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DEVELOPMENT OF AN ECONOMETRIC MODEL FOR ASSESSING THE IMPACT OF PRODUCTION COST COMPONENTS ON THE FORMATION OF INCOMES OF AGRICULTURAL ENTERPRISES

The object of research is the financial and economic activity of agricultural enterprises that grow plant products. The problem is that some components of the production cost have different effects on the growth of incomes of agricultural enterprises, and therefore they need to be identified for the purposes of managing the production of plant products. Therefore, there is a need to develop econometrically substantiated tools that will provide a quantitative assessment of the impact of the structural components of the production cost of plant products on the formation of net incomes of agricultural enterprises. This makes it possible to integrate the results of the analysis into the system of strategic management of such enterprises. An econometric model of the dependence of net incomes on the production cost of agricultural enterprises has been constructed. Statistically significant factors of influence have been identified and the degree of their elasticity has been established. It has been proven that the optimization of individual elements of the production cost has a differentiated effect on the formation of net incomes of agricultural enterprises. The results obtained have allowed to form the basis of analytical support for the management of plant production for making management decisions to increase the efficiency of agricultural enterprises. The research did not take into account global economic and political events, although they often change the structure of incomes and expenses in the agricultural sector. War, changes in foreign trade, inflation – all this significantly affects the results. The results obtained can be used in practice – the developed analytical tools work well in the crop production management system of agricultural enterprises. The multiple regression model helps management personnel see how individual components of the production cost of crop products affect net incomes, and quickly find inefficient areas of resource use. This opens the way for expense optimization, increasing profitability and improving the financial performance of an agricultural enterprise.

Keywords: production costs, regression analysis, agricultural enterprises, production management, incomes, expenses, analytical support.

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1. Introduction

Much depends on the quality of management of the production cost of crop production of agricultural enterprises. Global markets pose challenges: resource prices are growing, risks too, and competition is only intensifying. It is the structure of the production cost of crop production that directly affects the net incomes, profitability and financial stability of an agricultural enterprise. In such conditions, one cannot do without accurate quantitative methods of analysis – they help to make truly strategic decisions.

Often, the management of agricultural enterprises relies on general indicators and does not see how individual components of the production cost of crop production affect net incomes. When there is no clear model that shows the strength, direction and elasticity of the impact

of key expenses, strategic planning and risk management becomes significantly more complicated.

In the work [1], it was investigated how correlation analysis helps to assess the impact of production cost on the financial results of industrial enterprises. This approach is also advisable to use for agricultural enterprises. In [2], practical solutions were proposed for building multiple regression models to estimate expenses and their impact on enterprise efficiency. Meanwhile, in [3], a regression model was built for parametric cost estimation of industrial steel structures.

In [4], a regression-based model was presented that predicts unforeseen expenses for road network projects. This allows predicting such expenses in the future. In [5], a conceptual cost estimation model was built for the pre-design stage of road projects using multiple regression analysis.

In [6], correlation-regression analysis was used to investigate how fertilizer expenses affect the price of winter wheat. This is an effective example of how this method really helps the agricultural sector. In addition, in [7], a systematic review and meta-regression analysis of the technical efficiency of agricultural production systems was carried out, which emphasizes the importance of calculating resource expenses in numbers. In the scientific paper [8], machine learning with a regression approach was used to predict yield, which expands the possibilities of empirical research in crop production.

In the paper [9], it was investigated how intellectual capital is formed and developed using correlation-regression analysis. Their work is another example of how this method helps to assess the efficiency of various types of resources. At the same time, in the research [10], analytical procedures for auditing integrated reporting are used, which can also be applied to domestic Ukrainian agricultural enterprises. Such analytical procedures are advisable to use to assess the impact of the production cost of crop production on the income's formation of agricultural enterprises.

At the same time, in the research [11], the dependence of operating profit on expenses is determined, which creates the basis for empirical modeling of net incomes in agricultural enterprises. At the same time, this approach has certain limitations, since operating profit does not fully reflect the impact of external factors that are characteristic of agricultural enterprises.

In [12], factors influencing agricultural land prices in Northern Italy are investigated using spatial regression analysis. At the same time, research [13] demonstrates a comparative analysis of the impact of climate change on Italian agriculture: Ricardian regression analysis. At the same time, work [14] presents the possibilities of using regression in financial and auditing contexts. However, in other researches [15, 16], predictive models using multiple regression for resource optimization were developed.

In [17], the method of quantile regression analysis is considered. At the same time, research [18] highlights the issues of regression analysis with independent variables. A step-by-step regression analysis of factors influencing the implementation of Islamic banking was considered in [19]. At the same time, research [20] expands on this approach, emphasizing the strategic nature of expense management and the need to move from retrospective analysis to predictive modeling of financial performance modeling.

Research [21] determines the impact of government size on corruption using meta-regression analysis. Research [22] analyzes the CSR impact on firm profitability using meta-regression analysis. A comparative research of machine learning regression models for monitoring the state of production systems is presented in research [23]. At the same time, research [24] investigates regression analysis and social network analysis. At the same time, the issue of regression analysis of executive stock ownership and corporate earnings management is considered in research [25]. In particular, research [26] reveals a comparative analysis of the efficiency and completeness of the use of resource potential of trading enterprises.

At the same time, research [27, 28] substantiates the use of econometric models for prediction financial results in conditions of instability of the external environment, which is especially relevant for agricultural enterprises in Ukraine.

Research [29] examines the impact of the regulatory environment on financial indicators, which allows treating part of the expenses as dependent on external institutional factors.

The scientific work [30] considers the analysis of the effectiveness of functional strategies of trading enterprises, which in turn will be relevant for agricultural business. In [31], attention is focused on the application of regression analysis in the audit context. At the same time, regression analysis for the analysis of financial indicators of state banks is considered in [32].

The problem is that some components of production costs affect the growth of agricultural enterprises' incomes in different ways, and

therefore they need to be identified for the purposes of managing the production of crop products. Therefore, there is a need to develop econometrically substantiated tools that will provide a quantitative assessment of the impact of structural components of the production costs of crop products on the formation of net incomes of agricultural enterprises. Since ignoring heteroscedasticity, autocorrelation, nonlinearity and the impact of external factors (price, climatic, military) reduces the quality of analytical support for making management decisions. On the other hand, the limitations of qualitative statistical data and the insufficient use of modern economic tools lead to the simplification of models and a decrease in the reliability of the results obtained.

The object of research is the financial and economic activities of agricultural enterprises that grow crop products.

The aim of research is to develop an econometric model for assessing the impact of components of production costs on the formation of net incomes of agricultural enterprises that grow crop products, as well as determining the level of incomes elasticity to changes in key factors of production costs.

To achieve the aim, the following objectives were solved:

1) to build a multiple regression model for factor analysis of the impact of individual components of the production costs of crop products on the incomes of agricultural enterprises, to calculate elasticities to assess the strength of the influence of factors;

2) to build a strategic matrix for managing net incomes and production costs of crop products, which allows to determine the typological areas of activity of an agricultural enterprise and priorities for making management decisions.

2. Materials and Methods

The hypothesis of research is that there is a statistically significant correlation-regression relationship between the incomes and expenses of the enterprise, which allows predicting the level of incomes based on the dynamics of expenses. However, it is assumed that the growth of expenses is a factor in increasing incomes only if they are of an investment or productive nature, while unproductive expenses do not contribute to the growth of the enterprise's incomes. Therefore, the formation of a cost management strategy should be based on modeling the relationship between incomes and individual types of expenses. This allows to focus the attention of management personnel on those elements of expenses that do not directly affect the performance of the activity, and therefore require appropriate tactical measures to minimize (optimize) them. Visualization of the relationship between incomes and expenses in the coordinate system allows to assess the effectiveness of the selected expense management strategies in the long term.

The following methods were used in the research:

- series of dynamics to study trends in the incomes and expenses of agricultural enterprises for 2014–2025;
- analysis and synthesis were used to formulate the research conclusions;
- correlation-regression analysis for factor analysis of incomes changes due to individual components of the production cost of agricultural enterprises;
- relative values for constructing elasticity coefficients;
- analysis in the coordinate system for strategic analysis of the efficiency of incomes management and expenses of agricultural enterprises;
- expert assessment methods for constructing maps of analytical interpretation of the strategic behavior of incomes and expenses of agricultural enterprises in the coordinate system;
- moving average and exponential smoothing methods for predicting trends in changes in the production cost of crop products;
- graphical techniques for visualizing analytical researches;
- comparisons for developing source information for constructing a coordinate system.

This research used a quantitative approach and econometric modeling to understand how key variables affect the phenomenon under study. The research framework combines modern economic and management theories with empirical methods – this allows to test the hypotheses that have been formulated.

The conceptual model is built as a dependent variable Y changes under the influence of a certain set of independent variables (X_1, X_2, \dots, X_n), as well as control variables, namely

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \varepsilon, \quad (1)$$

where β characterizes the direction and strength of the influence of factors on the performance indicator, and ε is the error.

The basic basis of research is the data of the financial and statistical reporting of an agricultural enterprise specializing in the cultivation of crop products for the period 2015–2025.

The time period of the research was selected so that there were enough observations for confident statistical conclusions and, at the same time, to minimize the impact of structural gaps in the data.

The empirical analysis was carried out in several stages to enhance the reliability of the results. First, descriptive statistics were performed – it was looked at the main parameters of the sample: mean values, standard deviations, range of variation. The next stage was to conduct correlation analysis. Here it was important to find out how the variables are related to each other and whether there are any problems with multicollinearity.

3. Results and Discussion

3.1. Multiple regression model to determine the impact of each component of the production cost of crop products

It is proposed to implement a methodology for building a multiple regression model to determine the impact of the components of the production cost on the net incomes from the sale of goods, works and services of LLC “KRAEVYD PODILLIA”. At the same time, the factors

will include the following indicators that characterize direct expenses and general production expenses, in particular:

- 1) direct material expenses;
- 2) direct labor expenses;
- 3) other direct expenses and general production expenses.

Then the regression equation will have the following form

$$Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3, \quad (2)$$

where Y – net incomes from the sale of goods, works and services; x_1 – direct material expenses; x_2 – direct labor expenses; x_3 – other direct expenses and general production expenses; b_0, b_1, b_2, b_3 – parameters of the regression equation, which can be calculated by the least squares method, solving the system of normal equations:

$$\begin{cases} \sum y = b_0 \sum 1 + b_1 \sum x_1 + b_2 \sum x_2 + b_3 \sum x_3, \\ \sum y x_1 = b_0 \sum x_1 + b_1 \sum x_1^2 + b_2 \sum x_1 x_2 + b_3 \sum x_1 x_3, \\ \sum y x_2 = b_0 \sum x_2 + b_1 \sum x_1 x_2 + b_2 \sum x_2^2 + b_3 \sum x_2 x_3, \\ \sum y x_3 = b_0 \sum x_3 + b_1 \sum x_1 x_3 + b_2 \sum x_2 x_3 + b_3 \sum x_3^2. \end{cases} \quad (3)$$

The input data for solving the system of equations (3) are given in Table 1.

Data were calculated to determine the parameters of the regression equation (Table 2).

The found data were substituted into a system of normal equations:

$$\begin{cases} 3633075 = b_0 + 982146.8b_1 + 100391.2b_2 + 665681.80b_3, \\ 394199054865.30 = 982146.8b_0 + 118594374295.98b_1 + \\ + 11942551929.44b_2 + 67078620855.19b_3, \\ 42812738065 = 100391.2b_0 + 11942551929.44b_1 + \\ + 1345373805.5b_2 + 7010369000.8b_3, \\ 245977168088.2 = 665681.80b_0 + 67078620855.19b_1 + \\ + 7010369000.8b_2 + 48157327069.62b_3. \end{cases} \quad (4)$$

Table 1

Input data for LLC “KRAEVYD PODILLIA” for performing correlation analysis*

Year	Net incomes from sales of goods, works and services, thousand UAH (Y)	Production cost		
		Direct material expenses, thousand UAH (X_1)	Direct labor expenses, thousand UAH (X_2)	Other direct expenses and general production expenses, thousand UAH (X_3)
2024	587845.00	171131.30	17122.80	82466.20
2023	349276.00	198100.10	17377.90	73838.30
2022	626263.00	121288.50	13255.00	56145.20
2021	464417.00	81333.70	16485.50	53841.50
2020	355599.00	76554.70	13538.00	78712.40
2019	255911.00	84090.10	7521.60	80597.30
2018	327697.00	69127.80	5610.80	93641.90
2017	262260.00	52841.40	4070.20	83063.20
2016	174703.00	70363.00	3017.00	32562.10
2015	229104.00	57316.20	2392.40	20813.70

Note: based on [33]; * – the NBU exchange rate for 1 USBas of 13.05.2026 was 43.9709 UAH

Table 2

Calculated data to determine the parameters of the regression equation

$\sum y$	$\sum y x_1$	$\sum y x_2$	$\sum y x_3$	$\sum x_1$
3633075	394199054865.30	42812738065	245977168088.2	982146.8
$\sum x_2$	$\sum x_3$	$\sum x_1^2$	$\sum x_2^2$	$\sum x_3^2$
100391.2	665681.80	118594374295.98	1345373805.5	48157327069.62
$\sum x_1 x_2$	$\sum x_1 x_3$	$\sum x_2 x_3$	–	
11942551929.44	67078620855.19	7010369000.8		

The determinant of the system and partial determinants were found, on the basis of which the parameters of the regression equation were calculated:

$$b_0 = 184582.3349; b_1 = -0.187256779; b_2 = 20.01135364; \\ b_3 = -0.05764764.$$

Then the relationship equation, which determines the dependence of the effective sign of net incomes from the sale of goods, works and services on three factors (direct material expenses, direct labor expenses, other direct expenses and general production expenses), will have the following form

$$Y = 184582.3349 - 0.187256779X_1 + 20.01135364X_2 - \\ - 0.05764764X_3.$$

Thus, with an increase in direct material expenses by 1 thousand UAH, net incomes decreases on average by 0.187 thousand UAH. This indicates a high material intensity of production and insufficient return on material resources. With an increase in direct labor expenses by 1 thousand UAH, net incomes increases by 20.01 thousand UAH. This indicates a significant role of labor resources in shaping the final results of the enterprise.

There is a slight negative impact of other direct and general production expenses on net incomes, which may indicate an inefficiency of their structure or a disproportional growth of expense and incomes.

However, based on the regression coefficients, it is not possible to judge which of the factor characteristics has the greatest impact on the effective one, since the regression coefficients are not comparable with each other, because they are expressed in different units.

In order to identify the comparative strength of the influence of individual factors and their reserves, statistics calculates partial elasticity coefficients ε_i according to the formula

$$\varepsilon_i = b_i \cdot \frac{\bar{x}_i}{\bar{y}}, \quad (5)$$

where b_i – the regression coefficient for the i -th factor; \bar{x}_i – the average value of the i -th factor; \bar{y} – the average value of the calculated (theoretical) effective characteristic.

Partial elasticity coefficients show how many percent on average the effective characteristic will change with a change of 1% of each factor and a fixed position of other factors:

$$\varepsilon_1 = b_1 \cdot \frac{\bar{X}_1}{\bar{Y}} = (-0.1873) \cdot \frac{98215}{363308} = -0.0506; \quad (6)$$

$$\varepsilon_2 = b_2 \cdot \frac{\bar{X}_2}{\bar{Y}} = (20.0114) \cdot \frac{10039}{363308} = 0.553; \quad (7)$$

$$\varepsilon_3 = b_3 \cdot \frac{\bar{X}_3}{\bar{Y}} = (-0.05765) \cdot \frac{66568}{363308} = -0.0106. \quad (8)$$

Analysis of partial elasticity coefficients shows that the greatest impact on net incomes from the sale of goods, works and services of LLC "KRAEVYD PODILLIA" is provided by direct material expenses. In particular, with an increase in labor costs by 1%, the level of net incomes increases by 0.55%.

Direct material, other and general production expenses have a slight negative impact, which confirms the need to optimize resource consumption and improve the expense management system at LLC "KRAEVYD PODILLIA".

The developed model indicates a close relationship between the net incomes of an agricultural enterprise and the production cost of products. After all, the correlation coefficient is 0.76. The significant impact of the factors selected for the research (direct material expenses, labor expenses and other production expenses) is confirmed by the coefficient of determination $D = 0.578$. This means that the change in net incomes is due to 57% of the above factors. At the same time, the most significant change in net incomes is influenced by direct labor expenses. At the same time, material expenses and general production expenses have a minor impact.

The proposed regression model can be used to conduct factor and prediction analysis of the incomes of an agricultural enterprise. It allows to assess the impact on incomes of individual components of production costs and allows to focus the attention of managers on those expense items that are subject to optimization.

This model allows to plan the size of the net incomes of an agricultural enterprise, given the structural shifts in the components of production costs.

The use of such a model serves as information for making management decisions regarding the formation of pricing policy, and also allows to conduct a scenario analysis of trends in the development of crop production.

Thus, the constructed regression model can be integrated into the accounting and analytical support system, providing an agricultural enterprise that grows crop products with an analytical support for strategic and operational planning of activities, especially in conditions of economic instability and military challenges.

3.2. Strategic matrix for managing net incomes and production cost of crop products

It is proposed to analyze the strategies for managing net incomes from the sale of crop products and production cost of an agricultural enterprise for 2015–2024 (Table 3).

During the studied period, the net incomes from the sale of crop products of an agricultural enterprise increased from 229.104 thousand UAH in 2015 to 587.845 thousand UAH in 2024, i. e. increased by 2.5 times.

Analysis of the growth rate of net incomes allows to identify several clearly expressed phases of the development of an agricultural enterprise, which are cyclical in nature.

2016 is characterized by a decline in net incomes from the sale of crop products by 23.5%, which indicates a deterioration in the market situation or a decrease in the sale of such products. From the point of view of economic theory, such dynamics may be the result of the simultaneous influence of the price factor (decrease in the average sales price) and the production factor (reduction in gross collection).

During 2017–2018, there was a positive dynamics of an increase in the incomes of an agricultural enterprise, the growth rates of which were 50.12% and 24.95%, respectively.

At the same time, in 2019, a decrease in incomes (–21.91%) was observed, which is explained by the negative impact of external factors.

In the period 2020–2022, there was an intensive growth in the incomes of the agricultural enterprise, the growth rates of which were 38.95%, 30.60%, 34.85%. This trend is explained by the implementation of effective mechanisms for expanding product exports, optimizing the production structure and increasing prices for crop products on world markets.

In 2023, there was a negative trend in the decline in the incomes of the agricultural enterprise (–44.23%), which is due to the consequences of the war in Ukraine.

However, in 2024, the agricultural enterprise was able to restore the scale of its activities and increase its incomes by 68.30%.

To assess the effectiveness of incomes and expense management of an agricultural enterprise, it is proposed to supplement the coefficient analysis with visualization techniques for their strategic behavior in a coordinate system. This allows not only to diagnose the final results, but also to illustrate the main stages of their receipt.

The primary information for constructing strategic matrices is the data given in Table 3.

The strategic matrix of net incomes management and production cost of crop production of an agricultural enterprise is given in Fig. 1.

The strategic matrix for managing net incomes and production cost of agricultural enterprise is built according to two criteria:

- 1) vertically – the rate of incomes growth (ΔI);
- 2) horizontally – the rate of production cost growth (ΔC).

Within the strategic matrix for managing net incomes and production cost of crop production of agricultural enterprises, six typological zones of activity of such an enterprise are distinguished, which reflect qualitatively different states of financial and economic dynamics (Table 4).

Table 3

Input data for analyzing the effectiveness of the strategy for managing net incomes from the sale of crop products and production costs for 2015–2024

Indicator		Years									
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Net incomes from sales of goods, works and services	Absolute value, thousand UAH	229104	174703	262260	327697	255911	355599	464417	626263	349276	587845
	Absolute growth, thousand UAH	48804	-54401	87557	65437	-71786	99688	108818	161846	-276987	238569
	Growth rate, %	27.07	-23.75	50.12	24.95	-21.91	38.95	30.60	34.85	-44.23	68.30
Production cost	Absolute value, thousand UAH	80522.30	105942.10	139974.80	168380.50	172209.00	168805.10	151660.70	190688.70	289316.30	270720.30
	Absolute growth, thousand UAH	7522.30	25419.80	34032.70	28405.70	3828.50	-3403.90	-17144.40	39028.00	98627.60	-18596.00
	Growth rate, %	10.30	31.57	32.12	20.29	2.27	-1.98	-10.16	25.73	51.72	-6.43

Note: calculated by the authors based on Table 1

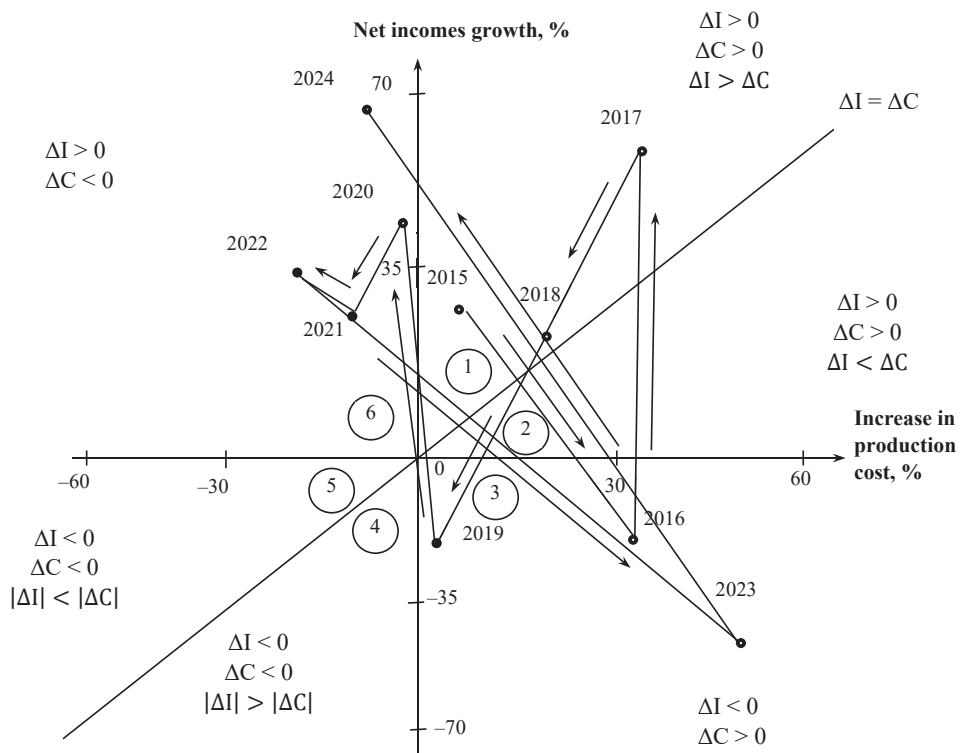


Fig. 1. Strategic matrix for managing net incomes and production cost of crop production of agricultural enterprise LLC "KRAEVYD PODILLIA" for 2015–2024

The agricultural enterprise was in the best zone 6 four times out of ten periods (2020, 2021, 2022, 2024) (Fig. 1), which means that the growth rate of net incomes is ahead of the growth rate of production cost of crop production. In 2020, there was a high margin of sunflower (over 20% in the structure). At the same time, in 2021, a significant impact was made by the high level of prices for agricultural products. In 2024, there was a drop in prices for raw materials (crop protection products, fertilizers), a change in crop rotation (abandonment of spring crops, only winter crops remained), and high yields of rapeseed and wheat. At the same time, weaker positions of the agricultural enterprise are observed in 2016, 2019, 2023 in zone 3, and the increase in potential opportunities in 2015, 2017, 2018 in zone 1 indicates the correct chosen strategy for managing the agricultural enterprise. In zone 1, the following factors influenced:

- a) change in business model;
- b) reduction of personnel and non-core activities;
- c) market conditions;
- d) cost and price management;

e) high productivity indicators due to a high level of production discipline.

Next, it is proposed to analyze the asset management strategies and production cost of the agricultural enterprise for 2015–2025 (Table 5).

During the studied period 2015–2025 (Table 5), the value of the assets of the agricultural enterprise increased from 168898 thousand UAH in 2015 to 1327909 thousand UAH in 2025, that is, almost 7.9 times. The most significant jumps were observed in 2021–2022 (91.82% and 77.96%, respectively), as well as in 2024 (39.28%). At the same time, a decrease in the value of assets was recorded in 2017, 2019 and 2023. The production cost indicator (Table 5) generally demonstrates an increasing trend, namely from 80522.3 thousand UAH in 2015 to 531319 thousand UAH in 2025 (growth of 6.6 times). 2025 is especially critical, when the growth rate was 96.26%, which exceeds the growth rate of assets (–11.85%), forming an imbalance of resource and expense development. The prediction value of the production cost of crop production of an agricultural enterprise is shown in Fig. 2.

Table 4

Typological zones of strategic positioning of an agricultural enterprise that grows crop production in the coordinate system “Net incomes growth – production cost growth”

Typological zone	Characteristics
1	The most attractive zone. In this zone, the growth rate of net incomes exceeds the rate of production cost of crop production. An agricultural enterprise falling into zone 1 is characterized by a stable tendency to increase operating profit
2	The enterprise enters this segment under conditions of simultaneous growth of net incomes and production cost, which may be due to improved marketing strategies and entry into new markets, the introduction of innovative technologies. At the same time, the growth rate of production cost exceeds the rate of incomes growth, which requires careful control over the expenses of an agricultural enterprise
3	This segment is characterized by an increase in production cost with a simultaneous decrease in the rate of growth of net incomes. This trend indicates a deterioration in the profitability of crop production and requires optimization of production expenses. Within this zone, it is necessary to implement anti-crisis management measures aimed at revising the cost policy, optimizing production processes, diversifying sales channels and restoring the incomes base
4	Getting into zone 4 is typical for agricultural enterprises that are reducing their economic activity or are gradually approaching bankruptcy. Deterioration of financial results is observed as the distance from the origin (from 0) and the bisector. Zone 4 is better than zone 3, but the strategy of such an agricultural enterprise regarding the management of net incomes and production costs of crop products is characterized as ineffective
5	Reflects a period of stabilization and adaptation, when the agricultural enterprise restructures the production costs of crop products and adjusts the operating model ($\Delta C \leq 0$, under conditions of slowdown or decrease in ΔD). The main management emphasis is focused on maintaining liquidity, increasing resource utilization and minimizing unproductive expenses. This zone can act as both a stage of preparation for a new growth cycle and a mechanism for responding to external shocks
6	Getting into zone 6 is the most desirable, but unlikely, since in this zone there is a decrease in the growth rate of production costs while the net incomes of the agricultural enterprise increases

Table 5

Input data for analyzing the effectiveness of the asset value and production cost management strategy for 2015–2025

Indicator	Years											
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Asset cost	Absolute value, thousand UAH	168898	242774	239197	291727	305648	353911	678880	1208128	1081554	1506422	1327909
	Absolute growth, thousand UAH	–20241	73876	–3577	52530	13921	48263	324969	529248	–126574	424868	–178513
	Growth rate, %	–10.70	43.74	–1.47	21.96	4.77	15.79	91.82	77.96	–10.48	39.28	–11.85
Production cost	Absolute value, thousand UAH	80522.3	105942.1	139974.8	168380.5	172209	168805.1	151660.7	190688.7	289316.3	270720.30	531319
	Absolute growth, thousand UAH	7522.30	25419.8	34032.7	28405.7	3828.5	–3403.9	–17144.4	39028.0	98627.60	–18596.00	260598.7
	Growth rate, %	10.30	31.57	32.12	20.29	2.27	–1.98	–10.16	25.73	51.72	–6.43	96.26%

Note: based on [33]

The prediction calculations of production cost of crop production for 2026–2027 (Fig. 2) demonstrate the expected adjustment, after a rapid growth in 2025. In 2026, production cost is prediction at 407,057.91 thousand UAH, which means a decrease compared to 2025. Such dynamics may indicate the stability of crop production management, adaptation to new economic conditions or the elimination of one-time expense factors that caused an excessive increase in production cost in 2025.

In 2027, the indicator is expected to increase to 437,788.80 thousand UAH, which indicates a gradual return to a moderate development trajectory. Therefore, the prediction provides for a transition from a sharp increase in expenses to a more balanced model of managing the production cost of an agricultural enterprise.

Let's assess the accuracy of the prediction of the production cost of crop production for 2026–2027 (Table 6).

The results obtained (Table 6) indicate an acceptable level of prediction accuracy and sufficient statistical reliability of the model in the medium term.

The strategic matrix of asset management and production cost of crop production of an agricultural enterprise is shown in Fig. 3.

Within the strategic matrix of asset management and production cost of crop production of agricultural enterprises, six typological zones of activity of such an enterprise are distinguished, which reflect qualitatively different states of financial and economic dynamics (Table 7).

Out of ten periods, three times (2016, 2019, 2022) the agricultural enterprise (Fig. 3) was in the most efficient zone 1, which means that the growth rate of assets exceeds the growth rate of the production cost of crop products. The success factors are the yield in 2019 and the still high level of export prices for crop products in 2022. At the same time, the agricultural enterprise occupied a weaker position in 2015, 2017, 2023, 2025, and the increase in potential opportunities in 2018 indicates the correct strategy for managing the enterprise's resources. During 2020, 2021, 2024, the agricultural enterprise was in the most desirable zone 6, which means that the expansion of assets was accompanied not by an increase in expenses, but on the contrary – by an increase in the efficiency of using resource potential. The right management decisions were made – technological maps were significantly revised (replacement of types of fertilizers and plant protection products, other seed hybrids, optimized application rates), a change in the structure of sown areas (i. e., abandonment of spring crops). Regarding 2021, it was an absolute record of profitability for the entire agricultural sector of Ukraine, there was a coincidence of two positive factors – high yields for all crops, and a very high level of world prices for crop products. Thus, in the above years, the agricultural enterprise demonstrated the most strategically desirable development trajectory, which created the prerequisites for increasing its market value, financial stability and competitiveness.

Next, it is proposed to analyze the strategies for managing the production cost and total expenses of an agricultural enterprise for 2015–2025 (Table 8).

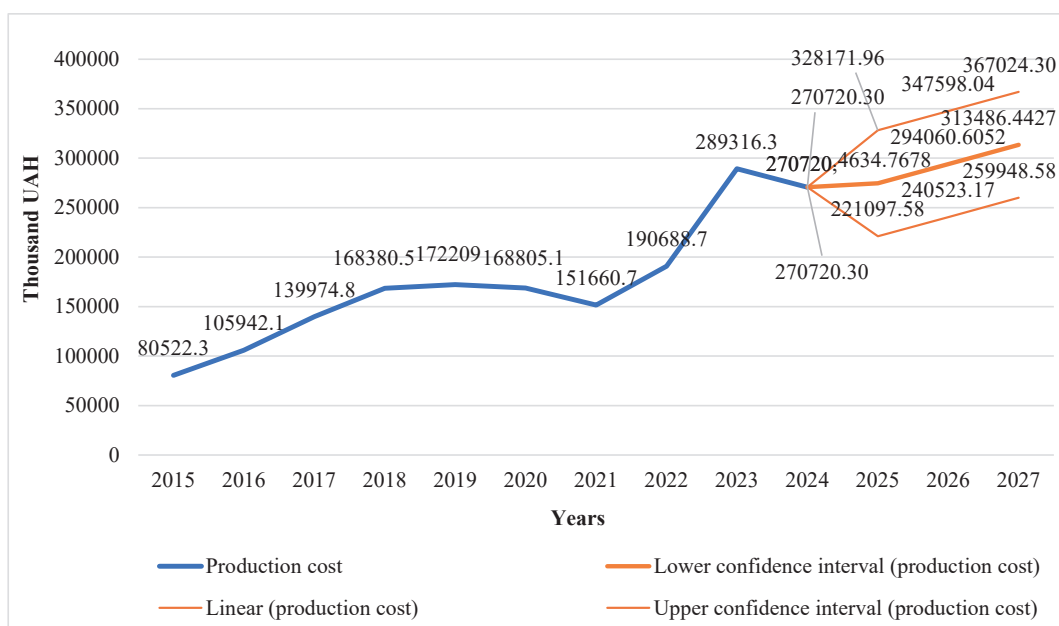


Fig. 2. Prediction value of production cost of crop production of agricultural enterprise for 2026–2027 (calculated by the authors using Microsoft Excel software based on Table 5 using the “Prediction Sheet” function)

Table 6

Assessment of the accuracy of the prediction of the production cost of an agricultural enterprise for 2026–2027

No.	Indicator	Years	
		2026	2027
1	Predicted value of production cost, thousand UAH	294060.6	313486.4
2	Lower limit of confidence interval (production cost), thousand UAH	240523.2	259948.6
3	Upper limit of confidence interval (production cost), thousand UAH	347598.0	367024.3
4	Absolute width of confidence interval, thousand UAH	107074.8	107075.7
5	Relative error, %	18.2	17.1

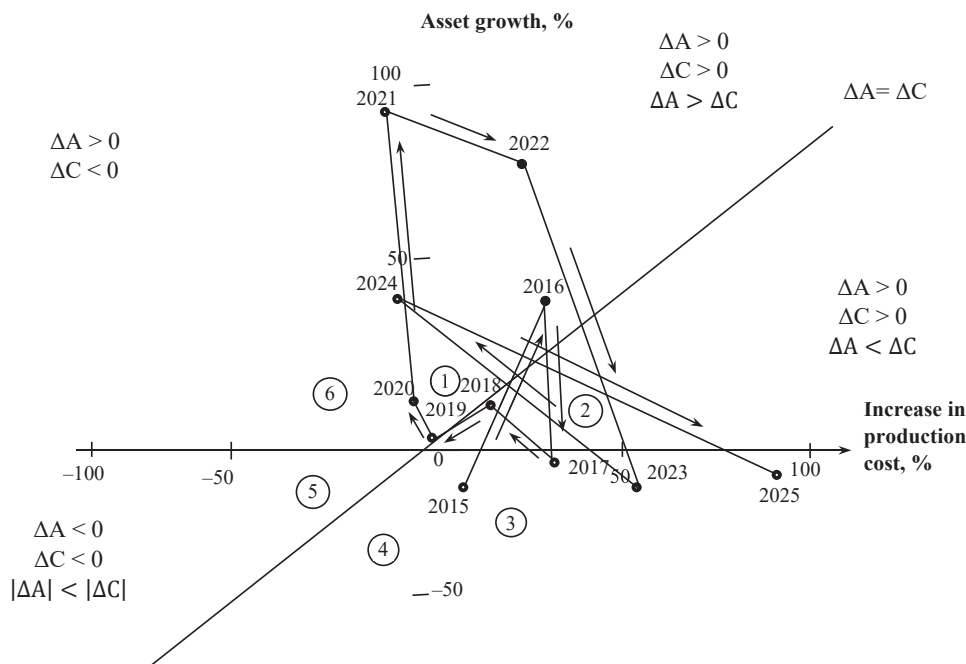


Fig. 3. Strategic matrix of asset management and production cost of crop production of agricultural enterprise LLC “KRAEVYD PODILLIA” for 2015–2025

Table 7

Typological zones of strategic positioning of an agricultural enterprise that grows crop production in the coordinate system “Asset growth – production cost growth”

Typological zone	Characteristics
1	This zone is characterized by the excess of asset growth over the rate of growth of production cost. At the same time, the rates of asset growth and production cost are greater than zero. This is the optimal segment in which the asset management strategy of an agricultural enterprise can be assessed as the most effective. It is here that a balance is achieved between investment development and control of the production cost of crop production, which creates the prerequisites for long-term financial stability and growth in the value of the agricultural enterprise
2	This zone is characterized by the absence of asset growth rates from the rate of growth of the production cost of crop production with a positive value of both indicators. The entry of an agricultural enterprise into this zone from zone 1 is accompanied by a certain lag in the growth of assets from the production cost of crop production. This indicates a weakening of the leading role of assets in the formation of financial results and a decrease in the efficiency of resource potential use
3	A farm enterprise entering zone 3 means an inefficient use of the resource potential of such an enterprise. Phase 3 actually reflects the gap between investment and operational efficiency, when expense management loses strategic coherence with asset management. In the long term, this can lead to a decrease in the profitability of crop production, deterioration of financial stability and loss of competitive positions
4	Zone 4 indicates that the farm enterprise is approaching bankruptcy, while both assets and the production cost of crop production tend to decrease. This configuration indicates a reduction in the scale of economic activity and a narrowing of the resource base of the farm enterprise. At first glance, a decrease in production cost can be interpreted positively, however, in combination with a reduction in assets, it indicates not optimization, but a compression of economic potential. Such dynamics means loss of production capacity and decrease in market activity of agricultural enterprise
5	Zone 5 is characterized by decrease in assets and production cost of crop production, however, the rate of decrease in assets is less than the rate of decrease in cost. This means that the agricultural enterprise operates in conditions of reduction of scale of activity, however, the rate of optimization of production cost of crop production exceeds losses of resource base of the enterprise. This may indicate that the agricultural enterprise is implementing a policy of cost restructuring
6	Agricultural enterprises fall into this zone very rarely, because this zone is characterized by decrease in growth rate of production cost of crop production and increase in growth rate of assets. This zone reflects an investment-efficient development model, in which the expansion of assets is accompanied by increase in operational efficiency

Table 8

Input data for analyzing the effectiveness of the strategy for managing production costs and total expenses of an agricultural enterprise for 2015–2025

Indicator	Years											
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Total expenses of the enterprise	Absolute value, thousand UAH	179298	156943	242253	310682	314650	344976	446788	663115	705802	498528	848239
	Absolute growth, thousand UAH	40203	-22355	85310	68429	3968	30326	101812	216327	42687	-207274	349711
	Growth rate, %	28.90	-12.47	54.36	28.25	1.28	9.64	29.51	48.42	6.44	-29.37	70.15
Production cost	Absolute value, thousand UAH	80522.3	105942.1	139974.8	168380.5	172209.0	168805.1	151660.7	190688.7	289316.3	270720.3	531319
	Absolute growth, thousand UAH	19467.9	25419.8	34032.70	28405.7	3828.5	-3403.9	-17144.4	39028.0	98627.6	-18596.0	260598.7
	Growth rate, %	31.89	31.57	32.12	20.29	2.27	-1.98	-10.16	25.73	51.72	-6.43	96.26

Note: based on [33]

During the period under study (Table 8), the total expenses of an agricultural enterprise increased from 179,298 thousand UAH in 2015 to 848,239 thousand UAH in 2025, i. e. 4.7 times. The dynamics of the total expenses of an agricultural enterprise was uneven, after a decrease in 2016 (-12.47%), steady growth was observed in 2017–2023, with the most significant growth rates in 2017 (54.36%) and 2022 (48.42%). In 2024, a sharp reduction in the total expenses of an agricultural enterprise was recorded (-29.37%), which could be a consequence of the optimization of internal factors and/or the influence of external factors. However, already in 2025 there was an increase of 70.15%, which indicates the restoration of the scale of economic activity or a significant increase in resource prices. The prediction value of the total expenses of an agricultural enterprise is shown in Fig. 4.

The prediction (Fig. 4) demonstrates the growth of total expenses of an agricultural enterprise, with a relatively small increase in 2027, which indicates the planning of a more controlled expense policy and stable operation of the enterprise in the future.

When assessing the accuracy of the prediction of total expenses, it should be noted that the prediction model is characterized by a moderate level of reliability. For the analysis of accuracy, confidence intervals of prediction values were used, which reflect the possible range of prediction fluctuations (Table 9).

The results obtained (Table 9) show that with an increase in the prediction horizon, the level of uncertainty increases, which leads to a decrease in the accuracy of the prediction. Despite this, the model allows to determine the general trend of the expenses of agricultural enterprises. At the same time, the significant width of the confidence intervals indicates the need for careful use of prediction estimates for making appropriate management decisions.

The strategic matrix of asset management and production cost of crop production of an agricultural enterprise is shown in Fig. 5.

Within the strategic matrix of management of total expenses and production cost of crop production of agricultural enterprises, six typological zones of activity of such an enterprise are distinguished, which reflect qualitatively different states of financial and economic dynamics (Table 10).

Out of ten periods, five times (2015, 2017, 2018, 2022, 2025) the agricultural enterprise (Fig. 4) was in zone 1, which means that the growth rate of the enterprise's total expenses exceeded the growth rate of the production cost of crop products. This phenomenon was caused by two different factors:

1) irrational use of resources – economically unjustified norms of fertilizers, plant protection products, fuel (with the services of third-party contractors);

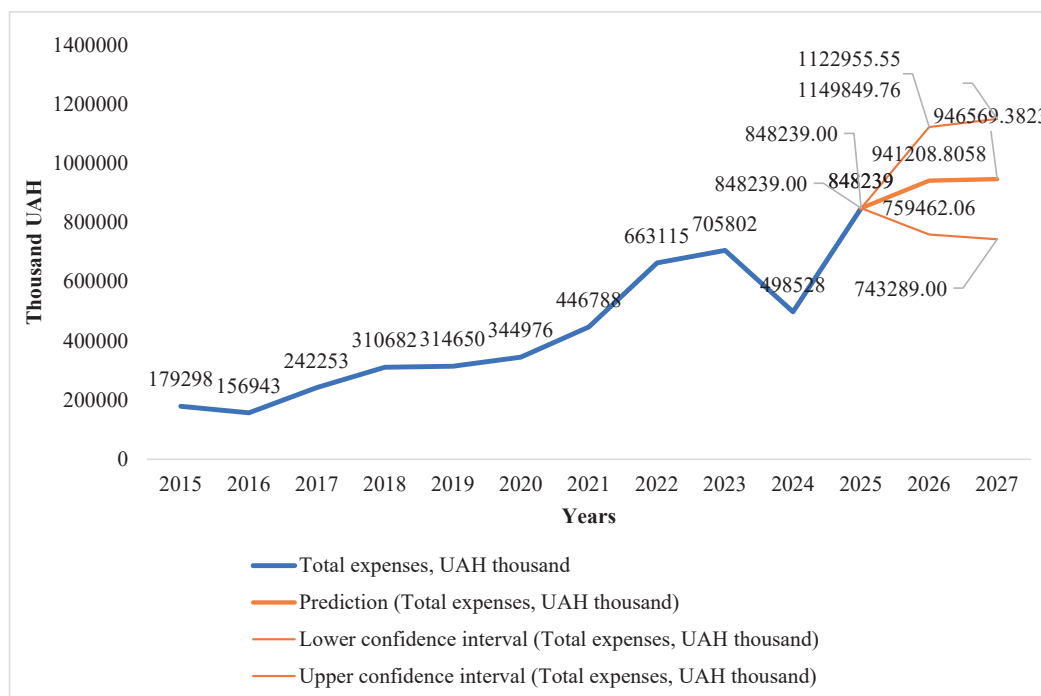


Fig. 4. Prediction of total expenses of an agricultural enterprise for 2026–2027 (calculated by the authors using Microsoft Excel software based on Table 5 using the “Prediction Sheet” function)

Table 9

Assessment of the accuracy of the prediction of total expenses of an agricultural enterprise for 2026–2027

No.	Indicator	Years	
		2026	2027
1	Predicted value of total expenses, thousand UAH	941208.81	946569.38
2	Lower limit of confidence interval (total expenses), thousand UAH	759462.06	743289.00
3	Upper limit of confidence interval (total expenses), thousand UAH	1122955.55	1149849.76
4	Absolute width of confidence interval, thousand UAH	363493.49	406560.76
5	Relative width of confidence interval, %	38.6	42.9

2) high expenses of logistics (field – elevator – port). At the same time, in 2019 and 2023, there was an increase in the growth of production cost over the growth of the agricultural enterprise's total expenses in zone 2 (caused by the growth of prices for mineral fertilizers and gas). It is observed a negative growth in total expenses and an increase in the growth in the production cost of crop production in zone 3 in 2016. At the same time, in zone 4 (2024), it is observed both a negative growth in total expenses and an increase in the production cost of crop

production (a possible reason is a change in the sowing structure, i.e. a complete refusal to sow spring crops – while part of the costs were incurred). At the same time, in 2020–2021, there was an increase in the total expenses of the agricultural enterprise, as well as a negative growth in the production cost of crop production. The high profitability of agricultural production in the post-Covid/pre-war period caused a sharp (by 15–25%) increase in expenses for renting agricultural land (rent per share), respectively, total expenses began to grow.

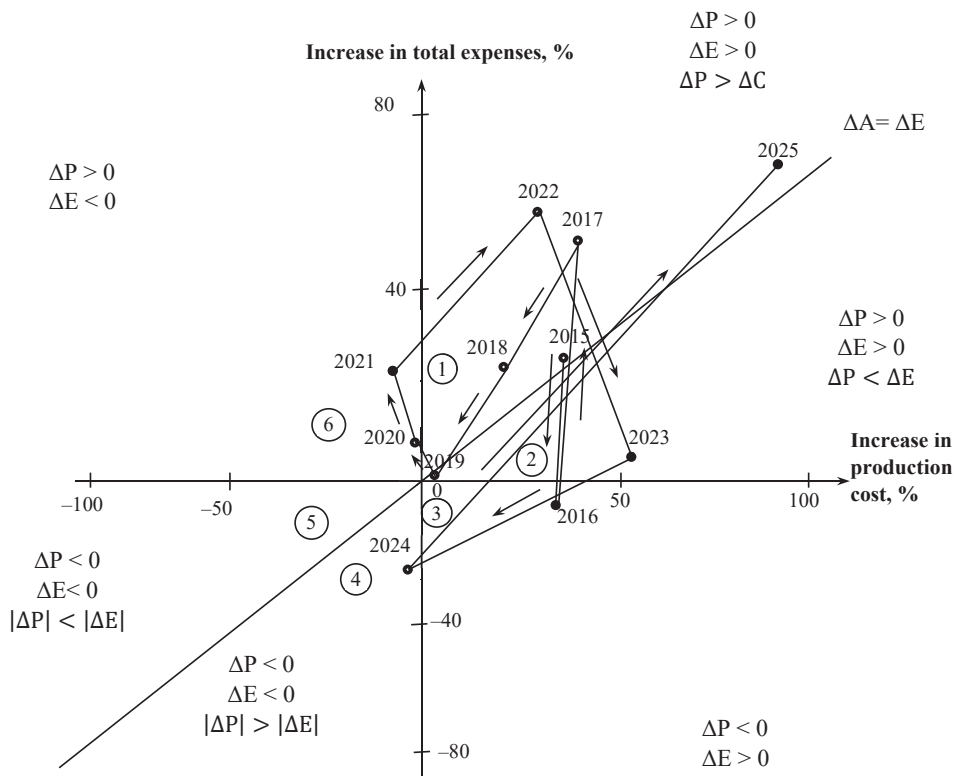


Fig. 5. Strategic matrix of management of total expenses and production expenses of crop production of agricultural enterprise LLC "KRAEVYD PODILLIA" for 2015–2025

Table 10

Typological zones of strategic positioning of an agricultural enterprise that grows crop production in the coordinate system "Increase in total expenses – increase in production cost"

Typological zone	Characteristics
1	This zone is characterized by moderate rates of change in total expenses and production costs of crop production, when their dynamics are consistent and do not go beyond the limits of permissible fluctuations. Total expenses and production costs of crop production are increasing, and the increase in total expenses is greater than the increase in production costs of crop production
2	Zone 2 is characterized by an increase in total expenses and production costs of crop production, and the increase in production costs exceeds the increase in total expenses of the agricultural enterprise. This indicates an expansion of the scale of production of crop production, as well as an increase in the specific weight of resource intensity of crop production
3	The entry of an agricultural enterprise into zone 3 indicates that the increase in total expenses is decreasing, but the increase in production costs of crop production is increasing. This indicates that the cost of resources used to grow crop products is increasing or the volume of crop production is increasing
4	Zone 4 indicates that the agricultural enterprise is approaching the cessation of production, since the increase in total expenses and production cost of crop products is negative, and the increase in total expenses exceeds the increase in production cost. Although the total expenses of the agricultural enterprise are decreasing faster than the production cost of crop products, this does not mean an increase in its efficiency
5	Zone 5 is characterized by a decrease in total expenses and production cost of crop products, but the rate of decrease in total expenses is less than the rate of decrease in production cost. This indicates that the production cost of crop products is decreasing faster than the total expenses of the agricultural enterprise. Unlike zone 4, zone 5 indicates a disproportionate reduction in the production component with a relatively slow adaptation of the management system
6	Zone 6 is characterized by a decrease in the growth in the production cost of crop products and an increase in the growth in the total expenses of the enterprise. Production costs are reduced (due to reduced production volumes or resource savings), while the total expenses of the agricultural enterprise increase. If this trend continues for a long period, the agricultural enterprise may enter a critical loss zone due to the accumulation of unproductive expenses

The results of the regression analysis clearly showed that the production cost of crop products does indeed affect the net incomes of agricultural enterprises in Ukraine – and this effect can be explained from an economic point of view. Variable expenses, such as seeds, mineral fertilizers, plant protection products and fuel, have the greatest effect. Fixed costs, on the contrary, have less effect on net incomes – their elasticity is lower. This is quite logical, because in agriculture it is the expense structure that often determines the financial stability of enterprises.

The results obtained correlate well with the research [1], which confirmed the systemic relationship between production expenses and the financial results of industrial enterprises. However, unlike correlation analysis, this research used a multiple regression model. It allowed to estimate the impact of individual components of the cost on the net incomes of agricultural enterprises in numerical terms. A similar approach was used in the research [6], which proves the dependence of the price of wheat grain on fertilizer expenses. However, it is advisable to pay attention not only to price parameters, but also to the overall financial result of agricultural enterprises. The methodological basis of research corresponds to the classical principles of specification of regression models, which are systematized in the work [2], which ensures the correctness of the interpretation of parameters and the economic validity of the conclusions obtained.

Comparison with international researches in the field of agricultural economics indicates the universality of the use of regression tools for analyzing the determinants of financial results. In particular, in the work [13] it is proven that the economic results of agricultural production are formed under the influence of both internal and external factors. The above-mentioned research focuses on climate change, while in our work the focus is on the internal structure of production costs as a controlled factor in the formation of net incomes of agricultural enterprises.

The results obtained are also consistent with the results of the research [10], which confirmed the effectiveness of regression analysis for predicting financial indicators of the enterprise. Unlike general corporate models, the model proposed in our research takes into account the specifics of crop production – seasonality of the production cycle, transformation of biological assets and high sensitivity to fluctuations in resource prices.

An important result of this research is the illustration of the synergistic effect of the integrated use of econometric modeling of strategic expense behavior based on correlation-regression analysis with matrix research methods, in particular, the method of strategic analysis of the effectiveness of expense and incomes management in the coordinate system based on a dynamic approach.

The proposed map of analytical interpretation of strategic incomes behavior depending on the level of expenses in each segment of the coordinate system makes it possible to coordinate strategic goals and tactical actions for more rational spending of enterprise resources. At the same time, the emphasis is placed on tracking the need to outpace the growth rates of incomes compared to the growth rates of expenses. Opposite trends lead to negative results in the form of losses.

The use of such an integrated approach to analysis based on a combination of various analytical tools makes it possible to coordinate the efforts of managers on the most important factors affecting the results of agricultural enterprises and to timely adjust their strategic goals aimed at optimizing incomes and expenses.

The results obtained can actually be used in practice – the developed analytical tools work well in the crop production management system of agricultural enterprises. The multiple regression model helps management personnel see how individual components of the production expenses of crop products affect net incomes, and quickly find inefficient areas of resource use. This paves the way for optimizing costs, increasing profitability and improving the financial performance of an agricultural enterprise.

When viewed more broadly, at the industry level, these conclusions are important for the formation of effective state support for the agricultural sector. The analysis confirms that it is necessary to create conditions for stable production costs, support investments in technological renewal of production and use resources in agriculture more efficiently. State agricultural policy must take into account the impact of macroeconomic factors – inflation, changes in external markets, geopolitical risks, because all this can seriously change the structure of expenses and incomes of agricultural enterprises.

In general, the use of the proposed analytical approaches will help to more effectively manage expenses at agricultural enterprises and make more informed decisions – both at the management level and at the level of agricultural sector development policy.

The analysis was conducted on the example of one agricultural enterprise in Ukraine that grows crop products. This limits the possibility of directly transferring the results to other enterprises in the industry, regions or countries with different climatic conditions.

In addition, it is advisable to take into account other factors that may have a significant impact on changes in net incomes, in particular weather risks, market risks, price fluctuations, political and social and technological factors, etc.

4. Conclusions

1. The research result is the improvement of the methodology for analyzing the incomes of agricultural enterprises depending on the production cost based on a combination of correlation-regression analysis with methods for visualizing the behavior of expenses in the coordinate system. Such an analysis is proposed to be carried out in two stages. At the first stage, it is proposed to form a multifactor regression model of the dependence of incomes on the total production cost and its individual components, which makes it possible to conduct a factor and prediction analysis of incomes depending on changes in direct material expenses, direct labor expenses, other direct expenses and general production expenses. The proposed model allows to focus the attention of management personnel on the "problematic" elements of production costs, which have an insignificant impact on the growth of the enterprise's incomes, but negatively affect the final financial result due to the irrational use of resources. As a research result, it was found that direct labor expenses have a positive effect on increasing incomes. In particular, with an increase in such costs by 1 thousand UAH net incomes increases by 20.01 thousand UAH. At the same time, the increase in direct material expenses had a negative impact. Thus, with an increase in direct material expenses by 1 thousand UAH, net incomes decreases by an average of 0.187 thousand UAH. This indicates a high material intensity of products and insufficient return on material resources. Therefore, managers of agricultural enterprises need to pay attention to the effectiveness of managing these expense elements. Possible success from using the proposed model is to reduce the production cost of crop products and increase the efficiency of agricultural enterprises.

2. A comprehensive approach to improving the assessment of the effectiveness of expense management of agricultural enterprises involves the use of techniques for visualizing the strategic behavior of indicators of the dynamics of incomes and expenses in the coordinate system. Depending on the directions and trajectory of the vectors of a pair of relative indicators (rates of growth of incomes and cost, or its individual components) over a certain period, conclusions can be drawn about the effectiveness of the enterprise's operational strategies aimed at increasing the profitability of the activity. Maps of analytical interpretation of individual cells of the matrix, in which the enterprise may find itself in certain periods, have been developed. For each zone, a system of tactical measures has been proposed that will contribute to increasing the efficiency of the enterprise's activities.

Integration of the strategic matrix of management of net incomes and production cost of crop production of an agricultural enterprise with accounting and analytical support allows:

- 1) to transform it from a descriptive tool into a mechanism of active strategic management;
- 2) to form an adaptive model of financial and economic behavior of an agricultural enterprise in conditions of an unstable agricultural market and macroeconomic shocks.

Thus, the strategic matrix acquires the status of an integrated analytical module of crop production management, which ensures timely identification of development phases, minimization of financial risks and increase of long-term sustainability of the agricultural enterprise.

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Conflicts of interest

The authors declare that they have no conflict of interest regarding this research, including financial, personal, authorship or other, that could influence the research and its results presented in this article.

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Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that no artificial intelligence technologies were used in the creation of the current paper.

Authors' contributions

Kostiantyn Bezverkhyi: Conceptualization, Methodology, Investigation, Validation, Supervision, Project administration, Writing – original draft, Writing – review and editing; **Volodymyr Khochai:** Resources, Formal analysis, Visualization, Data curation, Writing – original draft; **Iryna Parasii-Verhunencko:** Conceptualization, Methodology, Writing – original draft; **Yuliia Ostapenko:** Funding acquisition, Data curation, Writing – review and editing; **Mykola Matiukha:** Funding acquisition, Visualization.

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