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Original paper

Grouping of agricultural enterprises by land bank size for the Dnipropetrovsk region

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Abstract: The aim study is the development of the classification of agricultural enterprises, based on the properties of the distribution of enterprises depending on the size of the land bank. To achieve this aim, open databases of agricultural enterprises were used, from which data for the Dnipropetrovsk district were selected. The data is not official. They are collected according to the data provided by the agricultural enterprises themselves. Since the official statistics group of small enterprises with up to 200 ha of land includes a fairly large number of enterprises that exist only formally, and since actively functioning enterprises are voluntarily registered in the databases used for the study, the developed classification reflects the real situation with agricultural enterprises in the Dnipropetrovsk district. The proposed scheme of a grouping of agricultural enterprises is regular, logarithmically uniform and based on the exponential increase of the land bank of agricultural enterprises. Its parameters are chosen in such a way as to take into account the classification of farms used in the Tax Code of Ukraine. The developed grouping of agricultural enterprises was used to analyze such characteristics of enterprises as types of production and organizational and legal forms of management. The analysis of the distribution showed that with the decrease of the land bank the number of farms increases and the number of enterprises, whose forms of management are joint-stock companies of different types, decreases.

Keywords: exponential grouping of agricultural enterprises, landbank, exclusive type, classification of agricultural enterprises, types of agricultural enterprises

1. Introduction

According to paragraph 3 of Article 55 of the Economic Code of Ukraine (BVR, 2003), all enterprises are classified into 4 types: large, medium, small, and micro-enterprises. The division into types is based on the average number of employees and gross income from annual activities. It is this classification that is used for Ukrainian statistical reporting (Derzhavnyy Komitit Statystyky Ukrayiny, 2011). However, according to (Derzhavnyy Komitit Statystyky Ukrayiny, 2011), agricultural enterprises are divided into two groups: 1) large, and medium; 2) small. The first group includes those enterprises for which at least one of the 7 conditions is satisfied. Only one of these conditions takes into account the area of agricultural land. The area limit for this condition is 200 ha. That is, if the area of the enterprise is greater than or equal to 200 ha, the enterprise is considered both large and medium. If agricultural land is less than 200 ha, then other conditions are checked, most of which are related to the number of animals fed by the enterprise. Despite such a maximally simplified and rather contradictory classification (It is unclear whether the enterprise is large or medium if the land area exceeds 200 ha), the grouping of agricultural enterprises according to the size of the area of the main crops in (Derzhstat Ukrayiny, 2021) is performed not in two groups but in seven, as presented in Table 1.

Table 1. The scheme of a grouping of agricultural enterprises by area, according to (Derzhstat Ukrayiny, 2021)

Group	The size of the area used by the enterprise (ha)	Interval (ha)
1	up to 100.00	100
2	100.01–200.00	99.99100
3	200.01–500.00	299.99300
4	500.01–1,000.00	499.99500
5	1,000.01–2,000.00	999.991000
6	2,000.01–3,000.00	1,000
7	over 3,000.00	547,000

The value of the interval for each group in the Table 1 is calculated according to the limits of the size of the area in the group, namely:

$$I = x_{\max} - x_{\min} . \tag{1}$$

Since in the last group there is no value $x_{\max}$, the interval for a group with an area larger than 3,000 ha is calculated taking into account the fact that according to (Zemel'nyy dovidnyk Ukrayiny, 2020), the maximum size of land used by the Ukrainian agricultural enterprise "AGROPROSPERIS" is 550,000 ha.

Analysis of the intervals presented in Table 1, shows that they increase with increasing area of the land bank[1] (LB) of agricultural enterprises. However, the increase is not evenly, abrupt and irregular. The use of such uneven grouping can distort the analysis of statistical indicators of enterprises based on such grouping and lead to erroneous conclusions.

As Melnyk (2013) points out, the amount of agricultural land available to the enterprise is one of the important factors that affect the efficiency of the enterprise. This factor, as the author notes, does not directly affect the efficiency of production, but forces managers to choose certain strategies to achieve efficiency. The problems facing enterprises with similar values of the land bank are similar. Similar are the methods of their solution. That is why the purpose of the article is to develop a classification of agricultural enterprises based on the properties of the distribution of enterprises depending on the size of the land bank and to study the impact of distribution on other characteristics of agricultural enterprises.

2. Materials and methods

In scientific publications, there is no single approach to the grouping of agricultural enterprises by land size. In particular, Melnyk (2013) proposes to divide the agricultural enterprises into 4 groups: 1) small – up to 100 hectares; 2) medium – from 100.1 to 500 hectares; 3) large – from 500.1 to 3,000 hectares; 4) vary large – more than 3,000 hectares. At the same time, to analyze the distribution of farms in Ukraine by the size of agricultural land at the end of 2006 and 2011, Melnyk (2013) uses a more detailed grouping into 10 groups, shown in Table 2.

Table 2. The scheme of a grouping of agricultural enterprises by the size of the area used for the analysis of farms in (Melnyk, 2013)

Group	The size of the area used by the enterprise (ha)	Interval (ha)
1	0*	0
2	up to 5.00	5
3	5.1–10	4.9
4	10.1–20	9.9
5	10.1–50	40
6	50.1–100	49.9
7	100.1–500	399.9
8	500.1–1,000.0	499.9
9	1,000.1–3,000.0	1,999.9
10	over 3,000.0	547,000

[1]In this paper, the concept of a land bank is used in accordance with (Law and Smullen, 2008), according to which a land bank is the total amount of land owned or (and) leased by a private person or organization and used in a variety of activities.

Grouping not into 10, but into 11 groups is suggested by Ozturk (2012) and Nagelschmitz et al. (2013). The difference between the proposed groupings is related to the input data: minimum, maximum land area and grouping intervals. The minimum area of the land parcel of Ozturk (2012) classification is 0.5 ha, and the maximum is 500 ha; in the classification of (Nagelschmitz et al., 2013) the corresponding values are 2 ha and 5000 ha. A similar classification has been developed as a basis for the determination of farm topology in (FAO, 2018). The difference is also related to the initial data: the minimum size of a land parcel is 1 ha, and the maximum is 1000 ha.

There is an interesting feature of the grouping proposed by (FAO, 2018): the first group includes farms that do not have land. As a result, the number of groups in this classification is one more, i.e. equals 12. The classification proposed by Melnyk in (2013) has the same feature (see Table 1). As will be shown below, there are successful farms whose land parcels tend to be zero. All of the above grouping schemes have the same shortcomings, in particular, they are irregular and uneven.

To achieve this purpose used open databases of agricultural enterprises, presented in Zemel'nyy dovidnyk Ukrayiny (2020), Karta kurkuliv (2022) or Spravochnyk sel'khoz proyzvodyteley Ukrayny (2022). The total number of agricultural enterprises selected for the Dnipropetrovsk District was 3,273 (see Table 4). The data presented in Zemel'nyy dovidnyk Ukrayiny (2020), Karta kurkuliv (2022), or Spravochnyk sel'khoz proyzvodyteley Ukrayny (2022) are not official. They are collected based on data provided by enterprises voluntarily.

The Land Handbook of Ukraine for 2020 (Zemel'nyy dovidnyk Ukrayiny, 2020) states that there are 4,130 farms in Dnipropetrovsk District. Comparing this number of farms in the Dnipropetrovsk District with the number of farms collected for analysis in this article (2402 in Table 6), we can conclude that at least 58% of all agricultural enterprises, in the region were collected for analysis. It should be noted that in the official statistics, the group of small enterprises with up to 200 ha of land includes a fairly large number of enterprises that exist only formally, leasing their land to other enterprises. At the same time, actively functioning enterprises are voluntarily registered in databases (Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022). Data from databases (Zemel'nyy dovidnyk Ukrayiny, 2020; Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022) were collected during 2021 and are relevant until 2022. This information has been verified by the official source YouControl (2021).

3. Results

Figure 1 presents a graph of changes in the land bank of agricultural enterprises located in the Dnipropetrovsk district, information on which is selected from databases (Zemel'nyy dovidnyk Ukrayiny, 2020; Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022). Only those enterprises that are engaged in agricultural production have been elected. Enterprises engaged exclusively in the processing of agricultural products and various services were not included in the processing. The numbering and sorting of enterprises are carried out according to the size of the land bank, starting from the

first enterprise, the land bank of which is zero, and ending with the largest enterprise in the Dnipropetrovsk district with a land bank of 85,000 ha (LLC "AGROCENTER-UKRAINE") (Zemel'nyy dovidnyk Ukrayiny, 2020). Each company on the graph is indicated by a blue dot. According to the graph in Figure 1, the size of the land bank of Ukrainian enterprises is increasing exponentially. This indicates the fact that the larger the enterprise, the more opportunities it has to increase its land bank. Currently, there are no levers that could slow down the exponential growth of large agricultural enterprises. This means that in Ukraine the land banks of large enterprises will continue to grow, and, as the graph in Figure 1 shows, exponentially.

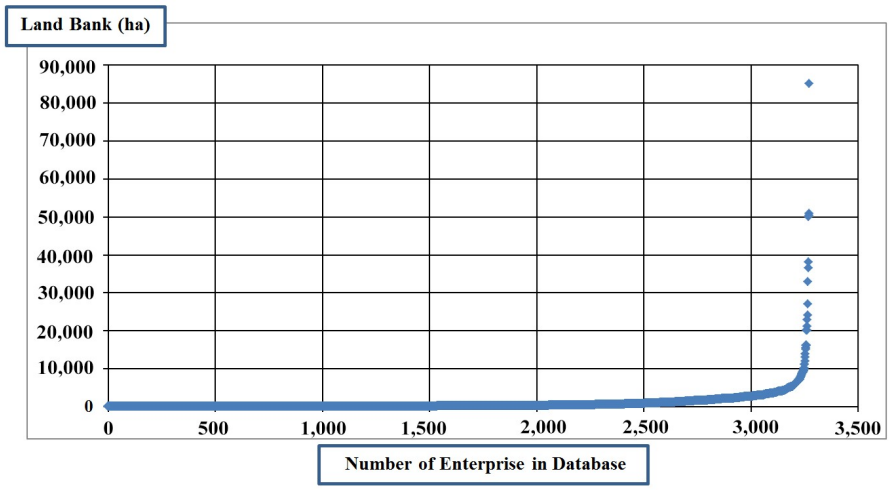

Fig. 1. Graph of change in the size of the land bank of agricultural enterprises of Dnipropetrovsk district

If we denote the value of the land bank by y, then the exponentiality of its change can be described by the equation:

$$y = a \cdot 10^{b \cdot x} - c, \tag{2}$$

where x is a variable that allows determining the number of the enterprise in the database that is used to form the graph of Figure 1, and which corresponds to the size of the land bank y; a, b are some constants that make it possible to bring the function y as close as possible to the numerical values of the land bank of each enterprise from the database.

Since there are a small number of enterprises as indicated in Karta kurkuliv, (2022), Spravochnyk sel'khoz proyzvodyteley Ukrayny (2022), the value of the land bank is equal to zero and since the logarithm of zero is equal to minus infinity, the value of c was equated to 1, namely:

$$c = 1. \tag{3}$$

Let's denote the logarithm of the value $y + c$, namely:

$$z = \log_{10}(y + c) = \log_{10}(y + 1). \tag{4}$$

Substituting equality (2) into (4) gives:

$$z = \log_{10} y = \log_{10} a + b \cdot x = A + b \cdot x, \tag{5}$$

where:

$$A = \log_{10} a. \tag{6}$$

To test the exponential growth of the land bank of agricultural enterprises, a graph of the logarithm of the change in the size of the land bank, i.e. a graph of the value of z, was constructed. This graph is shown in Figure 2. There, a dashed black line shows the magnitude of the linear trend built for z.

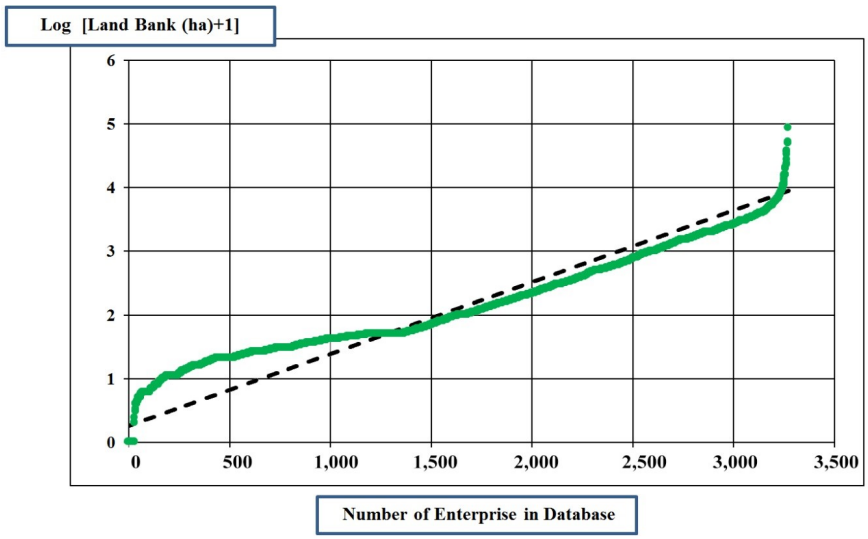

Fig. 2. Graph of changes in the logarithm of land bank in agricultural enterprises of Dnipropetrovsk District

According to Figure 2, the value z along almost the entire length of the graph coincides with the segment of the line constructed as a linear trend. This indicates that the function z is linear almost everywhere. Only at the beginning and end of the graph, the function z differs from the linear trend, which may indicate that both at the beginning and the end of the database the number of enterprises is not sufficient. The linearity of a quantity z means that the function y changes exponentially.

To form groups of agricultural enterprises, it is necessary to find the values a and b in Eq. (2), which can be determined using two different methods:

– least square method;
– based on regulatory documents taking into account the simplicity of application.

The first method allows us to tie the grouping scale as close as possible to the real data of the land bank of enterprises. For the data presented in Karta kurkuliv (2022), Spravochnyk sel'khoz proyzvodyteley Ukrayny (2022), these values were equal to:

$$A = \log_{10} a = 0.263679, \quad a = 1.835180 \approx 2 \text{ (ha)}. \tag{7}$$

The second method allows to choice of such constants a and b that the boundary values of the intervals are the simplest and take into account the classification of agricultural enterprises used in regulatory documents. In particular, according to Art. 281.2.1 (BVR, 2011), individuals who own land parcels no larger than 2 ha are exempted from paying land tax. According to Art. 291.4 (BVR, 2011), the simplified taxation system applies to agricultural producers who own or use parcels of at least 0.5 ha and no more than 20 ha. As indicated in Art. 291.5.3. (BVR, 2011), individuals – entrepreneurs who lease land plots with a total area exceeding 0.2 ha – cannot be single taxpayers. Thus, most of the boundary values of land areas used to establish various taxation rates (BVR, 2011) are multiples of 2 ha. That is why it is advisable to choose the value a, which is equal to 2.

Because, according to the numerical data presented in Eq. (7), the value a in the rounded form obtained by the method of least squares is also equal to 2, this is the most appropriate value. The simplest and most convenient value b in use is a multiple of 10, the same as shown in Eq. (7). In connection with the above, the following formulae are offered based on the grouping of agricultural enterprises:

$$b = 0.001126 \approx 0.001, \tag{8}$$

$$k_0 = 0, \qquad k_n = a \cdot 10^{n-1} \quad (n = 1, 2, \ldots). \tag{9}$$

In these formulae k_n mean the boundaries of grouping intervals. The exponential grouping scale constructed using Eq. (9) is presented in Table 3.

Table 3. Exponential scheme of a grouping of agricultural enterprises by the size of the land bank

No. of type	Type of agricultural enterprise	Landbank (LB) (ha)	Interval (ha)
1	Special (Exclusive)	$0 \le \text{LB} < 2\ 10^0 = 2$	2
2	Very small	$2 \le \text{LB} < 2\ 10^1 = 20$	18
3	Small	$20 \le \text{LB} < 2\ 10^2 = 200$	180
4	Medium	$200 \le \text{LB} < 2\ 10^3 = 2{,}000$	1,800
5	Large	$2{,}000 \le \text{LB} < 2\ 10^4 = 20{,}000$	18,000
6	Very large	$20{,}000 \le \text{LB} < 2\ 10^5 = 200{,}000$	180,000

According to Table 3, the first group of enterprises, as well as in the grouping proposed by Melnyk (2013), containing enterprises either have a land bank equal to zero, or their size is less than 2 ha. Such enterprises called small (Melnyk, 2013). However, these enterprises cannot be called small, they confirm the judgment of Melnyk (2013) that the amount of land available to the company is not always a measure of its success. That is why these companies are called special or exclusive. They have found their special niche in the country's economy and are running successful businesses. An example of such enterprises is the "Zdravlyk" farm, which grows Mediterranean snails, and PRAT "BDZHOLOAHROSERVIS" which is engaged not only in breeding and selling bee colonies, but also in the production of equipment, clothing, equipment for apiaries and the sale of veterinary drugs for the treatment of bees (Karta kurkuliv, 2022).

With the help of the proposed exponential grouping, the distribution of the number of agricultural enterprises by type depending on the land bank in the districts of Dnipropetrovsk district was performed. This distribution is presented in Table 4 and is clearly shown using the map diagram in Figure 3.

Table 4. Distribution of the number of agricultural enterprises by type depending on the land bank in the districts of the Dnipropetrovsk district, according to (Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022)

District	Number of enterprises by type						District total
	Exclusive	Very small	Small	Medium	Large	Very large	
Dnipro	9	77	225	160	66	5	542
Kamianske	3	80	272	150	48	0	553
Kryvyi Rih	4	123	204	176	52	0	559
Nikopol	4	42	79	85	51	0	261
Novomoskovsk	4	66	271	94	31	4	470
Pavlohrad	4	24	103	74	41	1	247
Synelnykove	6	69	301	186	76	3	641
Amount	34	481	1,455	925	365	13	3,273
%	1.0	14.7	44.5	28.3	11.1	0.4	100

Figure 3 shows a double map diagram, the upper part of which shows the distribution of the number of enterprises by types of exponential grouping, the lower – the sum of the areas of these enterprises within each type. Data from Table 4, Table 5 and Figure 3 allow us to conclude: even though the number of medium and small enterprises, in general, is greater than the number of large ones, the total area of the land bank of the latter is much

Table 5. Distribution of areas of agricultural enterprises by type in the districts of Dnipropetrovsk district, according to (Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022)

District	The total area of land banks of enterprises by type (ha)						District total
	Exclusive	Very small	Small	Medium	Large	Very large	
Dnipro	2.8	1,011.8	13,957.9	133,757.9	299,525.9	230,260.0	678,516.3
Kamianske	1.3	941.3	17,885.5	112,472.1	167,139.2	0.0	298,439.3
Kryvyi Rih	2.3	1,671.8	15,640.8	146,147.4	174,696.1	0.0	338,158.4
Nikopol	0.4	425.1	5,511.0	70,914.2	260,078.1	0.0	336,928.7
Novomoskovsk	0.4	797.3	16,570.5	68,606.6	120,308.4	89,792.0	296,075.2
Pavlohrad	0.4	236.7	7,515.0	60,690.4	165,172.4	38,008.0	271,622.9
Synelnykove	2.8	881.7	20,257.3	154,133.6	305,995.5	120,127.0	601,397.9
Amount	10.4	5,965.7	97,337.9	746,722.3	1,492,915.5	478,187.0	2,821,138.7
%	0.0004	0.2	3.4	26.5	52.9	17.0	100

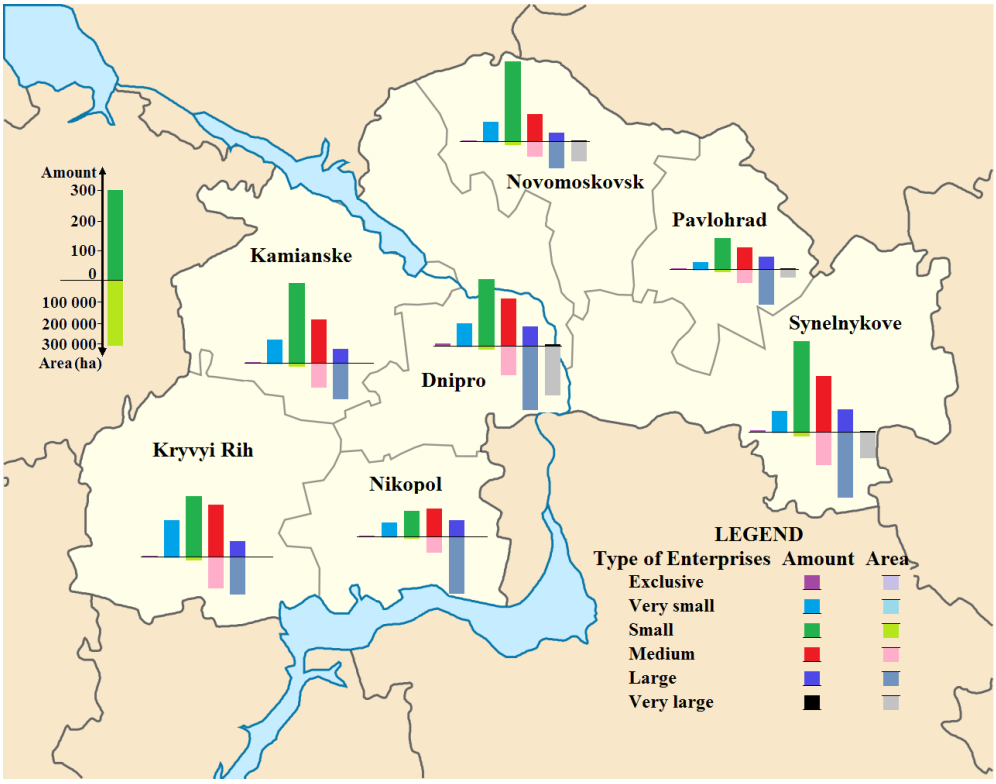

Fig. 3. Map diagrams of the number of agricultural enterprises (upper diagram) and the sum of their areas (lower diagram), formed by exponential grouping depending on the land bank, in the districts of Dnipropetrovsk district

larger than the area of the land bank of medium and small enterprises. This indicates the phenomenon of consolidation of enterprises and the gradual displacement of small and medium enterprises by large and very large ones. This indicates the phenomenon of consolidation of enterprises, and the gradual displacement of small and medium enterprises by large and very large ones, which is studied in detail in Deininger and Byerlee (2012).

According to the data in Table 4 and Table 5, the group of exclusive enterprises of the Dnepropetrovsk Region, i.e. enterprises with a land bank of less than 2 ha, makes up 1% of the total number of enterprises and owns 0.0004% of the land, which indicates a significant difference in the distribution of the land bank by plot size, which has placed in the world. As indicated in Lowder et al. (2016), farms of less than 2 ha own 12% of all arable land in the world.

For further analysis of various characteristics of enterprises, the article used not absolute but relative values calculated using the formula:

$$X_i = \frac{x_i}{\sum x_i} \cdot 100\%, \tag{10}$$

where x_i is the number of enterprises in the i-th group, which have the selected characteristics, Σx_i is the total number of enterprises in the group, X_i is the percentage of the number of enterprises that have the selected characteristics concerning the total number of enterprises in the group.

As mentioned above, only those enterprises engaged in agricultural production were selected for analysis. The following types of production were analyzed: crop production and animal husbandry.

Figure 4 presents histograms of the distribution of enterprises by groups of the proposed classification, which are engaged exclusively in crop production (Fig. 4a), exclusively in animal husbandry (Fig. 4c), and those engaged in both crop production and animal husbandry (Fig. 4b). Numbers on the abscissa of Figure 4 correspond to the numbers of enterprise group types defined using exponential grouping (see Table 3).

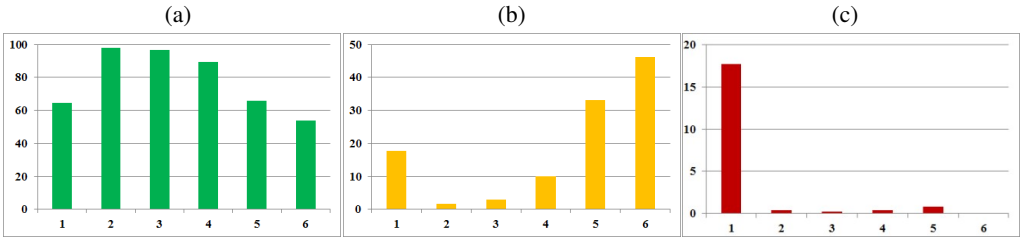

Fig. 4. Histograms of the distribution of agricultural enterprises by types of exponential grouping, engaged in: (a) crop production, (b) crop production and animal husbandry, (c) animal husbandry

According to the data shown in Figure 4, almost 100% of small and very small enterprises are engaged in plant production (Fig. 4a), i.e. those that have from 2 to 200 ha of the land bank. The number of enterprises engaged in the cultivation of both plant and animal products, according to Figure 4b, increases with the landbank increasing. The largest number of such enterprises (46%) are grouped in a group of very large enterprises, which have at least 20,000 ha of land. The exception is the group of exclusive enterprises (18%), in which there is no connection between the size of the land bank and the number of enterprises engaged in the simultaneous cultivation of both animal and plant products. A similar situation occurs for a group of enterprises engaged exclusively in the cultivation of animal products. It should be noted that such enterprises engaged only in animal husbandry do not exceed 1% of the total number of enterprises. The peculiarity of this group is that the largest number is grouped among exclusive enterprises (18%). As well as for the mixed enterprises the increase in quantity with the land bank increase is shown. However, among very large enterprises with a land bank of more than 20,000 ha, enterprises engaged only in animal husbandry are completely absent.

The forms of management of agricultural enterprises are quite diverse. According to Derzhstat Ukrayiny (2021), there are 88 different forms of management of enterprises in Ukraine. The number of enterprises of each form of management located in the Dnepropetrovsk district is presented in Table 6. The symbol "*" in Table 6 indicates the forms of management that still exist, but the current legislation does not provide for

the creation and state registration of new enterprises with such organizational and legal forms (DK, 2004).

Table 6. The number of agricultural enterprises in the Dnipropetrovsk district of each form of management according to the data (Karta kurkuliv, 2022; Spravochnyk sel'khoz proyzvodyteley Ukrayny, 2022)

Form of management	Code according to (DK, 2004)	Number of enterprises	% of the total number	Area (ha)
Farm	110	2,402	73.4	810,949
Private enterprise	120	196	6.0	311,802
Collective enterprise*	130	3	0.1	5,035
State Enterprise	140	25	0.8	38,277
Municipal Enterprise	150	5	0.2	330
A subsidiary company	160	9	0.2	39,238
Individual enterprise*	191	2	0.1	115
Private joint stock company	230	9	0.2	67144
Open Joint Stock Company*	231	3	0.1	5,945
Limited Liability Company	240	596	18.2	1,524,536
General partnership	260	3	0.1	1,387
Consumer partnership	331	1	0.0	453
Agricultural production cooperative	340	17	0.5	15,088
Individual Entrepreneur	910	2	0.1	840
Amount		3,273	100	2,821,139

As can be seen from Table 6, the most common form of management, 73%, is the farm. In second place in terms of prevalence, 18%, is a limited liability company, and in third place, 6% is a private enterprise. Despite the variety of forms of management, most agricultural enterprises in Dnipropetrovsk Region have a private form of ownership. State and municipal enterprises together make up 1% of the total number of enterprises.

From Table 6, the most common form of management (73%) is the farm. In second place in terms of prevalence (18%) is a limited liability company, and in third place (6%) is a private enterprise. Despite the variety of forms of management, most agricultural enterprises in the Dnipropetrovsk district have a private form of ownership. State and municipal enterprises together make up 1% of the total number of enterprises.

The distribution of farms and limited liability companies by type of exponential grouping of enterprise depending on the size of the land bank is not arbitrary. The analysis of the distribution showed that with the decrease of the land bank the number of farms increases and the number of companies of different types (Private joint stock company, Open Joint Stock Company, Limited Liability Company), decreases. This is clearly shown by the diagrams in Figure 5.

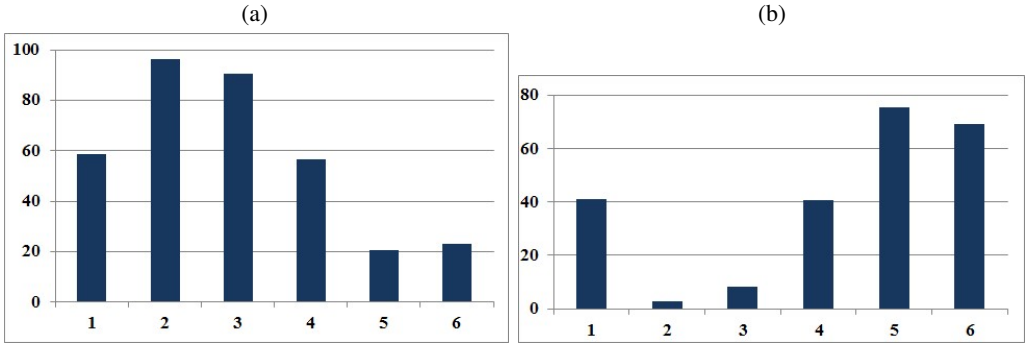

Fig. 5. Histograms of the distribution of agricultural enterprises by types of exponential grouping, which have forms of management: (a) farm, (b) company (Private joint stock company, Open Joint Stock Company, Limited Liability Company)

4. Discussion and interpretation of the results obtained

According to histograms presented in Figure 5, the smaller the size of the land bank of an agricultural enterprise, the more likely it is that its form of management is farming. In particular, among large enterprises with a land bank of 2,000 to 20,000 ha, only 21% of farms. Among medium-sized enterprises with a land bank from 200 to 2,000 ha, 57% already farms. Among small enterprises with a land bank of 20 to 200 ha, the share of farms reaches 90%. In the group of very small, with a land bank from 2 to 20 ha, farms are 96%.

The opposite situation is true for forms of management: companies. The group of large enterprises has the largest number, 75%. As the size of the land bank decreases, the number of enterprises with these forms decreases. For example, in the group of medium-sized enterprises, there are 41%, in the group of small enterprises – 8%, in the group of very small enterprises – 3% of enterprises with the form of management – company.

The group of exclusive enterprises demonstrates its peculiarity in this case as well. In particular, there are 59% of farms in this group, 37% less than in the group of very small enterprises, on the contrary, there are 41% of the companies, 14 times more than in the group of very small enterprises. The dependence of the form of management as a farm on the size of the land bank allows us to conclude that this form of management is more flexible and more suitable for medium and small enterprises.

5. Conclusions

The proposed exponential scheme of a grouping of agricultural enterprises is regular and logarithmically uniform. It fully reflects the exponential increase in the land bank of agricultural enterprises. Its parameters are chosen in such a way as to take into account the classification of farms used in the Tax Code of Ukraine. Histograms of the distribution of such characteristics of enterprises as types of production and forms of management,

constructed with the help of exponential grouping, allowed us to conclude that the above characteristics depend on the size of the land bank.

Author contributions

Conceptualization: E.N.; methodology development: A.P.; writing – original draft: D.B.; writing – review and editing: M.H., V.R.

Data availability statement

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an ongoing study.

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The manuscript does not have external founds.

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