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COST EFFICIENCY IN THE PRODUCTION OF CROP PRODUCTS AS A FACTOR OF FORMATION OF COMPETITIVENESS IN INTERNATIONAL MARKETS

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Abstract

It was established that there is a close relationship between the level of costs and the yield of crops. At the same time, there is a manifestation of the law of diminishing returns, which leads to a drop in the level of profitability and profitability of production with an increase in the level of costs. The construction of the dependence of the paired regression of productivity-costs-profit, productivity-costs-level of profitability was carried out. The value of the coordinates of the point of intersection of the dependence of the profit and costs on the productivity of wheat, corn for grain, and sunflower was determined. The economic meaning of the obtained coordinates will be that with a given increase in X (yield), the amount of profit per 1 ha of the sown area will exceed costs per unit of land area following the established dependencies. It is proposed to determine the economic efficiency index of crop production intensity. The calculation of this index made it possible to establish that it was on average 4.506 for sunflower, 2.500 for wheat, and 2.102 for corn. For the first time, the influence of the index of economic efficiency of the intensification of the production of individual crop on the level of their profitability was evaluated. It was established that this rela was non-linear for wheat and sunflower, and linear for grain corn. The practical significance of the obtained results is that the optimal values of the index of economic efficiency and production intensification were determined for sunflower and wheat.

Key words: *costs, economic efficiency, the law of diminishing returns, profitability, production intensity*.

INTRODUCTION

Ukraine is among the most important cereals producing countries in the world coming on the 9th position after China, USA, India, Russia, Brazil, Indonesia, Argentina, and France. By crop, at the global level, Ukraine is ranked 9th for wheat production, the 6th for maize and the 4th for barley [26].

In 2021, the export of grain crops exceeded 50 million tons. This level makes it possible to provide food for almost 400 million people in the world [27]. However, the Russian invasion of Ukraine almost stopped these exports, which could increase hunger in the world. This also applies to its position in the world markets of agricultural products. Therefore, the question arises: what are the potential opportunities for Ukrainian producers in terms of the level of efficiency and intensity of production of the main agricultural crops. This problem is also very closely related to international competition and features of state support for agriculture in different countries of the world. The fact is that agricultural products on the world market, which are exported from many countries, contain a subsidy component. In Ukraine, the level of subsidies in 2020–2021 was actually symbolic. This fact must be taken into account

when evaluating the cost effectiveness. As a working hypothesis, the assumption was put forward that the effect of the law of diminishing returns leads to a drop in the level of production efficiency and an increase in the cost of production. Based on the fact that competitiveness is considered by us as the ability of the enterprise to produce competitive products of appropriate quality and price under the conditions of maintaining profitability at a level that ensures expanded production and financial stability. It is the effect of the law of diminishing returns that ultimately leads to a deterioration in the level of competitiveness of agricultural producers. Only the presence of an economic mechanism that allows enterprises to receive an appropriate level of profit and the ability to effectively make investments can create a real basis for increasing the production of agricultural products and their export.

The problem of the formation and effectiveness of costs, and the value of goods is one of the central ones since the birth of economic science. At the same time, many questions remain today that require further research both from the point of view of theory and practice. This problem contains various components that determine the process of cost formation, which, in turn, makes it possible to conduct a wide variety of research. Let's dwell only on certain points that characterize the whole variety of cost efficiency problems.

It is emphasized that the joint use of the latest technologies by farmers in Ethiopia makes it possible to minimize the production costs while simultaneously eliminating the adverse effects of soil degradation and climate variability [15]. The influence of production concentration on cost efficiency is also confirmed in the studies of Pokharel and Featherstone [18]. They concluded that scaling up and diversifying production can reduce costs for agricultural cooperatives. Tohidnia and Tohidi, using different methods of measuring the global cost-effectiveness for homogeneous process networks, concluded that there is a relationship between the global economic efficiency of the network system and its subsystems [23].

Another problem that researchers from India are paying attention to is related to the price of resources. In their opinion, due to a market failure or other imperfections, the price mechanisms, and accordingly the distribution of resources, may differ from the socially optimal equilibrium, misinforming private and state institutions, which, in turn, negatively affects the general well-being of society [3]. An analysis of the impact of one of these resources, namely pesticides, carried out on the example of French farms, proved that the costs of this article could be reduced by more than 50 % by eliminating technological inefficiencies [8].

The authors concluded that the elimination of this inefficiency can help achieve the goals of reducing the use of pesticides and increase the level of greening of production. There was also a study of the relationship between the duration of the formation of transaction costs and their value on the example of food industry and agribusiness enterprises [1]. The authors' conclusions were that the buyer's solvency and leverage reduce the duration of transaction agreements, and accordingly, the costs. On the other hand, deals made during a recession generate additional costs.

Lukyanova, Kovshov, Zalilova consider the optimization of the structure of cultivated areas, fodder crops in particular, to be one of the important factors in reducing costs and increasing their efficiency [12]. In addition, another reserve for improving the efficiency of the livestock industry can be the optimization of livestock sizes, which will further increase the level of efficiency and, accordingly, reduce the relative amount of costs [6]. Jiang and Sharp also emphasize that the analysis shows a significant relationship between cost efficiency and capital intensity, livestock quality and livestock size [7]. The issue of the risk impact in the process of product value formation [2, 20], pricing [4], startups [24] is separately investigated. The relevant aspects of the problem of cost efficiency formation, optimization the degree of intensity, and their influence on agricultural competitiveness are underlined in the works of Ukrainian scholars [9–11, 14, 16, 17].

In this case, we presented a very small number of questions related to the problem of

determining the value of goods and the effectiveness of costs in agriculture. In fact, their circle is much larger and covers the period starting with the Physiocrats. In each time period, this issue had its own characteristics, but its relevance is not lost even today.

At the same time, for each country must emphasize the characteristics of the economic mechanism's construction, which compels producers on the one hand to successfully invest resources in production, and on the other – to raise their volumes and, therefore, contribute to economic development. Our study will focus on elucidating these challenges.

The purpose of the study is to assess the impact of the level of production intensity on the formation of its efficiency and competitiveness under the conditions of the law of diminishing returns and in this process. The goal was also to develop an own methodology for assessing the level of production efficiency of individual crops, which would take into account various factors of its formation.

MATERIALS AND METHODS

In the process of research, the dialectical method of cognition, the systematic approach to the study of economic phenomena and processes, and the monographic method (analysis of the scientific achievements of domestic and foreign scientists on the problems of estimating the level of income of the population, the structure of expenses, and the quality of life) were used. Of the special research methods, abstract-logical (for theoretical generalizations and formulation of conclusions), economic-statistical (construction of groupings), graphic (when constructing graphic images), correlational analysis (for construction of the dependence of the level of costs and productivity, productivity and level of profitability, level profitability of production). A proprietary methodology for determining the index of economic efficiency of intensification is proposed.

RESULTS AND DISCUSSIONS

Agricultural enterprises of the Kharkiv region acted as the object of the research. Data for 2020 on wheat, corn for grain, and sunflower were used for the analysis. The number of enterprises was the same for the production of wheat – 471, corn for grain – 319, and sunflower – 484.

At the first stage of the research, the dependences between the level of costs and three indicators of their effectiveness were modeled: yield, profitability, and profit per hectare of planted area (Table 1).

Table 1. Regression models of the dependence of the level of production efficiency on costs for individual crops in agricultural enterprises of the Kharkiv region in 2020

Indicators	Yield, c/ha (y)	Profit per 1 ha, UAH (y)	Level of profitability, % (y)
Wheat			
Costs (x)	У=40.58 + 0.00070x	У=13,761.5 – 0.30x	У=190.47 – 0.0065x
Corn for grain			
Costs (x)	У=45.75 + 0.00039x	У=8,994.2 – 0.174x	У=88.79 – 0.0008x
Sunflower			
Costs (x)	У=18.93+ 0.00027x	У=13,156.2-0.23x	У=171.69-0.0040x

Source: own calculations based on data from statistical reporting of agricultural enterprises.

The obtained values of the regression functions allow us to assess how the level of efficiency changes for each crop when the level of costs changes by 1 hryvnia. It was established that under the conditions of an increase in the level of costs by 1,000 UAH/ha, the fastest rate of change in all efficiency indicators occurs in wheat. Accordingly, on average, for the totality of enterprises, the increase in yield was equal to 0.7 c/ha, the decrease in profit was 300 UAH/ha, and the decrease in the level of profitability was 6.5 %. The last two results are evidence of the manifestation of the law of diminishing returns.

Moreover, a similar situation occurred with

corn for grain and sunflower. Another important point is the fact that all obtained regression equations are reliable. The actual values of Fisher's test (F) exceed those in the table. This is certainly because the formed aggregates included several hundred enterprises. In addition, the level of reliability (p) was less than the critical value (0.05) in all cases except one for corn in the "yield-profitability" dependence system.

To highlight the noted dependencies in more detail, it was decided to use the grouping method (Tables 2, 3, 4). All enterprises were divided into six groups. The first conclusion that can be drawn from the results of the groupings concerns the fact that the amount of yield and costs per unit of land area are closely related. For wheat, the average yield in the group of enterprises with costs up to 5,000 UAH/ha was 42.4 c/ha, with costs 10,000.1–15,000 UAH/ha – 54.3 c/ha, and with costs over 20,000.1–25,000 UAH/ha – 68.7 c/ha. At the same time, the productivity of enterprises with level of expenses over 25,000 UAH/ha turned out to be somewhat lower – 66 UAH/ha.

This fact indicates that the technological limit of productivity growth has been reached and the further increase in costs for wheat will not lead to an increase in productivity. As for corn for grain, the trend was similar. In enterprises with an expenditure level of up to 10,000 UAH/ha, the average yield is 50.1 c/ha, in enterprises with an expenditure level of 15,000.1–20,000 UAH/ha – 62.4 c/ha, and enterprises with an expenditure level of more than 35,000 UAH/ha – 63.4 c/ha. In this case, it is worth noting that the amount of productivity in the last two groups has almost not changed, with a significant difference in the level of costs. It may also indicate that the limit of technological efficiency has been reached.

For sunflowers, the dependence on costs and productivity was most clearly expressed. According to this crop, the average yield in enterprises with an expenditure of up to 5,000 UAH/ha was 18.9 c/ha, with an increase in expenditure of 10,000.1–15,000.1 UAH/ha – 21.8 c/ha, and in the last group with a level of costs over 25,000 UAH/ha – 39.9 c/ha.

Thus, in contrast to the two previous sunflower cults, the most favorable situation for increasing the level of productivity is created under the conditions of increasing production intensity.

Table 2. The influence of the level of costs per 1 sown area on the level of economic efficiency of wheat production in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 5,000	5,000.1–10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	over 25,000	average
Number of enterprises	21	103	173	97	38	39	471
Average costs per 1 ha, UAH	3,462	8,032	12,655	17,185	21,612	32,674	14,312
Yield	42.4	45.6	51.0	54.3	68.7	66.0	52.8
Costs per 1 ha, UAH:							
seed	397	818	1,076	1,454	1,591	2,251	1,195
mineral fertilizers	725	2,117	3,143	4,150	4,913	6,936	3,447
fuel	437	988	1,184	1,642	3,448	6,813	1,709
remuneration	347	760	1,589	2,596	2,486	2,912	1,767
depreciation	270	638	985	1,661	1,789	2,318	1,187
Cost of 1 c, UAH	82	176	248	316	315	495	271
Income per 1 ha, UAH	20,146	21,883	25,610	27,055	33,393	32,094	26,105
Profit per 1 ha, UAH	14,785	12,196	11,485	8,280	8,688	3,531	10,214
Level of profitability, %	276	126	81	44	35	12	64

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Thus, for all three crops, we have an established relationship between costs and productivity.

As for individual expenditure items, the trend turned out to be similar. For all three crops, the largest difference by the group was the cost item "Fuel". According to this the difference between the first and the last group was 34.4 times for sunflower, 15.6 times for wheat, and 10.8 times for corn for grain. Thus, it is a sunflower that has the highest level of differentiation in spending under this article. As for the cost items that had the least differentiation, they were different for the selected crops. The smallest difference was observed for sunflower, wheat, and the cost

item "Seeds", and for corn for grain – according to the cost item "Labor payment". As for expenses under the expense item "Depreciation", the pace of its change was higher than the average only for sunflower. This expense item is important because it serves as an indicator of the innovativeness of the production of a particular crop. In this case, the conclusion is also quite obvious – the increase in the level of expenses for fixed assets, and accordingly the amount of depreciation, is very closely related to the growth of the yield level of all crops. This is a completely logical result because obtaining high yields of crops requires not only investments in current costs, but also capital investments.

Table 3. The influence of the level of costs per 1 sown area on the level of economic efficiency of the production of corn for grain in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	25,000.1–35,000	over 35,000	average
Number of enterprises	57	96	69	42	34	21	319
Average costs per 1 ha, UAH	7,499	12,617	17,005	22,429	29,762	57,099	16,962
Yield	50.1	55.2	62.4	65.3	60.9	63.4	58.4
Costs per 1 ha, UAH:							
seed	1,235	2,164	2,930	2,972	3,880	6,689	2,595
mineral fertilizers	1,279	2,207	3,014	4,171	5,370	11,017	3,047
fuel	843	1,543	1,866	2,866	3,181	9,079	2,042
remuneration	1,065	1,051	2,083	3,391	4,816	4,966	2,063
depreciation	493	1,170	1,355	2,073	2,548	4,291	1,448
Cost of 1 c, UAH	150	229	272	343	489	900	291
Income per 1 ha, UAH	23,776	25,834	29,825	28,965	28,736	28,626	27,235
Profit per 1 ha, UAH	14,285	8,884	10,864	5,120	6,411	13,688	9,259
Level of profitability, %	151	52	57	21	29	92	52

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Table 4. The influence of the level of costs per 1 sown area on the level of economic efficiency of sunflower production in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 5,000	5,000.1–10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	over 25,000	average
Number of enterprises	20	103	178	89	50	44	484
Average costs per 1 ha, UAH	3,600	8,049	12,420	17,219	22,611	38,492	14,275
Yield	18.9	21.7	21.8	24.8	27.5	39.9	23.8
Costs per 1 ha, UAH:							
seed	776	943	893	603	672	588	795
mineral fertilizers	520	1,056	1,594	2,312	2,674	3,648	1,748
fuel	449	1,160	1,868	3,224	5,219	5,931	2,387
remuneration	288	811	1,574	1,841	2,487	9,899	2,007
depreciation	403	927	1,795	2,488	2,914	5,530	1,966
Cost of 1 c, UAH	173	672	1,112	1,501	2,294	2,709	1,228
Income per 1 ha, UAH	26,880	23,404	22,841	25,977	28,997	43,863	25,482
Profit per 1 ha, UAH	21,595	13,538	11,357	9,915	6,904	5,816	11,267
Level of profitability, %	409	137	99	62	31	15	79

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Regarding the effectiveness of the costs incurred. In this case, three indicators were determined for its evaluation: income and profit per 1 ha of cultivated area and the level of profitability of production. It was established that only the value of income per 1 ha of the sown area had a close direct relationship with the number of expenses incurred. In particular, for wheat, the average amount of income per 1 hectare was 20,146 UAH/ha in enterprises with an expenditure level of up to 5,000 UAH/ha, and in enterprises with an expenditure level of 10,000–15,000 UAH/ha – 25,610 UAH/ha. And enterprises with a level of expenses over 25,000 UAH/ha – 32,094 UAH/ha. For sunflower, this trend was most clearly manifested, and for grain corn, it was manifested to a lesser extent. Also important are the trends associated with changes in two other indicators – profit per hectare and the level of profitability. They clearly state the effect of the law of diminishing returns, which was first mentioned in the works of Turgot

[21, 22]. Today, in the most developed countries of the world, one of the main factors in overcoming the effect of this law is state support for agriculture [5, 11, 19, 25].

It makes it possible to maintain the appropriate level of production intensity.

In the absence of this support, the effect of the law of diminishing returns would inevitably lead to a decrease in the level of costs and, accordingly, the level of crop yields.

In Ukraine, the level of state support is very insignificant and, accordingly, has almost no effect on the formation of the level of intensity and efficiency of production.

To consider this situation in more detail, let's turn to the data on the level of state support according to the Producer Support Estimate (PSE) indicator. This indicator characterizes the amount of state support under various programs to the value of the gross product in agriculture (Table 5).

The given data refer to different countries and continents. According to 2021 data, the highest level of state support took place in Iceland (58.0 %) and Norway (49.6 %). At the same time, it was the smallest in Ukraine – 1.1 % of the value of the agricultural product. Moreover, in 2014, 2016, and 2017, its value was negative, which indicates that agriculture acted as a donor to other sectors of the economy. There was no such situation in any of the analyzed countries. Even Turkey has a significantly higher level of state support than Ukraine. Thus, under these conditions, the only competitive advantage of domestic producers of agricultural products on international markets should be the efficiency of production, in particular, costs under the conditions of the law of diminishing returns.

Table 5. The dynamics of income support for agricultural producers through budget transfers (PSE, %) in Ukraine and certain countries of the world for 2013–2021, %

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021
Australia	2.2	1.9	1.8	1.7	2.7	2.4	3.2	3.3	2.8
Canada	9.2	7.9	7.8	9.4	7.7	7.8	8.7	8.2	11.7
Iceland	41.4	50.5	57.1	59.7	58.9	57.5	56.5	57.2	58.0
Norway	56.6	59.3	59.4	60.6	55.1	58.1	55.4	53.4	49.6
Turkey	20.9	26.1	26.4	29.4	23.8	15.2	17.4	26.0	15.1
Ukraine	0.0	-1.4	0.5	-1.4	-0.8	2.1	2.8	1.4	1.1

Source: [13].

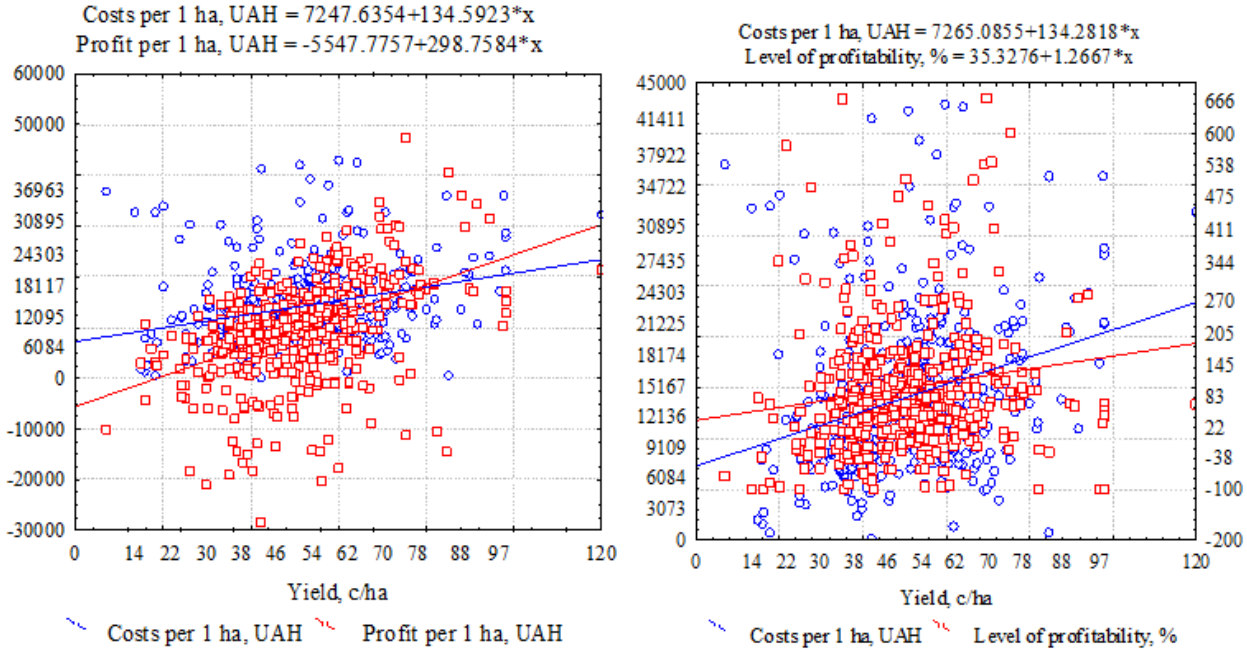

Fig. 1. Dependence of the level of profit and the level of profitability on costs and yield of wheat in agricultural enterprises of the Kharkiv region in 2020

Source: own calculations.

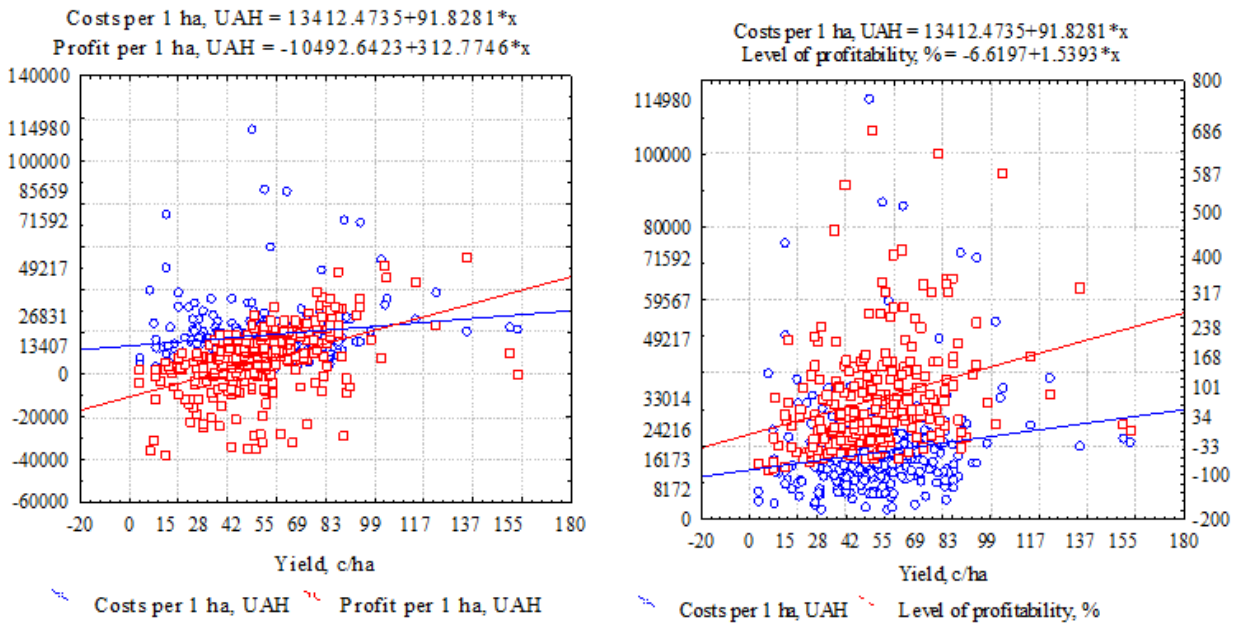

Fig. 2. Dependence of the level of profit and the level of profitability on costs and the yield of corn per grain in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

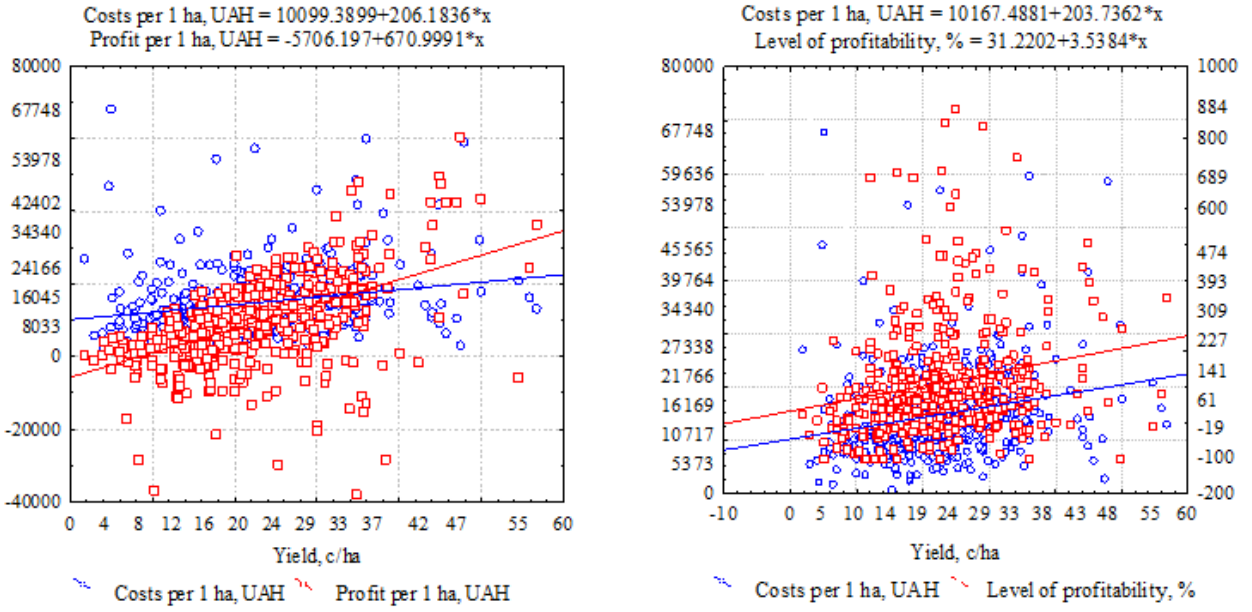

Fig. 3. Dependence of the level of profit and the level of profitability on costs and yield of sunflower in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

Therefore, the question arises: exactly what factors encourage entrepreneurs to invest capital in production. In this case, we have already emphasized the connection between the level of costs and the yield of crops. However, what is the nature of the relationship between productivity and profitability? To comprehend this, the dependencies between productivity and profit were built, as well as the paired regression dependences of productivity-costs-profit and productivity-costs-profitability. (Figs. 1, 2, 3). As a grouping indicator, crop productivity was used. As dependent variables, costs, profit, and level of profitability were chosen.
Even though the coordinates of the point of intersection of the regression lines can be clearly determined on the graph. It turned out

that both the profit and the level of profitability for all crops had a positive relationship with them. In addition, the intersection point of the regression line in the figures makes it possible to establish the level of productivity at which the rate of increase in the costs will be lower than the rate of increase in profit. This situation concerns the cost-yield and profit-yield dependences. This is because the dependent values have one dimension and, accordingly, the point of intersection. To mathematically determine these positions, it was decided to combine these equations and find the corresponding values of the X-axis (Table 6).

This point is located through the solution of the corresponding system of equations. The economic content of the obtained coordinates will be that at a given increase in X (yield), the profit per 1 ha of the sown area will exceed costs per unit of land area by the established dependencies. In other words, the level of profitability should be equal to 100 %.

This amount is such that it already provides an excess profit and significant incentives for the application of specific actions regarding the further growth of crop yields.

Table 6. The profit, productivity and the level of profitability of crop production in accordance with the obtained regression equations in agricultural enterprises of the Kharkiv region in 2020

Crops	The equation of regression of the dependence of consumption (y) – yield (x)	Profit-yield dependence regression equation	Estimated indicators	Value
Wheat	y = 7,247.6+134.59x	y = -5,547.78+298.8x	yield, c/ha	77.9
			expenses, profit UAH/ha	17,738
			profitability level, %	133.6
Corn	y= 13,412.5+91.83x	y = -10,492.6+312.78x	yield, c/ha	108.2
			expenses, profit UAH/ha	23,347
			profitability level, %	159.9
Sunflower	y = 10,099.4+206.18x	y = -5,706.2+671.00x	yield, c/ha	33.9
			expenses, profit UAH/ha	17,074
			profitability level, %	151.2

Source: own calculations based on data from statistical reporting of agricultural enterprises.

It was established that to wheat, this situation occurs at the level of productivity – 77.9 c/ha, the level of costs – 17,738 UAH/ha, and the level of profitability – 133.6 %. Regarding corn for grain, these indicators were equal to 108.2 c/ha, 23,347 UAH/ha and 159.9 %, respectively. For sunflowers, respectively – 33.9 c/ha, 17,074 c/ha, and 151.2 %. These positions form a group of enterprises that had the highest efficiency and competitiveness in the production of these crops

However, as we have already noted based on the above research results, the increase in costs leads not only to an increase in the level of crop productivity but also includes the law of diminishing returns, which in turn hurts the amount of profit per one hectare of the planted area, as well as on the level of profitability. In this case, a contradiction arises.

On the one hand, we have a situation where the increase in productivity makes it possible to increase the profitability of crop production, and on the other hand, the increase in productivity is directly related to costs per unit of land area, and accordingly, in the final case, will lead to a drop in profitability.

To more objectively assess this situation, we propose to determine the economic efficiency index of the level of crop production intensification according to the following formula:

$$I_{ef} = \sqrt[3]{\beta_c \mathrm{I}_c \times \beta_{profit} \mathrm{I}_{profit} \times \beta_\mathrm{p} \mathrm{I}_\mathrm{p}} \quad (1)$$

where:

I_{ef} – index of economic efficiency of intensification of crop production;

β_c, β_{profit}, β_p – weighting ratios of costs, profits and profitability;

I_c, I_{profit}, I_p – indices of compliance of actual data on the level of costs, profits per 1 ha of the sown area and profitability. Indices of correspondence of actual data to model data are calculated as the ratio of the actual value to the model value:

$$Ii = F_i/M_i \quad (2)$$

where:

I_i – index of compliance of actual data on the *i*-indicator;
F_i – the actual value of the *i-th* indicator;
M_i – model value of the *i-th* indicator.
In turn, weighting coefficients are calculated in proportion to the level of variation of the balances for each indicator. The residuals themselves are defined as the difference between the actual and model values of each indicator.

$$\beta i = r_{max}/r_i \quad (3)$$

where:
βi – *i*-culture weighting factor;
r_{max} – the maximum value of the coefficient of variation among these indicators;
r_i – the value of the coefficient of variation for the *i*-indicator.
The actual values of βi and coefficients for individual crops and indicators are shown in Table 7. The value at level 1 is evidence that the level of variation of the indicator was the highest in this culture. Accordingly, according to other indicators, its value will be more than 1. This allows you to eliminate the effect of the variability of individual indicators on the final result.

Table 7. The value of the β and coefficient for individual crops in agricultural enterprises for 2020

Culture	Costs per 1 ha, UAH	Profit per 1 ha, UAH	Level of profitability, %
Sunflower	1.00	2.60	3.07
Wheat	1.19	1.15	1.00
Corn for grain	1.00	3.23	1.28

Source: own calculations based on data from statistical reporting of agricultural enterprises.

The economic content of the index of economic efficiency of intensification is that if its value is equal to 1, we will have a situation when the level of expenses, the amount of profit or the level of profitability correspond to the values obtained by their value according to the models.
However, this is only one of the possible options. A situation is possible when one of the indices included in the model will be greater than 1, and the others will be smaller. This especially applies to the situation when the law of diminishing returns is in effect. In this case, the indices of correspondence of the actual data on the level of expenses will be greater than 1, and other indices will be less than 1.

Table 8. Grouping of agricultural enterprises by the value of the index of economic efficiency of intensification by individual crops for 2020

Economic Efficiency Index	Costs per 1 ha, UAH	Productivity, c/ha	Profit per 1 ha, UAH	Level of profitability, %
Sunflower				
under 1	16,469	24.8	-827	-3.2
1.1–2	15,608	19.2	1,913	9.7
2.1–4	12,097	23.0	16,116	180.6
4.1–6	14,713	26.4	14,655	108.3
6.1–8	14,434	28.3	15,581	106.9
over 8	15,188	26.3	14,002	112.4
Wheat				
under 0.5	17,018	56.2	497	1.8
0.51–1	17,358	51.3	-2,210	-8.3
1.1–1.5	12,952	54.3	13,675	111.5
1.51–2.5	12,668	50.3	13,430	113.4
2.51–3.5	14,493	52.1	12,191	84.5
3.51–4.5	14,268	54.8	13,148	94.9
over 4.5	13,612	53.5	12,745	96.1
Corn for grain				
under 0.5	18,562	58.5	-1621	-5.3
0.5–1	14,589	59.3	964	3.6
1–1.5	17,024	50.1	-1809	-7.5
1.5–2.5	15,822	55.9	13209	110.2
2.5–3.5	21,913	76.1	25386	212.9
over 3.5	21,375	90.1	32206	222.5

Source: own calculations based on data from statistical reporting of agricultural enterprises.

In any case, a value larger than one for the index of economic efficiency of intensification indicate that in this enterprise the values of the indices included in model

will exceed those results predicted by the existing dependencies. This, in turn, may indicate a higher overall efficiency of the production of this culture at the enterprise.

To assess the real situation with the peculiarities and dependencies of the index of economic efficiency of intensification, it was calculated using three selected crops as examples (Table 8). The first thing to notice is the significant variation of index values among crops.

The largest value of the index was found for sunflower – 4.506, then for wheat – 2.500, and the smallest value was for corn for grain – 2.102. It should be noted that this does not indicate that the production efficiency of sunflower was higher than corn for grain. The discrepancy data only indicate that the relative deviation of the actual data from the model data for sunflowers was higher than for corn for grain. This may be an indication of the greater riskiness of the production of this crop in terms of the costs incurred and the result obtained. The subjective factor also plays a greater role in this case, both from the point of view of production technologies and business.

Regarding the dependence of the value of the index of economic efficiency of intensification, we note that a clear dependence of its value on the level of costs and productivity was not established. This suggests that the level of expenses largely does not determine the final efficiency of management. That is, you can incur expenses, but this will not be a guarantee that we will get the planned yield.

This conclusion somewhat contradicts the one we made above about the existence of a dependence between costs and productivity, however, the used calculation method ties this dependence even to the profit per 1 ha and level of profitability of production. At the same time, such dependence took place in terms of the amount of profit per 1 ha of the sown area and the level of profitability.

For all three cultures, in the groups with the lowest value of the index of economic efficiency of intensification, the profit per 1 ha and the level of profitability turned out to be the lowest. For corn, there were even three such groups per grain. As for the further trend, it can be characterized as non-linear for wheat and sunflower, and linear for grain corn.

The non-linear nature of the dependence was verified on the example of primary data (Figs. 4, 5). In this case, we have confirmation of the revealed trend.

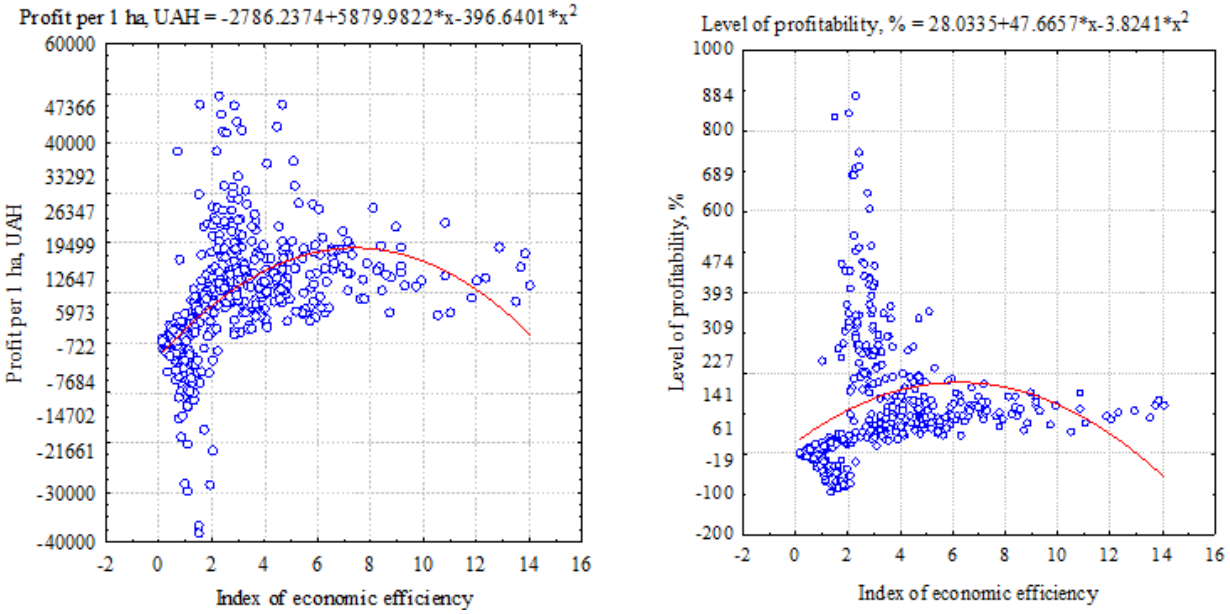

Fig. 4. Dependence of the level of profit and the level of profitability on the value of the index of economic efficiency of the intensification of sunflower production in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

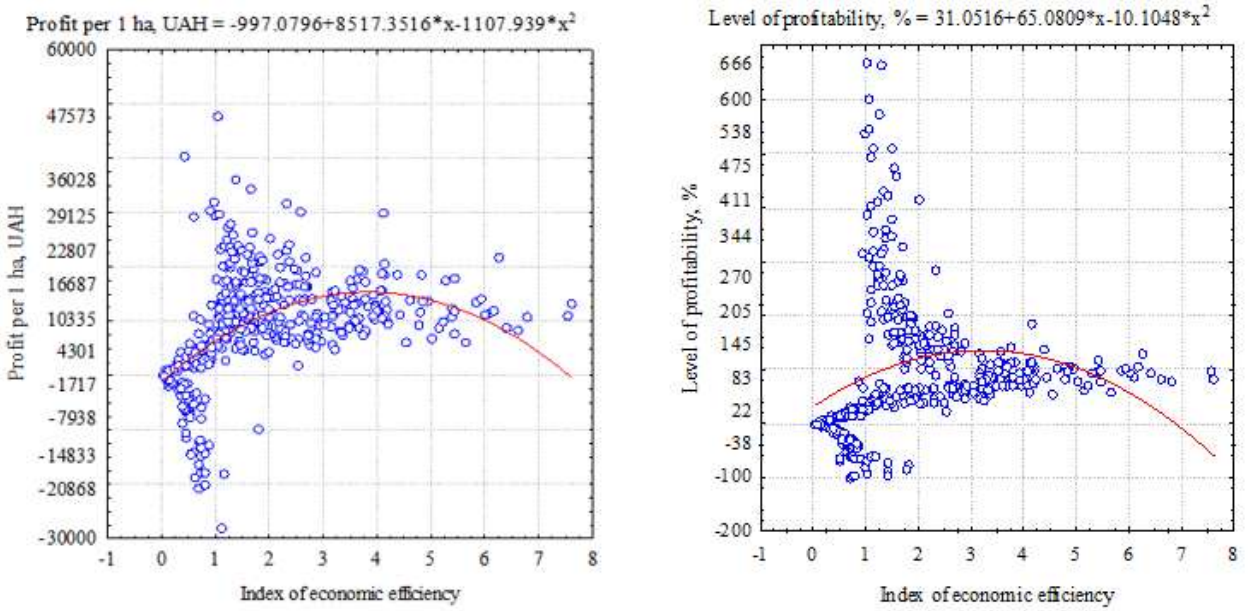

Fig. 5. Dependence of the level of profit and the level of profitability on the value of the economic efficiency index of the intensification of wheat production in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

To establish the maximum of the function, appropriate calculations were carried out. It turned out that the maximum function for sunflowers was 7.41 for profit, and 6.23 for profitability.

For wheat, these values of the economic efficiency index were respectively equal to 3.84 in terms of profit and 3.22 in terms of profitability. The question arises, what practical conclusions can be drawn based on the calculations made? First of all, any process that is evaluated from a new point of view makes it possible to notice those moments that were not ascertained before. Secondly, our analysis made it possible to establish that the economic mechanism for corn for grain, which should contribute to increasing the level of crop productivity, is working well. At the same time, the maximum of the index of economic efficiency of intensification occurs for sunflower and wheat, after which it decreases. In this case, this fact can cause the actions of producers, which will be aimed at stopping investment, and accordingly, reducing the level of productivity, and ultimately the competitiveness of the enterprise. To prevent this phenomenon, it is necessary, as already mentioned above, to introduce real state support for manufacturers. However, the question lies in the mechanism of providing this support. One of its options may be the use of the economic efficiency index of intensification as a criterion for determining its necessity and size. The specific parameters of this index for wheat and sunflower were determined by us.

CONCLUSIONS

The conducted research made it possible to establish certain important features of the formation of the mechanism of producers' interest in increasing the level of intensity of production of crops.

It was established that the level of connection between the costs and the efficiency of production of wheat, sunflower, and corn per grain is weak. This is due to the complex mechanism of the interaction of capital with nature and the significant influence of the subjective factor. At the same time, the level of reliability of the built models was high, which allows them to be used assess established trends.

It was found that there is a clear relationship between the costs and the yield of crops. It has a different character, both from the point of view of the rate of increase in productivity, and changes in costs for individual articles. This dependence is also supplemented by the action of the law of diminishing returns,

which leads to a drop in the level of profit and the level of profitability of production.

It was also established that the growth of productivity, under the conditions of optimal costs, is the basis of increasing both the level of profitability and the level of profitability of production.

The level of productivity of crops that allows forming the most effective parameters of production and competitiveness in terms of productivity, profitability, and level of profitability has been determined. These can serve as appropriate beacons for agricultural producers.

A methodology for determining the economic efficiency index of intensification is proposed. This index allows you to combine the level of productivity, costs, profitability, and the level of profitability of production at the same time.

The practical approbation of this methodology made it possible to establish that there is a direct relationship between the value of the economic efficiency index of intensification and the profit per 1 ha and level of profitability of corn production. As for wheat and corn per grain, this dependence has a non-linear character.

The value of the index of economic efficiency of intensification, at which the level of profit and the level of profitability was maximum, was determined.

We believe that one of the effective measures to maintain this level of profitability is state support for the production of these crops, taking into account the parameters of the economic efficiency index of intensification determined by us. This will make it possible to create an effective mechanism for further increasing the production of crops without reducing the level of competitiveness of enterprises.

Prospects for further research may be related to the development of a specific mechanism of state support for agricultural enterprises, taking into account the economic efficiency index of intensification.

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