SCIENTIFIC BASIS OF INNOVATION

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THE MAIN ASPECTS OF PRODUCTION OPTIMIZATION OF AGRICULTURAL BUSINESS STRUCTURES IN UKRAINE

Introduction. *Ukrainian agricultural sector has faced the conflict between private business and public interests of society. This situation has led to the necessity to optimize production and to study the conditions for sustainable development in agricultural sector involving the enhancement of economic, social, and ecological performance.*

Problem Statement. *Under the transformational changes of the domestic economy, risks of the war and the lack of funding, there is a need to ensure a high level of agricultural production efficiency. The achievement of this primarily depends on the rational use of available production resources.*

Purpose. *The purpose of the research is to focus on the ways of raising the production efficiency in order to provide the world food safety under the conditions of the war in Ukraine and the decreasing profit ability of agricultural production.*

Material and Methods. *The methodology is based on the theoretical discussion, including the overview of scholarly research literature and public sources using analysis, synthesis, as well as system, logical, structural-functional, comparative, and other methods.*

Results. *The developed optimization models allow raising the efficiency of the crop and livestock production in test agricultural enterprises A and B through reducing the production costs and increasing the profit. In addition, the chosen models take into account the risk factor, which helps to ensure with 95% probability that both enterprises remain profitable even under unfavorable circumstances.*

Conclusions. *Production optimization means to identify the quantitative and qualitative parameters of production process indicators and to bring this process, including the economic, social, and environmental production aspects to optimal conditions. The synergy of such approach is taking into account the interests of private business, society, and environment.*

Keywords: agricultural business structure, balanced development, stockbreeding, social efficiency, employment rate, production optimization.

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The crisis in the Ukrainian agricultural sector has created conditions for the conflict between private business and public interests of society. Its essence is in deterioration of social living conditions in the countryside as well as deterioration of land ecological conditions caused by the low level of organic fertilizers usage and the lack of crops rotation. This situation caused the need of production optimization and sustainable development research in agricultural sector involving issues of economic, social and ecological performance increase.

Under conditions of domestic economy transformational changes, risks of rising and the lack of funding, there is a need to ensure a high level of agricultural production efficiency. The achievement of this level primarily depends on rational use of available production resources. One of the methods to achieve this is production systems of the optimization of agricultural enterprises [4, 8].

Modern agricultural enterprises in Ukraine have dynamic size, whose specialization and production structure changes under the influence of the market condition. Most of the enterprises are at the assets accumulation stage, searching for their niche, which means economic activity diversification. At the same time, because of production costs increase due to the local currency devaluation, agricultural enterprises are optimizing the production costs trying to maximize return on investments [7, 12].

In such circumstances, production structure optimization of agricultural enterprises requires quantitative and qualitative usable resources analysis as well as environmental conditions consideration. The optimization purpose is to improve the enterprise production structure, profit increase as well as the enterprise and its output competitiveness growth for agricultural sector sustainable development, which includes economic, social and environmental performance. Since production optimization is one of the main methods to provide agricultural enterprises effective functioning in uncertain market environment it is extremely important to determine theoretical and methodological features of its implementation, correlation between inputs analysis and their impact on the output as well as parameters and constraints selection for optimization model building in terms of limited resources.

A significant contribution to the research of the production activities of the agricultural business structures and definition of production's optimization belong to such domestic scientists. In particular O. Shubravskaya claims that production optimization is among the main methods to provide agricultural enterprises effective functioning in the unstable market environment. Because of that, its theoretical and methodological implementation features, the correlation between production resources, and their influence on the output as well as parameters and restrictions for the optimization model development under limited resource conditions are extremely important [15].

Highly appreciating the contribution of these scientists for the development of theoretical and methodological foundations in the analysis of the production activity of agricultural enterprises and its efficiency, it should be noted that the question about the influence of the main factors of agrarian production on its effectiveness remains to be fully investigated and needs offers for improvement of the main economic, social and environmental indicators of agricultural production in conditions of economic risks increasing.

In accordance with the economic theory of social welfare, namely its provisions about efficiency of resource distribution, each enterprise should maximize the effect of the use of productive resources taking into account social interests. It means that in addition to the efficient use of resources according to an economic point of view, it should be taken into account the possible negative influence on the nature and potential social problems due to excessive automation of production and the failure of the enterprise to employ workable people of the countryside. Agricultural production in Ukraine belongs to the basic economy sectors of the country. In order to ensure sustainable development it should be stable, cost effective, socially oriented and environmentally friendly. Agricultural development demands ma-

intaining rational attitude between production factors: land, capital and labor.

The main, irreplaceable and eternal agricultural production factor is the land which cannot be ravaged by the time when it properly used. Among the factors, which influence land resources quality should be highlighted natural territory potential, industrial human activities and climate conditions. One of the methods to achieve agricultural land long-term productivity in the human industrial activity process is the compliance with the principle of preserving optimal nutrients balance in the soil.

Agricultural production organizations are made within enterprises, administrative districts, natural areas and regions. The spatial dispersion connected with harvest, fuel, fertilizers transportation as well as certain areas productivity level and intensity of their use, cost and energy resources demand [5]. Organizational and territorial arrangement of agricultural enterprises takes into account their industrial and legal forms as well as type of land ownership.

Agricultural production development has displayed the agricultural market conditions, which influence the production structure. Production structure optimization according to existing market conditions minimizes problems, allows the enterprise properly respond the challenges of market economy and increase its competitiveness. Competitiveness is one of the difficult market economy categories characterized by different criteria and at the different national economy levels evaluates products, enterprises, corporate structures, braches, regions and countries.

Production structure is a set of branches and industries, which are the part of the enterprise and which define the assortment of manufactured goods [1]. The main factors of production structure formation and change are production branch, technology and expertise enterprise level, geographical location, available resource potential etc. The optimal agricultural enterprise structure can be considered the one, which is the most favorable for solving of agricultural production problems, increasing of land protection and productivity, labor productivity, effective use of technological resources, reduce of transport and other production costs, maintaining of alive organisms environment etc.

There are certain concepts of social phenomena in economics, for example, concept "organization of agricultural production". Organization of agricultural production means forms and procedures of labor combining with other purposeful activity elements in order to ensure high-quality products and achieve high labor productivity based on the better use of land, labor and production assets.

According to social welfare economic theory, in particular its statement about resource allocation efficiency each enterprise should maximize the effect of production resources usage taking into account public interest. There are many definitions of "production optimization" in economics, the essence of the main of them is generalized in Table 1.

Table 1. **Balanced Development Interpretation in the Domestic Economic Theory**

Authors	Balanced development interpretation
Mocherny S.V. (2005)	Bringing the process of interaction between human and nature and between people when creating tangible and intangible goods to the optimal (the best) by choosing optimality criteria with quantitative and qualitative parameters with the purpose of productive forces and economic relations development [1].
Zagorodniy A. G. (2021)	Choosing the best (optimal) option from a set of possible ones. The essence is to find such values of economic indicators that correspond to the optimum, that is, the optimal state of the system. Most often, the optimum is the achievement of the best result from the given resource expenditure or the achievement of the given result with the minimum resource expenditure [2].
LepskiyV. V. (2019)	Bringing the system to an optimal state, implementing an optimal solution [9].

Given the mentioned interpretations and the fundamental principles of the welfare theory the most appropriate definition is as follows: production optimization is determining the optimal quantitative and qualitative indicators of the product or service creation process and bringing it into the optimal condition considering the economic, social, and environmental parameters of production. Calculating the optimal production structure options involves the identification of quantitative composition of production resources and the measurement of intensity of their usage required to provide the optimal agricultural production that is proportional to the market demand with the most efficient utilization of land, labor, material and financial resources.

It should be noted that any production optimization is not effective unless the economic, social and environmental aspects are taken into consideration. According to Nobel Prize winner Myrdal, any economist who does not take into account political and social impact on the economic events is dangerous. The scholar criticized economists of the general flow because of losing attention to the moral side of economic theory (Myrdal, G.). Therefore, in addition to effective usage of resources from the economic point of view it is necessary to consider possible negative impact on nature and potential social problems due to excessive production automation and enterprises inability to provide jobs for inhabitants of surrounding villages.

The optimal crop structure may be determined by solving an optimization task using economic and mathematical modelling methods. The objective function in optimization tasks can be of the two types: profit maximization or costs minimization. Let us consider the optimization task with objective function for profit maximization, rented soil land, and costs restrictions, given the risk factor (Skrypnyk A., 2016):

$$w = \sum_{i=1}^{N} c_i x_i \Rightarrow max,$$

$$\sum_{i=1}^{N} b_i x_i \le B,$$

$$\sum_{i=1}^{N} x_i \le S,$$

$$\sum_{i=1}^{N} \sigma_i^2 x_i^2 \le \sigma^2(V). \quad (1)$$

Let us suppose, there are N agricultural crops for which it is necessary to determine land areas x_1; x_2; ..., x_N, in order to provide profit maximization given the following agricultural crops characteristics: income per ha c_1; c_2; ..., c_N, costs per ha b_1; b_2; ...; b_N. The total costs should not exceed B (the budget constraint), while the total area should not exceed S (the area constraint). The last limitation in market conditions is not obligatory because the land can be rented in bigger amounts if budget constraint allows. The objective function is $w(x_1; x_2; ..., x_N)$. The standard linear programming optimization task with the two restrictions has the monoculture crop solution that means that profit maximization requires growing the crop with the highest profitability level: $max(c_i/b_i)$. However, this optimization task formulation does not take into account agricultural production risks as a result of unexpected weather conditions and volatility of the prices for production resources and agricultural products.

Among the existing science risk definitions there are some, which obtain quantitative assessments, especially: loss probability or lower profit level compare to forecast and profitability at a given confidence level (with defined probability). Among many risk indicators used in the economy the most common is profit dispersion, which allows estimating loss probability.

Suppose that in addition to task conditions it is known profit dispersions from 1 ha for each agricultural crop: σ_1^2; σ_2^2; σ_N^2. In order to add nonlinear constraint on the risk level (dispersion) it is necessary to quantify its maximum value. The profit variation coefficient will be appropriate for this purpose: $V = \sigma/\overline{w}$. Basing on normal profit distribution function at $V = 0.1$ losses probability is almost zero whereas at $V = 0.6$ loss probability reaches 5%, so it is necessary to specify at different enterprise profit level a possible range of vari-

ances $\sigma^2(V)$, which corresponding variation coefficient increase from 0.1 to 0.6 with a pitch of 0.1. So there is the following dispersion profit algorithm based on the expected profit and the specified variation coefficient (Skrypnyk A., 2016):

$$\sigma^2 = V^2 \overline{w}^2, V = 0.1; 0.2; ...; 0.6. \quad (2)$$

The total profit dispersion is given in six options for each enterprise according to previously mentioned algorithm. In addition to the common agricultural production indicators there are the following ones: expected profit, costs, profitability, income variation, used as an indicator of profit at 5% confidence level. This indicator used in banking and insurance for risks reduction. It allows defining the lower profit limit which will occur with 95% probability. In case of agriculture production, it means one case in 20 years. Profit at 5% confidence level is calculated in the following way (Skrypnyk A., 2016):

$$w_{0.05} = w - 1.64y. \quad (3)$$

ORGANIZATIONAL AND ECONOMIC EVALUATION OF THE AGRICULTURAL ENTERPRISES FUNCTIONING

Transformational changes are important part of social and economic development that affects the production structure and the size of agricultural enterprises. The typical feature of market transformations is increasing their frequency and impact level, which requires appropriate adaptation to new market conditions. Among the promising directions of agricultural enterprise development under permanent transformational changes is forecasting with further risk management system implementation.

Forecasting the production aims at predicting enterprise environment in the future and developing a corrective plan to deal with external challenges. Timely response to external challenges and production activity planning according to them allows reducing the negative effect of unfavorable transformational changes and to take benefit from potential opportunities for the enterprise. Providing forecast accuracy requires main areas detailed analysis of transformational changes origin, which influence enterprise economic activities. Depending on the enterprise type and transformational changes nature, the changes can vary by the level of impact and consequences for operational economic activity of the enterprise. Given that production resources are limited enterprises should analyze transformational changes impact level on their production activity to identify priorities for response.

Forming the optimal structure and sizes of agricultural enterprises is an important part of their adaptation to transformational changes. Firstly, it is necessary to analyze changes in the factors, which influence the optimal production structure and sizes of agricultural enterprises. The main factors to be considered during the production structure optimization should be: climate conditions, demand and supply of agricultural and food products, return on investment, invested capital turnover period, technological level of production assets and potential for modernization, availability and possibility to use national and international support, etc. For studying the internal and external factors impact on the enterprises economic activity researchers have developed special analysis methods. Among many of them, special attention should be paid to the SWOT-analysis and PESTEL-analysis methods [17].

The PESTEL-analysis method is widely used for studying the external conditions, in particular the political, economic, social, technological, environmental, and legal spheres. This method is appropriate for researching the agricultural sector in Ukraine (Table 2).

All mentioned factors should be considered during the determination of optimal production structure, which allows defining the direction and specialization of agricultural enterprises. Typically, production specialization means higher productivity indicators as compared with diversification. However, focusing on narrow production has higher economic risks in dynamically transformed economy.

The optimization structure should consist of rational combination of crop and livestock production branches considering market conditions as

well as providing economic, social, and environmental efficiency of agricultural production. Rational branch combination involves circulation and utilization of production waste, permanent employment for seasonal employees, increase in the efficiency of production and reduction of financial risks [12].

One of the directions to increase return on investments is the economy of scale. The biggest benefits from it belongs to large agricultural formations — agricultural holdings. These types of formation usually consist of few vertically integrated enterprises and use financial resources from industrial economy sector. The major agricultural holdings in Ukraine and changes in their land area are given in Table 3 [19].

Among the consequences of agricultural holdings development is monopolization of certain spheres of production in Ukraine. For example, *Kernel Group* is the domestic market leader in sunflower oil production with a market share more than 30%,

Table 2. **PESTEL-Analysis of Agricultural Sector in Ukraine**

P 1. Quotas for export of agricultural products 2. Unstable situation in the east and south regions of the country	E 1. Inflation in 2014—2018 at 68.2% 2. Devaluation in 2014—2018 at more than 200% 3. Limited availability of credit resources because of bank crisis
S 1. Dominance of low-skilled staff in the industry 2. Depopulation in Ukraine 3. Outflow of young people from the villages	T 1. Poor agricultural machinery quality in majority enterprises 2. Lack of infrastructure maintenance 3. Slow innovations implementation
E 1. Unstable weather conditions 2. Soil exhaustion and pollution because of failure to comply with agricultural crops growing technology 3. Pollution of ground water and air because of excessive livestock concentration on farms	L 1. Prohibition on land sale for companies until 2024 2. Obligatory sale of foreign currency earnings by exporters

Table 3. **Land Area of Major Agricultural Holdings in Ukraine, thousand ha**

No.	Agricultural holding	Years					
		2017	2018	2019	2020	2021	2021 in % to 2017
1	Kernel Group	387	531	570	533	530	137.0
2	Ukrlandfarming	626	605	578	508	500	79.9
3	NCH	430	430	430	400	396	92.1
4	Myronivskiy Hliboproduct	365	370	370	370	370	101.4
5	Astarta-Kyiv	248	250	250	250	250	100.1
6	Continental Farmers Group	183	182	168	192	195	106.6
7	HarvEast	x	x	x	124	127	102.4*
8	IMK	137	137	132	125	124	90.5*
9	Epicentr Agro	x	x	x	120	121	100.1*
10	Ukrprominvest Agro	x	122	118	120	120	100.0*
	Total	2376	2505	2616	2742	2733	115.5

Note. * as compared with 2020.

Ukrlandfarming produces about 50% of all chicken eggs in the country, *Myronivskiy Hliboproduct* produces about 50% of chicken meat etc. [14]. Moreover, one of the negative consequences of agricultural holdings development is growing social stress in countryside. Reducing number of agricultural enterprises and intensifying production lead to a reduction of employees in agricultural holdings and big enterprises.

There was more than 200% devaluation of Ukraine national currency during 2014—2020. As a result, machinery, fuel, fertilizers, and other costs have increased. In such conditions, the agricultural enterprises are searching for export markets to provide the highest cash flow from sales. The export opportunities improved after Ukraine's accession to the WTO on 16 May 2008 and after the signature of economic part of association agreement with EU on 27 June 2014. It has resulted in easing both the tariff and non-tariff restrictions on the export of Ukrainian goods to WTO members and EU member states, a market with more than 500 million of consumers and more than EUR 101.8 billion agricultural product import in 2021. At the same time, European producers also received free access to Ukraine's market, which will stimulate domestic agricultural enterprises to introduce efficient production and to further optimize the production sizes and structure. In order to improve the export opportunities for agricultural enterprises it is a good practice to implement security and quality standards for agricultural products, such as ISO 9001, Global Gap, FSSC 22000, etc. It should be mentioned that the implementation of international standards in manufacturing process expands the distribution channels [16].

The agricultural products quality requirements has become stricter in the domestic market, as well. For example, processing enterprises have started more careful inspection of agricultural products and made stricter the requirements for product quality. Large food retailers demand quality certificates and inspect production. To comply with the quality and food safety requirements, enterprises should have in place a production process control, which is almost impossible in private households.

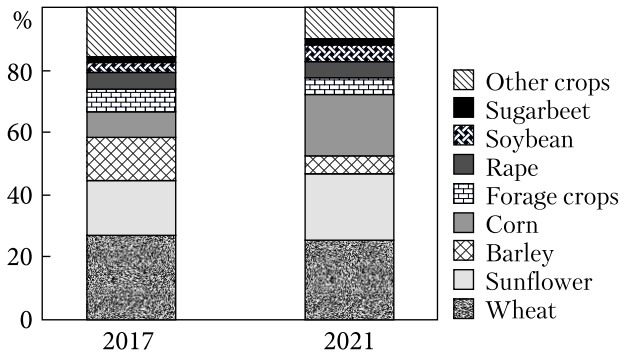

Fig. 1. Crop structure in Ukrainian agricultural enterprises

For studying the optimal production structure and determining the size dependence of Ukrainian agricultural enterprises, it is appropriate to use the statistical methods of economic analysis. According to these methods, usually, the most common types of specialization and sizes of enterprises should be most optimal. The analysis of crop structure dynamics in Ukrainian agricultural enterprises will help identify their specialization and the key market trends (Fig. 1).

The comparison of the crop structure in 2017 and 2021 has shown that agricultural enterprises focused on the most profitable crops production: wheat, corn, sunflower, and soy. The total cultivated land area of agricultural enterprises during the period under review increased from 19206 thousand ha to 19 812 thousand ha, with the share of cereal crops exceeding 50% [21]. At the same time, the structure of cereal crops has changed from 43.9% of wheat, 20.9% of barley and 12.7% of corn, in 2017, to 39% of wheat, 13% of barley, and 31.4% of corn, in 2021. One of the main causes of this change is higher profit and lower risks in the corn production process.

Another trend is reducing the forage crops cultivated area, which is connected with changes in the livestock and poultry structure and reducing the production output of certain animal products. The structure of livestock and poultry changes in the Ukrainian enterprises is shown in Fig. 2.

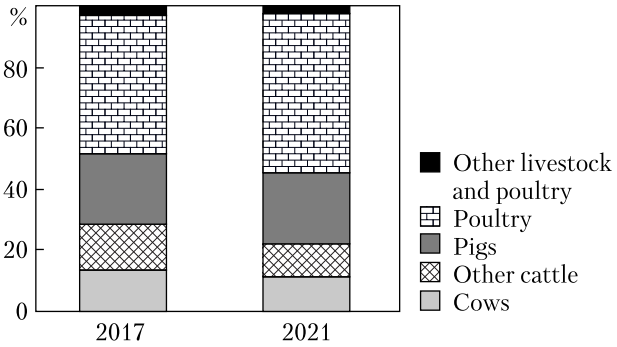

Fig. 2. Livestock and poultry structure of Ukrainian agricultural enterprises

The changes in the livestock and poultry structure are explained by higher profitability and faster capital turnover for the chicken and pork production. At the same time, the cattle production in the most of enterprises is generally unprofitable. As a result, a slump in the cattle production has negative social consequences (a reduction in employment and a decrease in income) and negative environmental consequences (a reduction in the use of organic fertilizers). In addition, creating large chicken and pigs production complexes leads to high risks in the case of disease spread and has a negative impact on groundwater and air pollution.

FORMATION OF OPTIMAL PRODUCTION STRUCTURE IN AGRICULTURAL ENTERPRISES

Most agricultural enterprises have many opportunities to improve their production efficiency. These opportunities are identified by detailed analysis of current situation at the enterprise with further proposals for improving its economic activity by production systems optimization.

As mentioned above, optimization is a process of providing anything with the most favorable characteristics and correlations, for example, optimization of production processes. To formulate an optimization problem requires setting certain parameters: optimality criterion (economical or other), parameters that can influence the process efficiency, process mathematical model, economic and structural conditions, restrictions, and so on.

The optimization task has been solved by using accounting reports for 2007—2021 given by typical test agricultural enterprises A and B of Cherkassy Oblast in Ukraine. The agricultural land area of test enterprises A and B is 3000 ha and 1400 ha respectively, which is used as optimization model constraints. For reducing the variation of indicators as a result of inflation, the data of enterprises are given in the prices of 2021. The main crop production types in the enterprises are: wheat, corn, sunflower, barley (not considered because of a low profitability) and soybean. Having calculated the profit and costs values for both enterprises, we find that they are similar. That is the reason for setting the same coefficients for the objective function and the left side of the constraints. Since the enterprises have different production scale, the right side of the constraints (budget constraint, land areas, dispersion) are given separately. The objective function and constraints in the vector form are written as:

$$\bar{c}\,(3.6;\ 4.9;\ 8.0;\ 4.1);\ \bar{b}\,(7.9;\ 9.4;\ 8.9;\ 6.4);$$
$$\sigma^2(5.0;\ 10;\ 440;\ 70);\ S_1 \le 3000 \text{ ha};\ S_2 \le 1400 \text{ ha};$$
$$B_1 \le \text{UAH } 25 \text{ million};\ B_2 \le \text{UAH } 10 \text{ million}.$$

The profit at 5% confidence level is completely acceptable for the risk level determination in agricultural production. It helps increase the quality of planned revenue forecast. However, the accuracy of calculations depends on the availability of required data for a long period. Therefore, in research we have used the statistical data for 2007—2021. The crop production optimization models for test agricultural enterprise A are given in Table 4.

According to the calculations, there are several model options of crop production optimization. The most optimal solution is option 4 that maximizes profit at 95% probability level. This option includes the following crop structure of 2777 ha total land: 1167 ha wheat, 1334 ha corn, 77 ha sunflower, and 199 ha soybeans. The highest profitability level is achieved at the highest risk (dispersion) in option 6.

However, this strategy is not optimal because of a significant increase in loss probability. The crop production optimization models for test agricultural enterprise B are given in Table 5.

For this agricultural enterprise, the risk constraint remains at the same level, while the budget constraint decreases to UAH 10 million. According to the calculations, the most optimal solution is option 1 that maximizes profit at 95% probability level. This option includes the following crop structure of 1111 ha: total land area: 443 ha wheat, 551 ha corn, 33 ha sunflower, and 84 ha soybeans. Tight budget constraint may encourage company's management to search for the fast solution of a financial situation to production crops with the highest profitability, but this strategy has a high risk level. Growing the crops with higher profitability increases the dispersion higher than the profit, which leads to a significant increase in loss probability. The comparison of the proposed solutions with the efficiency of crop production structure in the 2021 is shown in Table 6.

Table 4. **Crop Production Options of Optimization Models for Test Enterprise A**

Indicators	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Dispersion	$0.5 \cdot 10^7$ (2.24)	10^7 (3.16)	$2 \cdot 10^7$ (4.47)	$3 \cdot 10^7$ (5.48)	$4 \cdot 10^7$ (6.32)	$5 \cdot 10^7$ (7.07)
Land area, ha	1240	1795	2481	2777	2786	2792
including wheat	694	982	1388	1167	790	524
including corn	472	668	945	1334	1610	1805
including sunflower	18	25	35	77	115	141
including soybean	56	80	113	199	271	322
Profit, UAH million	5.2	7.3	10.4	12.2	12.8	13.2
Costs, UAH million	10.4	14.8	20.9	23.7	24.1	24.4
Profitability, %	49.7	49.4	49.8	51.3	53.0	54.0
Profit at 95% probability ($w_{0.05}$), UAH million	1.5	2.1	3.1	3.2	2.4	1.6
Profit variation, %	0.43	0.43	0.43	0.45	0.49	0.54

Table 5. **Crop Production Options of Optimization Models for Test Enterprise B**

Indicators	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Dispersion	$0.5 \cdot 10^7$ (2.24)	10^7 (3.16)	$2 \cdot 10^7$ (4.47)	$3 \cdot 10^7$ (5.48)	$4 \cdot 10^7$ (6.32)	$5 \cdot 10^7$ (7.07)
Land area, ha	1111	1121	1155	1181	1200	1216
including wheat	443	108	0	0	0	0
including corn	551	800	746	645	569	504
including sunflower	33	64	148	203	244	279
including soybean	84	149	261	333	387	433
Profit, UAH million	4.9	5.4	5.9	6.1	6.3	6.5
Costs, UAH million	9.5	9.8	10	10	10	10
Profitability, %	51.5	55.1	59	61	63	65
Profit at 95% probability ($w_{0.05}$), UAH million	1.2	0.2	−1.4	−2.9	−4.1	−5.1
Profit variation, %	0.45	0.57	0.76	0.9	1.0	1.1

It should be noted that the proposed optimization solutions are cost-effective for the studied enterprises. Test enterprise A has an increase in the average profit per ha by 102.2%, while enterprise B increases it by 102.1%. At the same time, an increase in the costs is lower for both enterprises: 46.6% for enterprise A and 40.2% for enterprise B. These calculations explain why wheat remains the main commodity in the crops production structure of many agricultural enterprises in terms of food security in market economy. This factor is caused by the ratio of profitability and risks, which guarantees a stable profit to company. The comparison of the proposed solutions with the efficiency of livestock production structure in 2021 is shown in Table 7.

The proposed optimization solutions are cost-effective for the studied enterprises. Test enterprise A has an increase in the average profit per conditional head by UAH 3879.7 (from UAH 2195.2/head to UAH 1684.5/head), while enterprise B increases it by UAH 7388.4 (from UAH 5983.9/head to UAH 1404.5/head). At the same time, an increase in the costs are low for both enterprises, 31,4% for enterprise A and 18.4% for enterprise B. The optimization models have been developed given the further production diversification through expanding the livestock production and increasing the total production due to crop rotation. The proposed optimization structure implementation requires the expansion of agricultural enterprises investment activities, in particular due to innovations.

Table 6. **Crop Structure Optimization of Test Agricultural Enterprises A and B and Its Effectiveness in the Future**

Indicators	2021		2025 (projected)*		Indicator change, %
	ha	%	ha	%	
Enterprise A					
Wheat	460	15.8	1167	37.3	+153.6
Corn	1850	63.4	1334	42.6	–27.9
Barley	135	4.6	0	0.0	–100.0
Sunflower	300	10.3	74	2.4	–75.3
Soybean	171	5.9	199	6.4	+16.4
Forage crops	0	0.0	355	11.3	+355 ha
Total area	2916	100	3129	100	+7.3
Costs, UAH/ha	9267.4		13582.7		+46.6
Profit, UAH/ha	3626.9		7334.7		+102.2
Enterprise B					
Wheat	134	9.6	443	315	+230.6
Corn	800	57.3	551	393	-31.0
Barley	130	9.3	0	0,0	–100.0
Sunflower	154	11.0	33	24	–78.5
Soybean	179	12.8	84	6.0	–53.0
Forage crops	0	0.0	292	208	+292 ha
Total area	1397	100	1403	100	+0.4
Costs, UAH/ha	9072.2		12722.8		+40.2
Profit, UAH/ha	3538.6		7149.0		+102.1

Note. * — costs and profit calculated in the prices of 2021.

At the same time, because of decreasing investments in the Ukrainian economy under the economic and political crisis of 2014—2018, in particular, as a result of a reduction in the investment attractiveness and changes in the institutional legislation, including the Internal Revenue Code, it is important to consider possible investment risks through the risk management implementation. Risk management involves the adoption and realization of management decisions for reducing unsatisfactory probability and minimizing possible losses during investment project implementation. The algorithm of decision-making process can be described as: risks identification, risk probability level analysis, estimation and accumulation of resources for risk counteraction.

One of the methods for addressing risks is insurance. Insurance is sharing the risk between the participants of economic process with obtaining the right for reimbursement of losses [10]. This enables more accurate cost and revenue planning. At the same time, to determine the risk insurance feasibility requires to analyze the risk coefficients for the main crop and livestock products, the insurance-related costs, possible losses in the case of risk occurrence, and the costs of risk counteraction by using internal resources. In particular, the optimization model calculations have shown that the crop production is associated with higher risk level than the livestock production. The Ukrainian agricultural insurance market is small: in 2021, less than 4% of cultivated crops were insured. At the same time, in USA, Brazil, Austria, Canada, and Spain, insurance companies cover 55—70% of agricultural crops (Vilenchuk O.) [20]. However, risk may be managed by enterprise's internal resources, if the effectiveness of this method is higher than that of insurance services. Usually, it means involving full-time and freelance employees into project implementation and risk remedy.

Table 7. **Livestock Structure Optimization of Test Agricultural Enterprises A and B and Its Effectiveness in the Future**

Indicators	2021		2025 (projected)*		Indicator change, %
	heads	%	heads	%	
Enterprise A					
Cattle	194	24.3	173	12,3	−10.8
including cows	60	10.4	143	10,9	+138.3
Pigs	1456	75.7	3838	87,7	+163.6
Livestock, condit. heads	577	100	1312	100	+127.4
Costs, UAH/condit. heads	11668.4		15329.8		+31.4
Profit, UAH/condit. heads	−2195.2		1684.5		+ UAH 3879.7
Enterprise B					
Cattle	565	63.8	190	19.1	−66.4
including cows	250	36.3	160	17.1	−36.0
Pigs	831	36.2	2521	80.9	+203.4
Livestock, condit. heads	688	100	934	100	+35.8
Costs, UAH/condit. heads	16143.3		19111.4		+18.4
Profit, UAH/condit. heads	−5983.9		1404.5		+UAH 7388.4

Note. * — costs and profit calculated in the prices of 2021; condit. heads calculated as cattle*0.6; cows*1; pigs*0.3 according to the Ukrainian national methodical recommendations.

Production optimization means to identify the quantitative and qualitative parameters of production process indicators and to bring this process, including its economic, social, and environmental production aspects, to optimal conditions. The synergy of such approach is taking into account the interests of private business, society, and environment. The main private business interest is to increase profit, to decrease costs, to shorten the capital turnover period, to ensure return on investments, etc. The main social and environment interests are to create new jobs, to increase salaries, to improve job conditions, to reduce pollution, to improve conditions of renewable resources, etc.

Studying the external environment of Ukrainian agricultural enterprises has shown that there are quotas for export of agricultural products to EU and unstable situation in the east regions. The economic sphere characterized by 68.2% inflation rate and more than 200% depreciation during 2014—2021, moreover, banking crisis have led to difficult access to finance resources. The social sphere can be described by the domination of low skilled employees and the outflow of young people from villages. The technological field is about low quality of agricultural machinery in major enterprises, insufficient maintenance of infrastructure and slow implementation of innovations. The environment field is unstable climatic conditions, soil and groundwater pollution. The legal sphere is characterized by the restrictions on land sale until 2025, the increasing tax pressure during 2014—2021, and the requirement for obligatory sale of foreign currency revenue by exporters.

The largest Ukrainian agricultural holdings have been continuingly increasing their rented agricultural land: in 2017—2021, the total cultivated area of the top 10 agroholdings almost tripled from 1190 thousand ha to 3104 thousand ha. The crop and livestock production in most enterprises is narrow, so the main crops are wheat, sunflower, and corn, which account for 25%, 21%, and 20% of the total cultivated area respectively. More than 50% of livestock in the agricultural enterprises is poultry, while the share of pigs is almost 25%.

The developed optimization models allow raising the crop and livestock production efficiency in test agricultural enterprises A and B due to reducing the production costs and increasing the profit. In addition, the models take into account the risk factor, which helps ensure with 95% probability that both enterprises remain profitable even under unfavorable conditions. These proposals ensure sustainable development of agricultural enterprises, which involves the enhancement of the economic, social, and environmental performance.

This research was prepared before the full-scale aggression of the Russian Federation against Ukraine, which has caused serious logistics problems for Ukrainian agricultural products. Also, domestic prices for most of agricultural products are 1.5—2 times lower than the world average prices. Moreover, fertilizers from Belarus and Russia (totally more than 20% of the world fertilizers production) have not been available for the Ukrainian producers any longer.

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ОСНОВНІ АСПЕКТИ ОПТИМІЗАЦІЇ ВИРОБНИЦТВА У СІЛЬСЬКОГОСПОДАРСЬКИХ СТРУКТУРАХ АГРОБІЗНЕСУ В УКРАЇНІ

Вступ. Сільськогосподарська галузь України опинилася в умовах конфлікту між приватними інтересами та інтересами суспільства. Така ситуація спричинила потребу виробничої оптимізації та вивчення питання збалансованого розвитку у сільськогосподарському секторі з урахуванням зростання економічних, соціальних та екологічних показників.

Проблематика. В умовах трансформаційних змін вітчизняної економіки, ризиків війни та недостатнього фінансування є потреба у забезпеченні високого рівня виробничої ефективності сільського господарства. Досягнення цього рівня, в першу чергу, залежить від раціонального використання доступних виробничих ресурсів.

Мета. Пошук шляхів підвищення виробничої ефективності для забезпечення світової продовольчої безпеки через військові дії в Україні та зниження дохідності вирощування сільськогосподарської продукції.

Матеріали й методи. Методологія передбачає дослідження наукової літератури та публікацій з відкритих джерел із використанням методів аналізу та синтезу, а також системного, логічного, структурно-функціонального, порівняльного та інших методів.

Результати. Розроблені оптимізаційні моделі підвищують виробничу ефективність галузей рослинництва та тваринництва у тестових сільськогосподарських підприємствах А та Б за допомогою зменшення виробничих витрат та підвищення прибутку. Крім того, обрані моделі враховують фактор ризику, який допомагає забезпечити 95 % імовірність отримання прибутку обома підприємствами навіть у випадку настання несприятливих умов.

Висновки. Виробнича оптимізація означає визначення кількісних та якісних параметрів виробничого процесу та приведення цього процесу до оптимальних умов, охоплюючи економічні, соціальні та екологічні виробничі аспекти. Синергія цього підходу полягає у поєднанні приватних інтересів бізнесу, а також соціальних та екологічних інтересів суспільства.

Ключові слова: структура аграрного бізнесу, збалансований розвиток, тваринництво, соціальна ефективність, рівень зайнятості, оптимізація виробництва.