
V(x)	4.4	9.4	11.2	35.6	48.7	59.2
II (Lubelskie, Łódzkie, Mazowieckie, Świętokrzyskie)						
2010 mean	17.9	35.2	28.3	13.9	4.1	0.6
2020 mean	15.8	36.4	26.4	14.3	5.7	1.3
s(x)	1.8	4.8	1.6	3.4	1.5	0.3
V(x)	11.1	13.2	6.1	23.8	26.3	26.2
III (Dolnośląskie, Lubuskie, Opolskie, Zachodniopomorskie)						
2010 mean	20.7	26.3	19.6	16.4	10.5	6.5
2020 mean	17.0	27.9	18.6	14.8	11.8	10.0
s(x)	2.1	2.8	1.2	1.2	1.7	3.4
V(x)	12.2	10.1	6.7	8.0	14.0	34.5
IV (Kujawsko-Pomorskie, Podlaskie, Pomorskie, Warmińsko-Mazurskie, Wielkopolskie)						
2010 mean	13.3	20.2	22.7	25.4	14.4	4.0
2020 mean	12.5	21.3	21.4	23.0	15.7	6.1
s(x)	2.6	1.8	2.2	2.2	2.6	2.3
V(x)	20.6	8.7	10.4	9.6	16.8	38.0

Source: authors' own calculations.
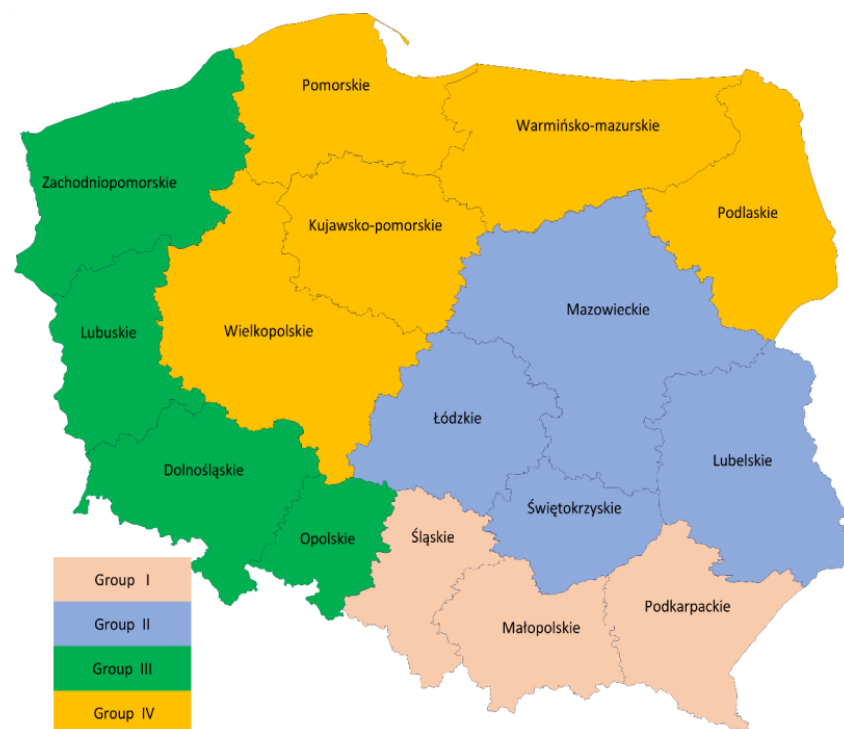
Figure 1. Groups of similar voivodeships by size structure of agricultural farms in 2020. Source: authors' own research.

Group III covers four voivodeships of south-western Poland: Dolnośląskie, Lubuskie, Opolskie and Zachodniopomorskie. The share of farms up to 5 ha is also high here, at 44.9%, but farms larger than 10 ha account for 36.6% of the total, with the highest share taken by farms larger than 50 ha—10% among all typological groups. In the voivodeships from this group, the shares of farms up to 2 ha, 5–10 ha and 10–20 ha decreased, while the shares of the other size groups increased, with the highest increase in the group of the largest farms—from 6.5% to 10%. In comparison with other typological groups, the structure of this group changed the most—its index of structural changes is at 0.063. The largest change (3.5 p.p.) covered the group of the largest farms, while the average change in shares is 2.1 p.p.

Group IV covers five voivodeships with the best structure: Kujawsko-Pomorskie, Podlaskie, Pomorskie, Wielkopolskie and Warmińsko-Mazurskie. Of all the typological groups, this has the lowest share (12.5%) of the smallest farms, while the shares of farms of 10–20 ha (23%) and 20–50 ha (15.7%) are at the highest. The trends here are the same as group III, namely an increase in the shares of farms of 2–5 ha, 20–50 ha and over 50 ha and a decrease in the share of other farms. The structural change index is at 0.045 for this group and the average change in shares per farm size group is 1.5 p.p.

In summary, 2010–2020 saw increases in the shares of farms from the two largest size groups, i.e., 20–50 ha and over 50 ha and farms of 2–5 ha, while the shares of farms up to 2 ha decreased. In groups III and IV, the shares of farms of 5–10 ha and 10–20 ha decreased, while in groups I and II, the shares of those farms increased. Similar conclusions were arrived at by Filipiak and Wicki [53], who indicated that share of farms above 20 ha increased by 7 p.p. between 2010 and 2020. This is probably on the back of purchasing land from small, often liquidated farms and its reclassification into larger size groups. Also, Wojewodzic et al. [54] indicate that the share of small farms is still significant but the situation is improving.

The size structure of farms in the typological groups is changing, albeit very slowly (Figure 2). In 2010–2020, the average change in the share per size group ranged from 1.3 p.p. in group II to 2.1 p.p. in group III.
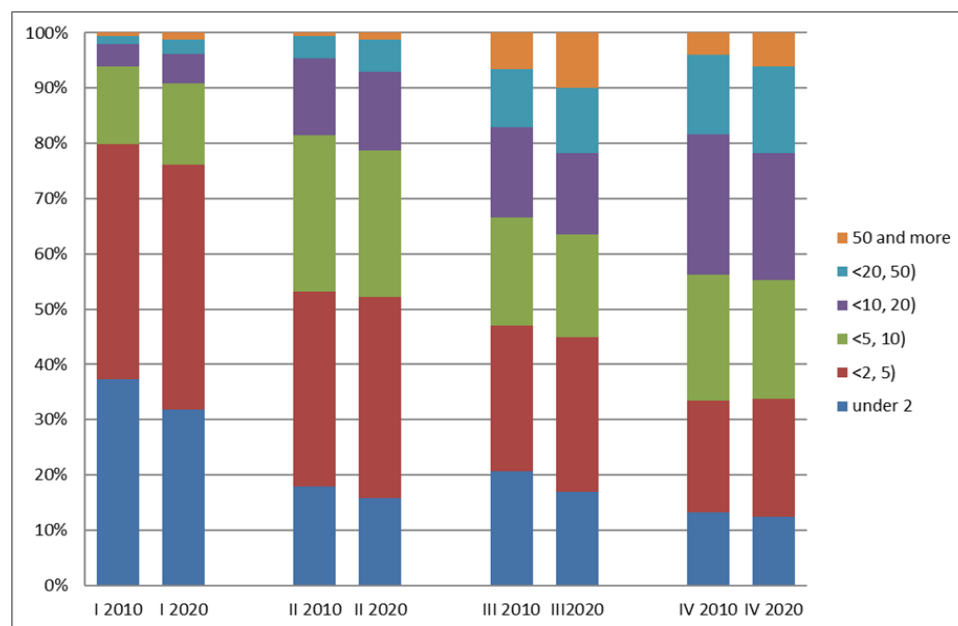
Figure 2. Size structure of agricultural farms in typological groups of voivodeships in 2010 and 2020. Source: authors' own research.

Table 4 shows the intergroup variation, calculated according to Equation (2).

Table 4. Inter-group variation in the farm size structure.

Groups		II	III	IV
I	2010	0.267	0.329	0.463
	2020	0.239	0.312	0.423
II	2010		0.177	0.251
	2020		0.163	0.234
III	2010			0.159
	2020			0.149

Source: authors' own calculations.

The greatest distance separates groups I and IV; the distance between these groups was 0.463 in 2010, and, by 2020, it decreased to 0.423. The closest are the structures of groups III and IV, with voivodeships from the west and north having the most favourable size structure. This distance was 0.159 in 2010, dropping to 0.149 by 2020. If the current structural trend continues in those voivodeships, they may form one typological group in the future. Between 2010 and 2020, the intergroup differences decreased among all groups, indicating that regional differences decreased.

An important factor in the agrarian structure, in addition to the number of farms in size groups, is also the area they occupy because it is the area of the farm that largely determines the economic conditions of agricultural production [11,31]. In this respect, the typological groups of voivodeships are more varied than in terms of the number of farms (Table 5). Very clear differences can be seen between group III and IV, where farms up to 10 ha occupy only 11% and 15%, and group I and II, where their share is 54.3% and 38%, respectively. The greatest differences exist for the largest farms of over 50 ha, with the most land taken by those farms in group III (63.5%) followed by group IV (40.6%) and the least in group II (16.6%). In all typological groups, farms up to 2 ha account for a small share of AL: from 1% in groups III and IV to 8.5% in group I.

Table 5. Structure of typological groups in terms of area.

Groups	Area Groups of Agricultural Land in Hectares						
	Total	Up to 2	<2.5)	<5, 10)	<10, 20)	<20, 50)	50 and More
I	100.0%	8.5%	27.1%	18.1%	12.0%	12.9%	21.4%
II	100.0%	2.5%	13.5%	22.0%	24.3%	21.2%	16.6%
III	100.0%	1.0%	4.0%	6.2%	9.2%	16.1%	63.5%
IV	100.0%	1.0%	4.1%	9.3%	18.8%	26.3%	40.6%

Source: author's own calculations based on: https://bdl.stat.gov.pl, accessed on 12 May 2023.

The structure of typological groups in terms of area clearly pinpoints the differences between the voivodeships of south-eastern and central Poland, covered by groups I and II where the farm holding is very fragmented, and the voivodeships of western and northern Poland (groups III and IV) where the structure of farms is more favourable.

3.3. Changes in the Number of Farms in Absolute Terms According to Typological Groups of Voivodeships

Despite only minor structural transformations, the number of farms in absolute terms changed significantly in the analysed typological groups (Table 6). The direction and rate of changes in relative terms (shares) did not always coincide with changes in absolute terms. For example, at the national level, there was a 10% decrease in the number of 2–5 ha farms, while the share of those farms increased from 32.5% to 33.4% (Table 1). These inconsistencies were due to changes in the overall number of farms.

Table 6. Change in the number of farms in typological groups of voivodeships between 2010 and 2020.

Groups	Total		Area Groups of Agricultural Land in Hectares											
			Up to 2		<2, 5)		<5, 10)		<10, 20)		<20, 50)		50 and More	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
I	−68.8	0.81	−40.9	0.70	−24.0	0.85	−7.9	0.84	0.7	1.05	2.3	1.55	1.1	1.65
II	−78.1	0.88	−24.5	0.78	−20.9	0.91	−33.0	0.82	−9.3	0.90	6.0	1.21	3.5	1.80
III	−16.2	0.89	−8.2	0.73	−2.2	0.94	−4.6	0.84	−4.5	0.80	0.0	1.00	3.2	1.37
IV	−28.5	0.92	−6.3	0.87	−2.6	0.96	−11.7	0.86	−15.1	0.84	1.3	1.03	5.8	1.48

Note. A—change 2020 − 2010 (in thousands). B—index $\frac{2020}{2010}$ Source: authors' own calculations based on: https://bdl.stat.gov.pl accessed on 12 May 2023.

The largest number of farms (566.3 thousand, i.e., 43% of the total number of farms in the country) fell into group II (Table 7). Those farms held 4849.6 thousand hectares of AL, i.e., 32.4% of the national AL total. In this group, the structure changed the least among all typological groups (the rate of structural change was the lowest), while in absolute terms, the greatest changes occurred here, with the largest number of farms disappearing (78.1 thousand), mainly from the size group below 10 ha, and a relatively large number of farms above 50 ha (3.5 thousand) were created (Table 7). The largest loss occurred among farms in the 5–10 ha size group (33 thousand, i.e., 18%). The number of farms up to 5 ha decreased by a total of 45.4 thousand. Regardless of those major decreases, voivodships from this group hold nearly half of the total number of farms from smaller size groups: 2–5 ha and 5–10 ha (45% and 52%, respectively) in 2020. Those farms hold almost 350 thousand hectares of AL, of which 2–5 ha farms occupy 199 thousand hectares, which is more than half (56.3%) of the AL held by this size group in the whole country and 150 thousand hectares, or 525 (Table 7) in the case of 5–10 ha farms. This means that group II is positioned to undergo further significant changes improving the agrarian structure: a decrease in the number of farms up to 10 ha and the flow of land to larger farms.

Table 7. Number of farms in typological groups of voivodeships in 2020.

Groups	Total		Area Groups of Agricultural Land in Hectares											
			Up to 2		<2.5)		<5, 10)		<10, 20)		<20, 50)		50 and More	
							Number of farms							
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total	1317.4	100.0	245.5	100.0	440.1	100.0	289.0	100.0	195.5	100.0	106.6	100.0	40.7	100.0
I	290.2	22.0	93.7	38.2	132.7	30.2	41.0	14.2	13.5	6.9	6.5	6.1	2.8	6.9
II	566.3	43.0	86.9	35.4	199.0	45.2	150.8	52.2	86.5	44.2	35.2	33.0	7.9	19.4
III	126.6	9.6	21.8	8.9	36.0	8.2	24.0	8.3	18.5	9.5	14.4	13.5	11.9	29.2
IV	334.3	25.4	43.2	17.6	72.3	16.4	73.2	25.3	77.0	39.4	50.6	47.5	18.0	44.2
							Area of farms							
	C	B	C	B	C	B	C	B	C	B	C	B	C	B
Total	14,952.9	100.0	336.7	100.0	1415.3	100.0	2049.3	100.0	2700.0	100.0	3195.5	100.0	5256.0	100.0
I	1520.6	10.2	130.0	38.6	411.5	29.1	275.8	13.5	182.0	6.7	196.2	6.1	325.1	6.2
II	4849.6	32.4	121.2	36.0	655.6	46.3	1065.5	52.0	1176.1	43.6	1027.4	32.2	803.7	15.3
III	2804.1	18.8	29.0	8.6	112.9	8.0	172.6	8.4	257.6	9.5	451.6	14.1	1780.4	33.9
IV	5778.5	38.6	56.5	16.8	235.3	16.6	535.4	26.1	1084.3	40.2	1520.2	47.6	2346.9	44.7

Note. A—in thousands; B—in %; C—in thousands of hectares. Source: author's own calculations based on: https://bdl.stat.gov.pl accessed on 12 May 2023.

Significant changes in the number of farms were also noted for group I: the total number of farms fell by 68,800, i.e., by 19%, being one of the sharpest drops among all typological groups. The most farms disappeared from the size group of up to 2 ha. Their number decreased by 40.9 thousand, i.e., by 30%. There was also a decrease in the number of 2–5 ha farms (by 24,000, i.e., 15%) and 5–10 ha farms (by 7900, i.e., 16%). On the other

hand, the number of farms in other size groups increased. In 2020, voivodeships in this group accounted for 22% of the total number of farms in the country, holding the smallest share of AL—10.2%, of which more than half (53.7%) is occupied by farms of up to 10 ha in size. For this group, too, a continuation of previous trends and significant changes towards improved structures can be expected.

The smallest number of farms—16.2 thousand—were in group III, half of which were farms up to 2 ha in AL. In terms of the number, this group is the smallest as it accounts for a mere 9.6% of the country's total number of farms, with 18.8% of the total AL.

In group IV, a drop in the number of farms was relatively low at 8% (i.e., 28.5 thousand), in comparison with their number in 2010. This group recorded the greatest decrease in the number of farms of 10–20 ha, dropping by 15.1 thousand, i.e., 16%. The number of 50–10 ha farms decreased by 11.7 thousand (14%). It is important to note that this group contributed the most to the growing number of +50 ha farms, whose number increased by 5.8 thousand in relation to 2010. The 20–50 ha size group proved to be the most stable in terms of numbers, both in group IV (an increase of only 3%) and in group III, where no change was recorded.

In 2020, an overwhelming share of farms up to 10 ha is present in groups I and II: 73.6% up to 2 ha, 75.4% 2–5 ha, 66.4% 5–10 ha (Table 7). Group II is a peculiar group as almost half (the largest number among all typological groups) of the total number of farms nationwide from smaller-size groups, i.e., 2–5 ha and 5–10 ha (45% and 52%, respectively) are located here, but that also applies to larger farms of 10–20 ha (44%) and a significant number of 20–50 ha farms (33%). Those farms hold similar shares of the total national AL held by a given size group: 46.3%, 52%, 43.6%, 32.2%, respectively.

Group IV occupies the largest AL (5778.5 thousand ha, i.e., 38.6%). Almost half of the total national number of large farms are located there, that is, 20–50 ha (47.5%), and the largest, +50 ha (44.2%).

The distribution of the number of farms and the distribution of the area they occupy within each size group relative to the typological groups is similar.

In summary, Poland's agrarian structure presents itself more favourably in regional terms than in national terms. The structure of the western and northern voivodeships (group III and IV) is similar to such EU countries as Austria, Estonia, Lithuania and Latvia [14]. The remaining voivodeships show a very high farm fragmentation of unfavourable land use structure.

The farm size determines, to a large extent, the agricultural production development direction and has a bearing on the type of activity pursued by the farm. Commodity crop production is profitable over large areas; hence, large differences are observed in the average purchase of agricultural products per 1 ha of AL in the respective typological groups. In voivodeships where large farms are predominant, 1382 kg of basic cereals per 1 ha of AL (group III) and 866 kg (group IV) are purchased, while the average for group I is 299 kg (data for 2020 (authors' own calculations based on data from the Local Data Bank https://bdl.stat.gov.pl/bdl/start accessed on 5 June 2023)). Very significant differences are also observed in the case of sugar beet purchase: for group III, the average is 1149 kg, for group IV—1170 kg, and group I—224 kg. In the case of slaughter livestock and milk purchase, the variation between the typological groups is not that strong, and the smallest indicators for the average purchase volume per 1 ha of AL are observed in group III, which was the leader in terms of plant product purchase. The highest average purchase volume of pigs was observed in group IV—214 kg per 1 ha of AL. The average purchase volume of cow's milk was the highest in this group, too, totalling 1147 l per 1 ha of AL.

The labour input of people working on farms and the number of people working on farms is driven by their size. The larger the farm, the smaller the number of people working per unit of surface area.

By analysing the average labour input per 1 ha of AL expressed in AWU (conventional unit of agricultural labour input, meaning full-time equivalent. It is calculated by dividing the number of hours worked in a year by the annual number of hours equivalent to a

full-time job. https://stat.gov.pl/metainformacje/slownik-pojec/pojecia-stosowane-w-statystyce-publicznej/2616,pojecie.html accesed on 5 June 2023) in the respective typological groups, clear differences appear between the average for group I (0.17 AWU per 1 ha of AL) and the average for group III (0.05 AWU per 1 ha of AL). This means that the average labour input required to perform the necessary work per ha of AL in the group where very small farms are predominant is more than three times higher than in the group with a significant share of farms with the largest size. If, in turn, we consider the amount of AL per one person working on the farm, similar differences between the groups can be observed. Thus, in group I, one person works 2.8 ha of AL on average, and in group III, one person works 11.6 ha of AL, i.e., almost four times more. If we look at the voivodeships responsible for the largest gap in this indicator, i.e., Małopolskie (2 ha) and Zachodniopomorskie (16.2 ha), the ratio of values of this variable is close to eight. That clearly shows that large farms are usually more efficient; hence, a change in the size structure of farms may be a way to strengthen Polish agriculture and improve its competitiveness. The problem of structural change does not, however, concern only countries in economic transition, but also those where the economic system is more permanent. According to Berbeki and Nouvellon [55], the number of farms decreased by more than 67% in France in 1976–2016, while the average size of the farm increased by 18.8 ha, reaching 60.9 ha. The structure of farms in the US changed quite significantly between 1978 and 2017 [56], as the total number of farms decreased by 11% and their total area by 33.5%.

According to Murel and Lacquement [57], large size farms are turning into agricultural enterprises, demonstrating high economic efficiency. Komorowska concludes that increasing the size of farms for which cereals are the primary source of income is a way to improve their efficiency [58]. The low efficiency of small farms is pointed out by Ślusarz [59]. According to this author, farm fragmentation leads to de-agrarianisation in Podkarpackie. He also indicates a positive development, which is the increase in the share of farms larger than 15 ha. Also, Wicki confirms that smaller farms are characterised by low efficiency and have no potential to improve it, while larger farms are much more efficient [4]. The output in agriculture in fixed prices increased by 17% [60] in the period from 2010 to 2020, while commodity production in the period grew by 21.7%, which indicates a clear improvement in the economic efficiency of Polish agriculture, contributed to, among others, by the improvement in the farm size structure.

It should, therefore, be concluded that the present study confirms the conclusions of other studies about a properly directed, albeit slowly progressing, change in the agrarian structure in Poland.

4. Conclusions

The size structure of agricultural farms in Poland demonstrates large regional variation of a permanent nature. For this reason, the structure should be analysed in both national and regional terms. In 2020, four groups of voivodeships were distinguished, each characterised by a different type of the farm size structure. The group composition is the same as in 2010, which proves that the observed split is permanent in nature and changes in the number of farms are similar in the voivodeships belonging to the same group.

Group I consists of three south-eastern voivodeships: Małopolskie, Podkarpackie and Śląskie, where the structure is the most fragmented. Very small farms, with up to 5 ha of agricultural land, dominate here and account for as much as 80% of all farms.

Group II comprises four voivodeships: Lubelskie, Łódzkie, Mazowieckie, Świętokrzyskie, with a predominance (63%) of farms with an area of 2–10 ha.

Group III is made up of the western voivodeships of Dolnośląskie, Lubuskie, Opolskie and Zachodniopomorskie, where almost half of the farms are 2–10 ha in size, but there is also a high proportion of farms larger than 20 ha (22%).

Group IV includes five voivodeships (Kujawsko–Pomorskie, Podlaskie, Pomorskie, Wielkopolskie, Warmińsko-Mazurskie) with the best structure, i.e., the lowest percentage of small farms of up to 5 ha (33.5%) and a significant share of large entities over 20 ha (22%).

Although the structure of the typological groups changed little between 2010 and 2020, changes in the number of farms in absolute terms were significant. The following trends were identified:

- the total number of farms decreased in all typological groups and the number of farms in size groups of up to 10 ha decreased, while the number of very large farms of at least 50 ha increased in all groups;
- the rate and scale of the changes varied regionally with the greatest number of farms being lost in the voivodeships from group I and II, characterised by the most fragmented area structure.

The identified size changes are positive, as the decrease in the number of small farms and the increase in the number of large farms leads to a gradual improvement in the structure and land concentration in larger farms.

The obtained results can serve as a starting point for studying the correlation between farm size and capital within the typological groups during the study period. They can also be used to conduct an analysis of changes in the level of agricultural development within the identified groups.

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