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Land Concentration and the Optimal Size of Agricultural Enterprises in the Polissia Zone of Ukraine

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Abstract

Determining the optimal size of farms has been one of the most enduring practical issues and theoretical concerns in agricultural economics over the past one hundred and fifty years. (Bielik & Rajcaniva, 2004; The problem lies in this. While increasing size and resulting economies of scale will initially lead to higher marginal returns and lower marginal costs, owing to more effective use of the factors of production, the point is eventually reached where the opposite effect—lower marginal returns and higher marginal costs—takes hold. Finding the optimal size of enterprises thus remains a pressing practical and theoretical concern. Recent processes of land consolidation in Polissia, one of Ukraine's natural climatic zones and a major centre of agricultural production, provide an opportunity to develop new insights into this long standing practical and theoretical concern. Utilizing data from the Ukrainian State Department of Statistics on different groups of agricultural enterprises, this paper explored the dynamics of land use change in Polissia from 2007 to 2012. It is evident that a strong tendency towards concentration of land took place. The optimal size for agricultural enterprises was then determined, taking into account specialization of production by enterprises. For purposes of analysis, all the enterprises in the study area were divided into three groups, based on the relative density of the plant growing branches in the commodity output structure. A complex indicator of the efficiency of use of farmlands, combining both monetary and natural indicators of efficiency of use of farmlands, is put forward. Nonlinear functions are used to determine the optical size for each type of agricultural enterprise in the Polissia zone, depending on its specialization. The analysis shows that the optimal size for agricultural enterprises devoted solely to crop production is 3732 hectares, the optimal size for those having some livestock production (up to 40 per cent) is 5336 hectares, and the optimal size for those devoted more than 40 per cent to livestock production is 5392 hectares.

Keywords: optimization, optimization criteria, specialisation, concentration, agricultural enterprises, efficiency, full assessment

Introduction

The challenge of determining the optimal size of agricultural enterprises has had a considerable history. Initially, the issue arose in the observed advantages that large commodity producers have over small producers. One of the first to make this observation was the French philosopher Charles Fourier and his disciple Victor Considerant. M.Tuhan-Baranovskyi, a Russian-Ukrainian economist who studied the artistic legacy of the French scientists, noted that the main tendency of society's development lay in an all-embracing takeover of small manufacturing establishments by large ones. In his opinion, the main credit for the development of a theory of production concentration should go to Considerant, in whose book *Destinee Sociale*, it was developed in the most complete form. (Tuhan-Baranovskyi, 1906, 81) The question of the optimal size of agricultural production units was taken up by Tuhan-Baranovskiy. He observed that "in agriculture...large manufacture, against the small, is not so favourable." (1994, 2, 183), but went on to specify that: in agriculture, large economy...has considerable benefits.

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For example, big structures come rather more cheaply than small ones; large agricultural production can better use machines and the labour of working cattle; spend less lands for rads and pass ways; can invite more skilled and scientifically-prepared people for business management, etc. (1994, 183) Tuhan-Baranovskiy identified the main drawback of large agricultural enterprises as the need to attract and pay labourers, who require adequate supervision, with the result that human resource costs rise in relation to stock, cattle, and land. He identified transportation expenses as a deterrent to greater consolidation of agricultural production. The Russian economist Olexandr.V. Chaianov was one of the first to approach the complex issue of the optimal size of agricultural enterprises. (1923) He generated theoretical and methodological principles concerning the advantages of large scale agricultural production over small scale, and offered his own approach to defining the optimal size of agricultural enterprises. "We should," he observed, "undoubtedly recognize that under equal conditions, large economy will always have considerable advantage over a small-scale enterprise: it is one of organic laws of economy and it would be ridiculous to object to it." (1923, p.6.). He did concede that, comparing the rates of productive efficiency achieved by consolidation of other industries versus agriculture, "in agriculture the quantitative expression of advantages of large economy over a small-scale enterprise is not so considerable." (1923, p. 7) Chaianov was led to conclude that "in the process of increase in sizes of agricultural economy concerning all manufacturing elements, the cost price curve will fall down but its falling will be, firstly, insignificant compared to a similar falling off in manufacturing industry, and, secondly, its speed will decrease in parallel integration." (1923, p. 9) He formulated the problem of optimizing the sizes of agricultural enterprises as the need to find "such sizes of the area of operation at which, under other equal conditions, the cost price of received products will be the least." (1923, p. 18) This formulation shows that Chaianov considered the area of land as the main indicator of size. He ultimately concluded that the optimal sizes in terms of land area were 2,000 hectares for land rotation, 800 hectares for an extensive three-course rotation system, 500 hectares for an intensive three-course rotation system, and 200 hectares for crop rotation. (1923, p. 18)

Another push in the direction of economic science concerning the optimal size of agricultural enterprises came in the works of Alfred D. Chandler, Jr., an American specialist in business history. Taking enterprises from different areas of the economy, he sought in an integrated way to generalize about their experience and activities on the basis of size. He was able on that basis to generate a strategic vision about their level of success in the market under conditions of constantly increasing competition. In particular, Chandler asserted that successful large enterprises were simply those that were ready to carry out on a large scale "three interconnected groups of capital investments: in manufacture, marketing network and management." (1990, p. 35). The central problem for any enterprise is thus traffic of goods on a large scale. Chandler connected the effects of scale and the sizes of enterprises, arguing that "economy in manufacturing scale depends simultaneously on sizes - its capacities, and the speed or intensity with which these capacities are used." (1990, p. 24). The optimal size of agricultural enterprises is a related, but separate, economic problem. The Ukrainian economist V.Y Mesel-Veseliak noted in this regard that the agriculture enterprises have to "provide optimum volumes of output production for the achievement of high efficiency of areas, a reasonable use of the labour force and basic production assets, a decrease in the cost of production, and, an increase in the productivity of work." (1990, p. 227) In fact, it is a question of making sure that all criteria of production efficiency are in place. He defined optimality as "such an economy which provides the best organizational conditions for the use of land, material and labour force, which promotes the maximum volume of production from unit of activity at minimum expense of work and means." [1990, p. 37]. The optimal size of enterprises is, therefore, that which ensures the maximum efficiency.

The concentration of agricultural enterprises is evidenced in many countries of the world. As Demyanenko and Von Creman-Taubadel have concluded , "in the industrialised countries of Europe and North America, the trend towards larger farm structures and consolidation is clear." (2002: 2) The evidence from the United States and Canada, two of the most significant players in the global agricultural marketplace, deserves note. V. Ambrosov and T. Marenych have noted the constant increase in the number of large farms in the United States, to the point where (2006:7) 157,000 of these enterprises, some 8 per cent of the total number of farms, accounted for seventy per cent of agricultural production and almost 80 per cent of total profits. The same pattern is true for Canada. According to the Global Network, (8) the number of large farms has steadily increased over the last seventy years. In 1941, for example, there were 732,832 farms and the average size was 96 hectares. By 2011, the number of farms had shrunk to 205, 730 and the average size had increased more than 3 times to 315 hectares.

This analysis is concerned with Ukraine, which has historically enjoyed a strong reputation for grain production, ranking first in Europe and fourth globally behind the United States, China, and Canada in 1970. It has only recently in 1991 emerged from the Soviet system of state and collective farms, and allowed private ownership of agricultural enterprises. The first research question is whether Ukraine has in recent years displayed any of the tendencies towards concentration of agricultural enterprises noted in countries such as the United States and Canada, , and if so, what have been the economic dynamics driving developments in this direction. The focus is on the Polissia zone.

1. Tendencies towards Land Concentration among Agricultural Enterprises of the Polissia zone of Ukraine

Polissia, a mixed forest zone, is one of the three natural agro-ecological zones in Ukraine. Accounting for 19 per cent of Ukraine's land area, it is a marshy flatland area lining the Pripyat River in Southern Belarus, Northern Ukraine (in the Volyn, Rivne, Zhytomyr, Kyiv, and Chernihiv oblasts), and partly in Poland and Russia. This study is concerned with enterprises in northwestern Ukraine, in the Ivano-Frankivsk, Zhytomyr, Volyn, Lviv, Kyiv, Chernihiv, Rivne, Khmelnytskyi, Ternopil and Sumy regions. Data on concentration were collected for the years, 2007, 2009, and 2012 from the Ukrainian State Department of Statistics for all agricultural enterprises located in the Polissia region. Table 1 presents statistics on changes in the size of agricultural enterprises in Polissia for the years 2007, 2009, and 2012.

Table 1: The Distribution of Agricultural Enterprises in Polissia, Ukraine, by Land area, for the Years 2007, 2009, and 2012

Groups of enterprises according to the area (ha)	2007		2009		2012		Deviation—2012 from 2007 (+, -)	
	Number of enterprises (%)	Area of agricultural lands (%)	Number of enterprises (%)	Area of agricultural lands (%)	Number of enterprises (%)	Area of agricultural lands (%)	Number of enterprises (%)	Area of agricultural lands (%)
< 50	2.3	.1	5.5	0.1	5.9	0.1	3.6	0.0
51-100	.5	0.0	4.3	0.3	3.7	0.2	3.2	+0.2
101-500	26.4	8.9	31.1	9.4	27.3	6.6	0.9	-2.3
501-1,000	32.7	23.4	24.0	17.8	22.1	12.4	-10.5	-10.9
1,001-2,000	27.8	38.7	21.9	30.4	21.0	22.7	-6.7	-16.0
2,001-3,000	7.2	17.2	6.1	15.1	8.1	15.6	0.9	-1.6
3,001-4,000	1.5	5.4	2.0	7.0	2.2	5.8	0.7	+0.4
4,001-5000	0.3	1.3	1.1	5.0	2.4	8.6	2.1	+ 7.2
> 5001	0.3	4.9	1.2	14.9	4.1	27.9	3.8	+23.0
Enterprises without arable lands	1.1	0.0	2.8	0.0	3.1	0.0	2.1	0.0
Enterprises with arable lands	98.9	100.0	97.2	100.0	96.9	100.0	0.0	0.0

As can be seen, overall between the 2007 to 2012, the number of enterprises in the 5 groups increased in total by 13.4 per cent (3.6 +3.2 +0.7 +2.1+ 3.8 =13.4 %). The 5 groups where the total increase of 13.4 per cent took place are: enterprises with the area less than 50 hectares (by 3.6 %), 51 to 100 hectares (by 3.2%), 3001-4000 hectares (by 0.7%), 4001-5000 (by 2.1%), and more than 5000 hectares (by 3.8%). A number of points should be noted in terms of land concentration. First of all, though a number of groups showed an increase in their numbers, the density of enterprises grew most in the largest categories. Between 2007 and 2012, in the area of agricultural lands (see the last column of the table 1) there was a small increase in the number of small enterprises with less than 50 hectares—an increase of .01 per cent—and also those with 51 to 100 hectares—an increase of .2 per cent, but more notable growth for enterprises with 3,001—4,000 hectares—an increase of .4%, and enterprises with 4,001—5,000 hectares—an increase of 7.2 per cent. The largest growth in the area of agricultural lands – by 23.2% - was in the 5,001 hectares and more categories. The number of large enterprises (5001hectares and more) accounted for only .3 per cent of total farms in 2007, but 4.1 per cent in 2012, and their land holdings increased to 27.9 per cent (see the third last column) of the total in 2012, up from only 4.9 per cent in 2007. The concentration of agricultural lands in the largest enterprises took place mainly at the expense of enterprises with land holdings from 501 to 2,001 hectares. Taken together, farms with holdings of 501-1,000 hectares, and farms with holdings of 1,001-2,000 hectares accounted for 60.4 per cent of enterprises, and 62.1 of land holdings in Polissia in 2007, but only 43.2 per cent of enterprises and 35.2 per cent of agricultural lands in 2012. The growth in the number of agricultural enterprises with land holdings of 101—500 hectares is interesting. Their share of the total number of enterprises increased .9 per cent in the study period, but their share of land holdings decreased by 2.3 per cent, which indicates a reduction in their size overall. To sum up, the Polissia zone in Ukraine has intensive agricultural activities, living up to Ukraine's historic reputation. In the five years from 2007 to 2012, the number of agricultural enterprises grew overall.

A small portion of that growth occurred in small farms, but the most notable development is the same pattern of concentration in agricultural enterprises as measured by land holdings that has happened in other jurisdictions such as the United States and Canada over a long period of time. Farms are clearly getting larger, and doing so largely at the expense of middle size enterprises. Summary statistics leave unanswered, however, theoretical important questions relating to the dynamics behind concentration in the Polissia zone. Has the trend towards concentration been, as theory would suggest, a move towards the optimal size of agricultural lands, or have other factors been at work? If the latter, which? The remainder of the analysis seeks to answer these questions by linking land concentration in Polissia to specialization. That is to say, trends in Polissia between 2007 and 2012 may help define a thus far elusive optimal size of land holdings for specialization in any area of agricultural production. Therefore, there is a question: to what extent are these tendencies due to the movement to optimum size value of agricultural lands, and in what measure are they caused by other factors? The answer to this question from our point of view should be connected with the account of specialisation of the enterprises. The question here is not about detailed analysis of enterprises from the point of view of the structure of manufacturing production, but about their classification based on the enterprises' specialization in crop or livestock production.

2. Determining the Optimal Sizes of Agricultural Enterprises in Ukraine's Polissia Zone

For purpose of analysis of the link between specialization and concentration of agricultural enterprises in Ukraine's Polissia zone, all such enterprises were divided into three groups, as follows:

1. Enterprises which specialise exclusively in plant growing production;
2. Enterprises which specialize in plant growing production, but also engage to a lesser extent (less than 40 per cent) in animal industry production.
3. Enterprises in which commodity outputs of animal industry is considerable (more than 40 per cent).

Integrated poultry farms and vegetable factories were excluded from analysis as they have special organizational structures more typical of industrial production than of agricultural production. Also, enterprises which had no agricultural lands and those for which there were no data on commodity (plant or animal) production were excluded. This methodology will give us an opportunity to optimize the size of the agricultural enterprise based on the structure of agricultural production. It is also important to establish a firm conceptual foundation around the notion of criteria of optimisation of the sizes of agricultural enterprises. The most logical of these in a market economy would be the amount of profit achieved from a given unit of land area. However, in reality it is only one of the criteria that go into displaying the final financial result. There are also a number of restrictions on its practical use. In the beginning of the growing season, for example, it is very difficult for farmers to define the exact amount of profit they expect because they have rather low ability to forecast the price that they will receive for their outputs during the peak of the harvest season. The price in turn depends to a great extent on the quantity of production of various kinds, and also the influence of the balance of supply and demand in world markets. Thus, in 2010, near drought conditions resulted in high prices and favourable profits, whereas in 2011, more normal conditions resulted in large crops, especially grain crops, which in turn resulted in low prices and profits.

Another approach is to concentrate on inputs at the beginning of the crop production cycle. This would require that farmers specify all of the technological parameters that would apply for a given level of intensity in growing crops. Estimates could then be made of the quantity of production of various crops that could be expected under normal conditions. The volume of production, or commodity output size, could in this way be added to profit as a criterion in determining the optimal size of agricultural enterprises. Finally, it is important to focus on the most important kinds of crops cultivated in the Polissia zone. These include corn grain, winter wheat, sunflower, winter rape, soya, and rye. The kinds of crops mentioned above accounted for some 55.4 % of all crops in 2012, more than half of the cultivated lands. Their simultaneous account becomes possible if to change absolute values in relative indexes. These indexes are calculated by dividing productivity on a particular enterprise on average land productivity in the Polissya zone. The next step is calculation of the average value proportionally to value of any particular culture in the structure of cultivated lands under crops.

Taken together, these considerations lead us to three indicators as criteria for determining the optimality of the sizes of agricultural enterprises in the Polissia zone. They can be operationalized as follows:

1. The level of profit realised from production on 100 hectares of agricultural land
2. The amount of commodity production from 100 hectares of agricultural land
3. The average value of the productivity index of the selected main agricultural crops.

Their simultaneous real use can take place through the calculation of a complex indicator of the efficiency of use of agricultural lands. It is necessary to note separately that the problem of the full assessment of any economic phenomenon is a quite difficult methodical problem which is solved in several stages.

First, the indicator of the regional/territorial development is defined compared with the best values in other regions according to the formula:

$$R_j = \sum_{i=1}^{n} \frac{x_{\max} - x_{ij}}{x_{\max} - x_{\min}} + \sum_{i=1}^{n} \frac{x_{ij} - x_{\min}}{x_{\max} - x_{\min}}, \quad (1)$$

Where R_j is a sum of ratings of a certain region according to each of the indicators;

X_{ij} - value of i^{th} indicator of j^{th} region (i = from 1 to n);
X_{max}, X_{min} - maximum and minimum values of indicators.

The first part of the formula is used for the assessment of indicators, the growth of which has positive value, the second part for the assessment of indicators, the growth of which has negative effect.

At the second stage, the arithmetic average of the sums of the rating of certain regions is defined according to the formula:

$$R_{cp} = \frac{R_j}{n}, \quad (2)$$

Where: R_{cp} - arithmetic average of the sums of rating of a certain region according to each of the indicators; n - quantity of indicators according to which the calculation was carried out. By results of calculation, the place of each region in the general rating is defined. The region whose arithmetic average of ratings has the lowest value is the best. In our particular case the situation is simpler, since only three indicators are used. Nonetheless, methodological issues remain concerning the connection among them. To address them, the following technique was used. First, the rationing of indicators occurs. This is necessary due to the fact that selected indicators are measured in identical units; their average value essentially differs considerably. Thus, a simple definition of the average from two values can give essential prevalence of the influence of the bigger of the indicators. For purpose of the solution of the specified problem, a standardization of indicators is also carried out. The formula for its calculation is the following:

$$X_i = \frac{x_i}{\bar{x}}, \quad (3)$$

where: X_i - standardised value;

x_i - value of the i^{th} indicator in the given set;

$\bar{x}$ - average value of the indicator collectively.

Proceeding from the formula of calculation, X_i can have three variants of values:

1) $X_i > 1$;
2) $X_i = 1$;
3) $X_i < 1$.

The first of these will testify that the value of the indicator exceeds the average collectively, the second equals average, and the third is smaller than the average. Thus, proceeding from the economic content of both selected indicators we will have a situation, when the bigger the value of the standardised indicator the better.

At the second stage, a complex indicator of efficiency of use of farmlands is calculated according to the formula:

$$R = \frac{\sum \beta \times X_i}{n} \quad (4)$$

Where: R - complex indicator of the efficiency of use of farmlands;
X_i - standardised value of the i-indicator;
n - average value of the indicators collectively.
β_i - weight of the i^{th} indicator.

The last indicator represents itself as criterion of importance of a certain one from two selected values of efficiency of land use. The overwhelming majority of economists suggest defining this indicator based on expert judgement and methodology. However, such a methodology is based essentially on subjective factors and cannot be regarded as objective approach. Therefore, it was decided to use the value of the variability indicator. The higher level of the fluctuations of indicators collectively, the higher its influence on the complex indicator of efficiency of use of farmlands. In order to consider this indicator, the following formula for factor definition β_i is offered:

$$\beta_i = \frac{\sigma_{\min}}{\sigma_{\max}} \quad (5)$$

Where: β_i - weight of i^{th} indicator in full assessment of efficiency of use of farmlands;

$\sigma_{\min}$, $\sigma_{\max}$ - standard deviation of the 1st and 2nd indicator.

In this case, in the numerator there should be a value of standard deviation which is smaller of the two. The received value of weight factor will reduce the influence of the indicator with the higher standard deviation. As for the weight factor of the second indicator, it will equal 1.

3. Results—the Optimisation of the Sizes of Agricultural Enterprises of Different Specialisation in Ukraine's Polissia Zone

With the methodology established, we can proceed to consideration of received results. Functions of dependence between the area of agricultural lands and the size of the complex indicator of efficiency of use of farmlands are stated. This dependence was described by function in the form of a parabola of the second order. This parabola always has at least one maximum or minimum. A parabola of the third order can have values of both maximum and minimum. As it is well-known, to define a function optimum it is necessary to take its derivative. If, as a result of further decision, the received value has positive value, it is a sign of a maximum of function, and at negative value - a minimum. The functions and their optimum values are given in Table 2. The data give the grounds to conclude that the optimal size of agricultural enterprises in Ukraine's Polissia zone varies according to specialization of products. For enterprises which specialised in growing crops, the optimum size is shown by optimality indicators to be 3732 hectares.

Table 2. Optimum Values of Function of Dependence between the area and value of Complex Indicator of Efficiency of use of Farmlands in Polissia Zones in 2012

Groups of enterprises	Function	Value of maximum
Relative density of commodity output of animal industry 0%o	y=0,2397+0,000048636*x-0,000000006516*x^2	3732
Relative density of commodity output of animal industry from 0 to 40%	y=0,3353+0,000088925*x-0,0000000033081*x^2	5336
Relative density of commodity output of animal industry more than 40%	y=0,1119+0,0001*x-9,2733E-9*x^2	5392

At the same time, for enterprises which devoted up to 40 per cent of their land area to animal husbandry, the optimal size is shown to be 5336 hectares. Finally, for enterprises which devoted more than 40 per cent of their land to animal husbandry, the optimal size almost equalled to the previous group, at 5392 hectares. Certainly these values averaged also consider only the general situation without certain features of each enterprise. At the same time, they give an opportunity to define reference points in concentration of manufacture proceeding from general situation. For example, in 2012, the average size of the agricultural enterprise in the Polissya zone was 2243 hectares. Based on the earlier determined optimal size of the enterprise, we may conclude that for different types of agricultural enterprises the process of land concentration has a natural character and is based on economic factors. However, in Ukraine the creation of so called agro holdings which may control thousands or hundreds of thousands of hectares of agricultural land will have an impact on the optimal size of the enterprise. The move to establish such types of enterprises may not be economically effective based on the optimal size of the enterprise we determined in this study. This factor should be taken to consideration by government authorities when developing regional development policies and programs for the Polissia region and elsewhere. This issue requires and merits further detailed study.

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