VARIABILITY OF THE INFLUENCE OF CAPITAL INVESTMENTS ON THE COST EFFICIENCY OF THE GRAIN INDUSTRY

Vitaliy MAKOHON
Ph.D. (in Economics), Associate Professor, Associate Professor of Department of Finance, Banking and Insurance, State Biotechnological University, Ukraine
e-mail: witmak.ua@gmail.com

The grain industry is recognized as the leader of the domestic agricultural market and the entire economy of Ukraine. The level of its development is a priority lever that guarantees food and national security of the state. Ukraine is one of the main players in the international grain trade market, and the tendency to increase production volumes remains quite stable for a long period. Unfortunately, the start of hostilities in Ukraine poses significant obstacles to the further normal development of the grain industry, since according to forecasts, wheat production in Ukraine should reach 34 million tons by the end of 2029 and the country would enter the 5 countries - leading grain exporters (Cheremisina, S., et al., 2001).

Maintaining this dynamic requires increased investment in the latest technologies for grain production, harvesting and processing. At the same time, contrary to expectations, there is a decrease in the number of grain harvesters in agricultural enterprises from 65.2 thousand units. in 2000 to 26.5 thousand units. at the beginning of 2022. The reasons for this are the imbalance of price trends for finished products and means of production, which causes a decrease in the return on investment in the latter. Considering this, the need of the hour is the study of methodical approaches to modeling the size of capital investments of agricultural enterprises to update grain harvesting equipment according to the criterion of maximizing the return on costs of the grain industry.

Considerable attention was paid to the problems of estimating and increasing the economic efficiency of costs for the production of grain crops in the works of V. Andriychuk (2006), V. Boyka (2007), Yu. Voskobiynyka (2013), L. Zaburanoi

(2014), O. Zakharchuk (2020), M. Zubets, P. Sabluka (2011), I. Klochan (2018), I. Kuzmenko (2015), Yu. Lupenko (2017), V. Mesel-Veseliaka (2018), O. Shpychak (2013) and many other researchers.

The problems of the development of material and technical support of the grain industry were investigated in the works of V. Adamchuk (2012, 2015), Y. Bilouska (2019), M. Hrytsyshina (2015), O. Popka (2011), V. Skotsika (2012) et al. In their works, the named authors highlighted the state and prospects of providing this industry with technical resources and updating its material and technical base.

At the same time, the vector of development of technical science is mainly aimed at researching the issues of using grain-harvesting equipment, increasing its productivity, and determining the optimal load on it. A significant contribution to the development and research of the organization of the use of grain-harvesting equipment was made by D. Voytyuk (2004, 2005), V. Dubrovin (2004), T. Ishchenko (2004), V. Baranovskyi (2005), V. Bulhakov (2005), A. Rud' (2012), I. Bendera (2011), P. Sysolin (2002), T. Rybak (2002), V. Salo (2002) and many others. However, approaches to determining the optimal amount of investment in the renewal of the fleet of combine harvesters, taking into account the level of concentration of production, price dynamics on the markets of means of production and agro-production, agrobiological factors of production and design features of combine harvesters, require further research.

The purpose of the article is to highlight the results of modeling the impact on the efficiency of costs for the production of wheat grain of capital investments of agricultural enterprises to update grain harvesting equipment.

The first step of the study was the determination of the analytical form of the dependence of wheat yield on variable costs per hectare of harvested area. Based on the statistical reporting of agricultural enterprises of Ukraine for 2020, it was established that it is reflected by the equation:

$$f_1(x) = -0{,}180x^2 + 6{,}425x, \quad (1)$$

where $f_1(x)$ – yield of wheat, tons/ha; x – variable production costs per 1 ha of harvested wheat area, UAH thousand.

This dependence is characterized by a high level of statistical reliability, as evidenced by the value of the coefficient of determination (R^2), which for function (1) is 0.9106, as well as the excess of the estimated value of the Fisher coefficient (Fp = 28.0) over its tabular value (Ftab. = 0.116). At the same time, based on the values of the Student's t coefficient, the coefficients for the linear and quadratic terms of the formula (1) were also highly reliable. In particular, with the tabular value of this coefficient from -1.72 to 1.72, its actual values with the specified members were equal to 3.2 and 6.17, respectively.

Using (1), variable costs per unit of crops were calculated, which guarantee the achievement of maximum productivity. To do this, it was differentiated with respect to x, which made it possible to determine the first derivative:

$$\frac{df_1(x)}{dx} = -0{,}359x + 6{,}425 \quad (2)$$

Equating the right-hand side of (2) to zero and solving the resulting equation with respect to x, it was established that when the production intensity approaches the productive optimum of variable costs per unit of crops, which characterizes the value of variable costs, which ensures the maximization of productivity and is equal to 17.9 thousand hryvnias/ ha, the maximum yield reaches 57.5 hundredweights per hectare. The key to its achievement is the observance of optimal harvesting periods, which in the case of single-phase (direct) harvesting should not exceed 6-10 days after the wheat reaches full maturity. At the same time, an analysis of the conditions and timing of early grain harvesting in 2016-2020 shows that due to the insufficient quantity and unsatisfactory technical condition of most of the grain harvesting equipment, its duration was from 32 to 55 days (Oliynyk, O., et al., 2021). At the same time, the extension of the duration of the harvesting campaign beyond a ten-day period caused a daily decrease in productivity by 1% (Kyrychenko, V., et al., 2015), as a result of which more than 10% of the potential harvest was lost, i.e. 6-6.5 million tons of grain.

Taking this into account, the next task was to determine the optimal level of variable costs, which will allow, by slightly reducing the expected yield level, to minimize crop losses and maximize the return on production. For this, the variable d was introduced into equation (1), which characterizes the duration of harvesting, and the percentage of daily losses after the completion of ten days from the moment the wheat reaches full maturity, which is equal to 0.01. Taking this into account, the function of the dependence of wheat yield on variable costs per hectare of harvested area and harvesting time, provided that it lasts more than ten days:

$$f_2(x,d) = -0{,}180x^2 + 6{,}425x - 0{,}01 \cdot (d-10) \cdot (0{,}180x^2 + 6{,}425x) = \\ = (1{,}1 - 0{,}01d) \cdot (-0{,}180x^2 + 6{,}425x), \quad (3)$$

where $f_2(x)$ – yield of wheat, tons/ha; x – variable production costs per 1 ha of harvested wheat area, UAH thousand; d – duration of the collection campaign, days.

Therefore, taking into account the variability of approaches to determining yield for different durations of the harvesting campaign, equations (1) and (3) were combined into a system, the application of individual functions in which depends on the threshing period:

$$f_3(x,d) = \begin{cases} (-0{,}180x^2 + 6{,}425x), if\ d \le 10 \\ (1{,}1 - 0{,}01d) \cdot (-0{,}180x^2 + 6{,}425x), if\ d > 10, \end{cases} \quad (4)$$

where $f_3(x)$ – yield of wheat, tons/ha; x – variable production costs per 1 ha of harvested wheat area, UAH thousand; d – duration of the collection campaign, days.

It should be noted that, according to many researchers, the duration of the harvesting campaign determines the expected gross harvest, as well as the number and productivity of grain harvesting units (Voytyuk, D., et al., 2008; Pastukhov, V., et al., 2001; Ruzhyts′kyy, M., et al., 2011; Shmat, K., et al., 2003). At the same time, based on the generalization of the results of field experiments, M. Ruzhitsky (2011) established that the most relevant estimate of the expected duration of collection is given by the formula:

$$d(pl, \text{Ур}, n) = \frac{pl \cdot \text{Ур}}{W_{\text{год}} \cdot \text{Т}_{\text{зм}} \cdot n \cdot \text{К}_{\text{врч}}}, \quad (5)$$

where, pl – harvested area, ha; $У_р$ – expected yield, tons/ha; $W_{год}$ – hourly productivity of the grain harvester, hundredweight/hours; $Т_{зм}$ – shift duration, hours; $К_{врч}$ – coefficient of utilization of the working time of the shift; n – number of grain harvesting units, units.

Based on the assumption that for the purposes of modeling the impact of technical support of harvesting operations on the technical and economic efficiency of wheat production, it is acceptable to calculate yield using (1), formula (5) underwent the following transformation:

$$d(pl, x, n) = \frac{pl \cdot f_1(x)}{W_{\text{год}} \cdot \text{Т}_{\text{зм}} \cdot \text{К}_{\text{врч}} \cdot n}. \quad (6)$$

As you know, the productivity of the grain harvesting unit is determined by the throughput capacity of its thresher (q_k), which depends on the power of the engine and can vary depending on the design features of grain movement from the header to the hopper. At the same time, according to DSTU ISO 8210:2012, the formula is used to calculate the productivity of the grain harvester:

$$W_{\text{год}} = \frac{3600 \cdot q_k \cdot (1 - \nu_{\text{УР}})}{(1 + \alpha_{\text{сол}}) \cdot 100}, \quad (7)$$

where, $W_{год}$ – hourly productivity of the grain harvester, hundredweight/hours; q_k – nominal throughput capacity of the combine thresher, kg/s; $\nu_{ур}$ – yield variation coefficient (recommended value 0.2); $\alpha_{сол}$ – ratio of grain and straw in mass (recommended value 1÷1.2).

In turn, taking into account that, according to the data of statistical reporting, units with an engine power of 330-335 hp are mostly used by domestic grain producers. a similar model was chosen during the simulation as the base model. The analysis of the market of grain harvesting equipment shows that the closest to the indicated capacity are the sixth class combines widely represented on it - *New Holland CR7.90*, *John Deere S670*, *John Deere S770*, *CASE IH 7140*, *CASE IH 7240*, *Gleaner S97*, *Claas Lexion 740*, *Massey Ferguson 9540*, *Massey Ferguson 9545* [31]. At the same time, taking into account the results of the analysis of the offer of aggregates from this list on the website Tractothouse.com [32], the model with the largest number of lots - John Deere S670, which has a nominal engine power of 317 hp, was chosen as the base during the calculations. and thresher throughput – 8.5 kg/s. Based on these considerations, substituting the last value into (7), it was established that the hourly productivity of this harvesting unit is 111.27 hundredweight/hours:

$$W_{\text{год}} = \frac{3600 \cdot q_k \cdot (1 - \nu_{\text{УР}})}{(1 + \alpha_{\text{сол}}) \cdot 100} = \frac{3600 \cdot 8{,}5 \cdot (1 - 0{,}2)}{(1 + 1{,}2) \cdot 100} = 111{,}27 \text{ hundredweight/hours}. \quad (8)$$

Further, assuming that the agricultural enterprise uses one of its own *John Deere S670* combine harvesters, the technical and economic efficiency of purchasing one or two similar units was assessed. To do this, by substituting the hourly productivity of the *John Deere S670* combine harvester, shift duration (12 hours), shift working time utilization factor (0.7) into function (6), and assuming that the harvesting area is 500 hectares, it was determined that in the case of using one harvester, the dependence of the threshing period on the variable operating costs per sowing unit is characterized by the equation:

$$d(500, x, 1) = \frac{500\cdot(-0{,}180x^2+6{,}425x)}{111{,}27\cdot12\cdot0{,}7\cdot1} = -0{,}096x^2 + 3{,}437x, \qquad (9)$$

where x – variable production costs per 1 ha of harvested wheat area UAH thousand.

On the other hand, in the case of using two or three combines, the dependence of the threshing period on the variable operating costs per sowing unit is as follows:

$$d(500, x, 2) = \frac{500\cdot(-0{,}180x^2+6{,}425x)}{111{,}27\cdot12\cdot0{,}7\cdot2} = -0{,}048x^2 + 1{,}719x, \qquad (10)$$

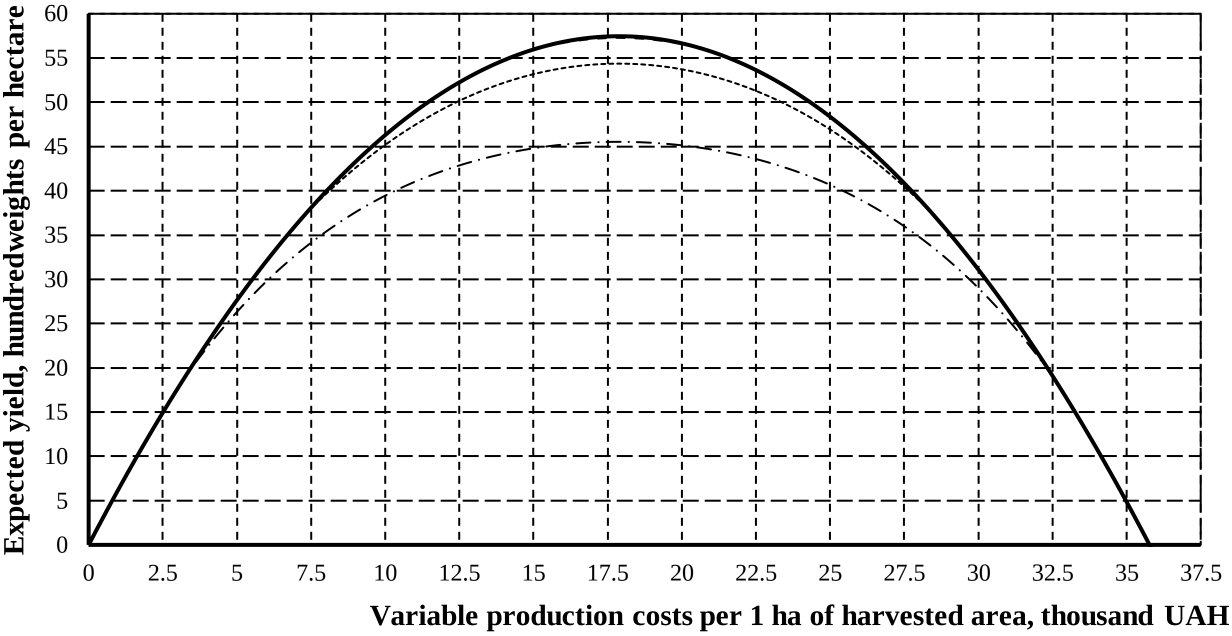
where x – variable production costs per 1 ha of harvested wheat area UAH thousand.

and

$$d(500, x, 3) = \frac{500\cdot(-0{,}180x^2+6{,}425x)}{111{,}27\cdot12\cdot0{,}7\cdot3} = -0{,}032x^2 + 1{,}146x, \qquad (11)$$

where x – variable production costs per 1 ha of harvested wheat area UAH thousand.

So, if an agricultural enterprise uses wheat grain production technology with variable costs per crop unit equal to 17.9 thousand UAH/ha, then 500 hectares of wheat will be threshed by one combine in 30.7 days (3.437 · 17.9 – 0.096 · (17,9)2). Taking this into account, 20.7% ((30.7-10)*1%) of the potential harvest will be lost, which is equivalent to 11.9 hundredweights per hectare, and the expected yield will be 45.6 hundredweights per hectare. Instead, harvesting with the involvement of two harvesters will allow the work to be completed in 15.4 days (1.719 · 17.9 – 0.048 ·(17.9)2). At the same time, 5.4% ((15.4-10)*1%) of the potential harvest will be lost, which is equivalent to 3.1 hundredweights per hectare, and the expected yield will be equal to 54.4 hundredweights per hectare. The obtained results, as well as their graphic illustration (Fig. 1), confirm the positive impact of the increase in the level of technical support on the technological efficiency of grain production.



Dependence of productivity (hundreds per hectare) on variable production costs per 1 hectare of harvested area (thousand UAH)

under the conditions of the end of the harvesting company in the optimal agro-technological terms

under the conditions of using one John Deere S670 grain harvester and a harvesting area of 500 hectares

under the conditions of using two John Deere S670 grain harvesters and a harvesting area of 500 hectares

Fig. 1 Impact on wheat yield of production intensity and technical support of harvesting operations in agricultural enterprises of Ukraine in 2020.

Source: Author's own calculations according to the official website of the State Statistics Service of Ukraine http://www.ukrstat.gov.ua/

So, the results of modeling wheat yield indicators using the system of equations (4) indicate a positive effect of improving the technical support of grain production on its technological efficiency. This gives grounds for its use in modeling the impact of the intensity and technical support of grain production on its economic efficiency. For this reason, the system of equations (4) was transformed. In particular, based on the assumption of one hundred percent marketability of grain production, to determine the expected volume of marketable products, the first and second equations were multiplied by the average price of wheat sold by agricultural enterprises of Ukraine in 2020, which, according to the official website of the State Statistics Service, was 386.75 UAH per quintal.

Taking into account the measurement of variable costs per unit of crops in the system of equations (4) in thousand UAH, the price of 1 t of wheat grain was converted into the unit of the same name. Taking this into account, the system of equations for estimating the expected yield of marketable products per unit of crops has the following form:

$$f_4(x,d) = \begin{cases} 0{,}3868 \cdot (-0{,}180x^2 + 6{,}425x), if\ d \leq 10 \\ 0{,}3868 \cdot (1{,}1-0{,}01d) \cdot (-0{,}180x^2 + 6{,}425x), if\ d > 10, \end{cases} \quad (12)$$

where $f_4(x)$ – expected output of marketable products, thousand UAH per ha; x – variable production costs per 1 ha of harvested wheat area, thousand UAH; d – duration of the collection campaign, days.

After that, system (12) was adapted to determine the expected marginal profit, for which the right-hand side of the first and second equations was reduced by the amount of variable costs x:

$$f_5(x,d) = \begin{cases} 0{,}3868 \cdot (-0{,}180x^2 + 6{,}425x) - x, if\ d \leq 10 \\ 0{,}3868 \cdot (1{,}1-0{,}01d)(-0{,}180x^2 + 6{,}425x) - x, if\ d > 10, \end{cases} \quad (13)$$

where $f_5(x)$ – expected marginal profit, thousand UAH per ha; x – variable production costs per 1 ha of harvested wheat area, thousand UAH; d – duration of the collection campaign, days.

The calculation of the expected operating profit requires taking into account fixed costs, the average value of which in the production of wheat grain, according to the results of the analysis of statistical reporting, in relation to the production costs of agricultural enterprises of Ukraine for 2020, is UAH 2,711 thousand/ha.

At the same time, the involvement of additional grain-harvesting units causes an increase in depreciation. For its calculation, the average costs for the purchase of a grain harvester in the reporting year - UAH 4,845.4 thousand were evenly distributed over the 12 years recommended by the John Deere company as a guideline for the productive use of this brand of combine harvester. The obtained value - UAH 403.8 thousand per combine harvester was used to calculate the increase in depreciation deductions:

$$A = \frac{403{,}8 \cdot (n-1)}{pl} = \frac{403{,}8 \cdot (n-1)}{500} = 0{,}808 \cdot (n-1), \quad (14)$$

where, pl – harvested area, ha; n – number of grain harvesting units, units.

In addition, the potential increase in fixed costs was taken into account under the conditions of interest payments for the use of a loan taken out to cover the costs of purchasing a combine harvester. Thus, according to the statistical data of the official website of the National Bank of Ukraine, in 2020, agricultural commodity producers attracted long-term loans for the purchase of equipment at an average rate of 16%.

Thus, under the conditions of linear accrual of interest payments, the annual cost of paying interest (I) will be equal to:

$$I = \frac{4845{,}4 \cdot 0{,}16 \cdot (n-1)}{pl} = \frac{4845{,}4 \cdot 0{,}16 \cdot (n-1)}{500} = 1{,}553 \cdot (n-1), \quad (15)$$

where, n – number of grain harvesting units, units.

So, taking into account the values of average fixed costs per unit of crops and their potential growth, the system of equations for determining the expected amount of operating profit looks like this:

$$f_6(x,d,n) = \begin{cases} 0{,}3868 \cdot (-0{,}180x^2 + 6{,}425x) - x - 2{,}711 - , \\ -0{,}808 \cdot (n-1) - 1{,}553 \cdot (n-1), \ if\ d \le 10; n > 1 \\ \\ 0{,}3868 \cdot (1{,}1 - 0{,}01d) \cdot (-0{,}180x^2 + 6{,}425x) - x - \\ -2{,}711, \ if\ d > 10; n = 1 \\ \\ 0{,}3868 \cdot (1{,}1 - 0{,}01d) \cdot (-0{,}180x^2 + 6{,}425x) - x - 2{,}711 - \\ -0{,}808 \cdot (n-1) - 1{,}553 \cdot (n-1), \ if\ d > 10; n > 1 \end{cases} \quad (16)$$

Further, by substituting the right-hand side of the function (9) into the second equation of the system (16), it was established that in the case of using one harvester and a harvesting area of 500 hectares, the dependence of the operating profit per unit of wheat crops on the variable costs for the same area is as follows:

$$f_6(x) = -0{,}00007 \cdot x^4 + 0{,}0048 \cdot x^3 - 0{,}162 \cdot x^2 + 1{,}734 \cdot x - 2{,}711 \quad (17)$$

Instead, by substituting the right-hand side of functions (10) and (11) into the third equation of the system (16), it was established in the case of using two or three harvesters and a harvesting area of 500 hectares, the dependence of the operating profit per unit of wheat crops on the variable costs for the same area has the form :

$$f_6(x,2) = -0{,}00003 \cdot x^4 + 0{,}0024 \cdot x^3 - 0{,}119 \cdot x^2 + 1{,}734 \cdot x - 5{,}070 \quad (18)$$

and

$$f_6(x,3) = -0{,}00002 \cdot x^4 + 0{,}0016 \cdot x^3 - 0{,}105 \cdot x^2 + 1{,}734 \cdot x - 7{,}428 \quad (19)$$

A graphic illustration of the behavior of the graphs of the function (17)-(19) shows that, in contrast to the increase in the technological efficiency of wheat production in the case of an increase in the number of used grain harvesting units, the dynamics of economic efficiency indicators is the opposite (Fig. 2).

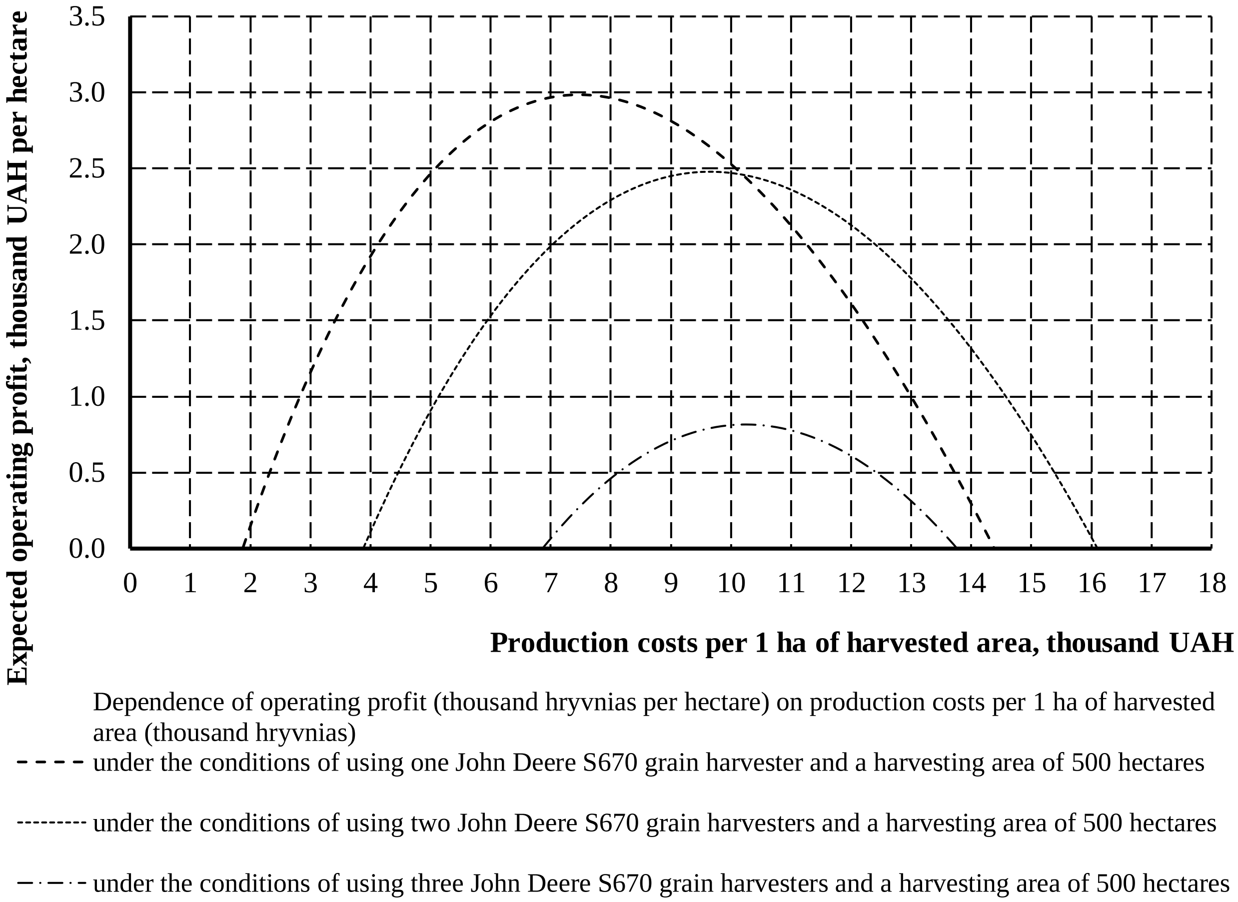


Fig. 2 The influence of the intensity of production and technical support of harvesting operations on the output of operating profit from the sale of wheat grain by agricultural enterprises of Ukraine in 2020.

Source: Author's own calculations according to the official website of the State Statistics Service of Ukraine http://www.ukrstat.gov.ua/

Thus, an increase in the number of used grain-harvesting units leads to a simultaneous reduction in threshing periods, an increase in the profitable optimum of costs and a decrease in the amount of operating profit per unit of crops. At the same time, the optimum costs still remain lower than its value calculated under the conditions, if the duration of the collection campaign does not exceed ten days. To clarify the reasons for this, it should be recalled that according to the rules of differential calculus, the general formula for determining the optimum of a parabolic function, which describes the dependence of profit on costs, has the form:

$$x_{max} = \frac{b \cdot p - 1}{2 \cdot a \cdot p} \qquad (20)$$

where, *a*, *b* – regression coefficients for the linear and quadratic terms of the parabolic function; *p* – the price of 1 t of wheat grain, hryvnias.

In turn, it should be recalled that without taking into account the influence of the factor of harvesting periods and potential losses, the dependence of the operating profit per unit of wheat crops on the variable costs for the same area, as well as additional costs due to the purchase of harvesters, looks like this:

$$f_6(x) = -0{,}069 \cdot x^2 + 1{,}485 \cdot x - 2{,}711 \quad (21)$$

Using formula (20), it was established that in the case of using one *John Deere S670* combine harvester, the profitable optimum of variable costs per unit of crops is UAH 10.7 thousand/ha. Instead, by differentiating the function (17) with respect to x, its first derivative was determined:

$$\frac{df_6(x,1)}{dx} = -0{,}00028 \cdot x^3 + 0{,}0144 \cdot x^2 - 0{,}324 \cdot x + 1{,}734 \quad (22)$$

Later, in the PTC Mathcad 15.0 environment, it was established that, under the conditions of using one John Deere S670 combine harvester, the profitable optimum of variable costs per unit of crops, taking into account the actual harvesting periods and resulting crop losses, is 7.5 thousand UAH/ha. The results of similar transformations with functions (18) and (19) show that the use of two or three such harvesters leads to an increase in the profitable optimums of variable costs to 9.5 and 10.2 thousand UAH/ha.

The development of methodological principles for determining the optimal level of costs for various production conditions should be directed, first of all, to the practicality of its use. On the other hand, it is not possible to determine the profitable optimum of function (17) using formula (20). This makes it necessary to reduce the form of function (17) to a parabola of the second order by expanding the latter into a Taylor series:

$$f(x) = f(x_0) + \frac{f'(x)}{1!}(x - x_0) + \cdots + \frac{f^{IV}(x)}{4!}(x - x_0)^4 + R_4(x) \quad (23)$$

where, x_0 – fixed value of the profitable optimum, relative to which the approximation takes place.

Therefore, based on (23) in the PTC Mathcad 15.0 environment, the function (17) was approximated by a parabola of the second order:

$$f_6(x) = -0{,}00007 \cdot x^4 + 0{,}0048 \cdot x^3 - 0{,}162 \cdot x^2 + 1{,}734 \cdot x - 2{,}711 \approx$$
$$\approx -0{,}077 \cdot x^2 + 1{,}154 \cdot \mathrm{x} - 1{,}332 \quad (24)$$

After that, comparing the values of the regression coefficients for the linear and parabolic terms in functions (21) and the last part of (24), it was determined that the value of the first decreased by 22.3% ((1.154-1.485)/1.485*100) and the second increased by 11.6 % ((0.077-0.069)/0.069*100). This led to a decrease in the profit optimum in the case of taking into account the influence of organizational factors on wheat productivity as a function of the dependence of profit on production costs.

Continuing the coverage of the research results, we note that under the conditions of using technology with variable costs at the level of the profitable optimum and harvesting with a single John Deere S670 combine harvester, the agricultural enterprise will be forced to abandon the performance of a significant number of technological operations or to reduce the price of some of them by reducing the doses of fertilizers and protective means etc. At the same time, the operating margin will be equal to 5.7 thousand UHA/ha. Instead, the use of technology with variable costs at the level of the harvest optimum increases the potential yield, but the loss of a fifth of it due to the lengthening of the harvesting period to 30.7 days causes a negative return on variable costs of 0.3 thousand UAH /ha (table).

At the same time, in the case of harvesting with three *John Deere S670* grain harvesters, the calculated value of the profit optimum is 36.0% higher compared to the case of using one unit. Under such conditions, the list of performed technological operations is wider, and the application doses of fertilizers, herbicides, and protection agents are closer to optimal. This is a guarantee of an increase in the operating margin up to 8.2 thousand UHA/ha, but it is possible to recommend harvesting with three harvesters only if all of them are already owned by the agricultural enterprise.

However, when evaluating the economic feasibility of the purchase of two *John Deere S670* combine harvesters, one should take into account the increase in overhead costs due to the payment of interest for the loan taken out under this measure, as well as the increase in depreciation deductions. Thus, in the case of using technology with variable costs at the level of the profitable optimum and harvesting with one combine harvester of this brand, fixed costs are 47.6% of the operating margin.

The influence of variation in the number of John Deere S670 harvesters on the intensity and efficiency of wheat production in agricultural enterprises of Ukraine on an area of 500 hectares in 2020.

Indicators	Number of grain harvesters, units		
	one	two	three
Optimum variable costs, thousand UAH/ha plenteous	17,9	17,9	17,9
profitable	7,5	9,5	10,2
The duration of the harvesting campaign (days) under conditions of production intensity at the level crop optimum	30,7	15,4	10,2
profitable optimum	20,4	12,0	8,3
Productivity (c/ha) with variable costs at the level crop optimum	45,5	54,4	57,3
profitable optimum	34,1	44,0	47,6
Marginal profit/loss (thousand UAH/ha) with variable costs at the level crop optimum	-0,3	3,2	4,2
profitable optimum	5,7	7,5	8,2
Fixed costs, thousand UAH/ha	2,711	5,070	7,428
including average value	2,711	2,711	2,711
additional depreciation	X	0,808	1,616
interest expense	X	1,551	3,101
interest payment expenses under the "5-7-9" program*	X	0,485	0,969
Operating profit/loss (thousand UAH/ha) with variable costs at the level crop optimum	-3,0	-1,9	-3,2
profitable optimum	3,0	2,4	0,8
Operating profit/loss (thousand hryvnias/ha) in case of involvement in the "5-7-9" program with variable costs at the level of crop optimum	-3,0	-0,8	-1,1
profitable optimum	3,0	3,5	2,9

Source: Author's own calculations according to the official website of the State Statistics Service of Ukraine http://www.ukrstat.gov.ua/

** Taking into account the reduction in interest rates for business loans according to the government program "Affordable loans "5-7-9%".*

On the other hand, when harvesting with three grain harvesters, their share increases to 79.4%, which causes a decrease in operating profit from UAH 3.0 to 0.8 thousand/ha. Therefore, the purchase of additional grain-harvesting units for a 500-hectare crop area is economically impractical.

Obviously, the catastrophic consequences for the economy of the beginning of the war require the adjustment of the investment policy of grain producers. At the request of time, the decision of the Cabinet of Ministers dated March 18, 2022 significantly expanded the program "Affordable loans "5-7-9%". Yes, any business entity during martial law and one month after its end will be able to get a loan of up to UAH 60 million at 0%. After that, the loan rate will be 5%. The term of lending under the "5-7-9" program in case of implementation of an investment project and debt refinancing will be up to five years, and for replenishment of working capital - up to three years [33]. The assessment of the impact of attracting a loan under the "5-7-9% Available Loans" program to finance the renewal of the fleet of grain-harvesting equipment on the profitability of production proved that it is more profitable to thresh 500 hectares of wheat with two combines. So, the proven methodological approach to modeling the effectiveness of costs for wheat production in the conditions of investments in rearming its technical base allows avoiding unproductive costs.

The unsatisfactory technical condition of the fleet of grain harvesters of most agricultural enterprises of Ukraine causes unproductive losses of a part of the potential harvest and leads to a decrease in the efficiency of operating costs for the production and sale of grain industry products. At the same time, despite the rather fast pace of development of the grain industry, the rate of growth of investments in updating the own fleet of grain harvesters of agricultural producers is quite slow, the prerequisites for which are the high cost of these machines and the possibility of their involvement for the period of harvesting on lease terms.

The proven methodical approach makes it possible to evaluate the effectiveness of costs for the production of wheat grain and investments in updating the fleet of grain harvesting operations, taking into account the agrobiological features of wheat production and harvesting, the price situation for grain industry products and grain harvesting combines, and financial factors. The conducted calculations undermined the economic impracticability of investing funds in updating the fleet of grain harvesters for small and medium-sized commodity producers. At the same time, the assessment of the impact of attracting a loan under the program "Available loans "5-7-9%" to finance the renewal of the fleet of grain-harvesting equipment on the profitability of production proved that threshing 500 hectares of wheat with two combines is more profitable. Therefore, the application of the proven approach will avoid unproductive costs due to the comprehensive consideration of technological and market factors of forming the optimal level of production costs.

Taking into account the established significant impact of fixed costs on the financial performance of wheat production under the conditions of intensification of the investment activity of the agrarian enterprise, in the future it is advisable to pay more attention to the study of the riskiness of their implementation. In particular, the methodical aspects of assessing the influence of fixed costs on the formation of operating leverage and its effect in the conditions of the effect of diminishing returns inherent in agricultural production need to be clarified.

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