

Ways to improve mechanisms for providing agricultural production with technical means

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Abstract. The scientific work reflects the ways of improving the mechanisms for providing agricultural production with technical means. The article scientifically substantiates that losses during harvesting of agricultural crops amount to about 3 percent of the total harvest. The article calculates the prospective change in the volume of agricultural machinery by analyzing the level of acquisition of new machinery by peasant (farming) households, and these calculations are expressed in formulas. The work divides the forecasting of agricultural machinery modernization processes into 3 main groups and performs a conditionally multifactor regression analysis. The study recommends that when purchasing agricultural machinery, first of all, a correct assessment of the financial condition of manufacturers is carried out. The article presents an analysis of the dependence of peasant farms on technical modernization and proposes a multifactor regression method for carrying out calculations.

1 Introduction

The development of the agricultural sector of our republic largely depends on the level of mechanization of agriculture. Thus, with the reduction of manual labor in agriculture and the complete mechanization of production, not only the cost of production is reduced, but also labor productivity increases, and the volume of losses during harvesting is reduced, due to the reduction in the number of technological processes for harvesting. The development of agriculture in our republic, the intensification of production, and the increase in production efficiency largely depend on the conservation and rational use of resources. According to research, losses during harvesting, as well as the high priority of manual labor, lead to a loss of 2-3 percent of the harvested crop. At the same time, the growth of resource intensity of production and the increase in labor force involvement also create the basis for an increase in the cost of production.

Therefore, mechanization and technical modernization of agriculture is the demand of today. Modernization of agricultural machinery is of great importance in the industrialization and intensification of production. On the one hand, this ensures efficient use of resources, and on the other hand, it reduces the amount of manual labor in production and creates a basis for the reduction of the cost of the produced product.

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2 Materials and methods

Today, the use of agricultural machinery and the purchase of modern equipment by entities operating in the agricultural sector of our republic are mainly financed by their own funds, leasing and credit funds. By analyzing the level of purchase of new equipment by farmers, we can calculate the future change in the volume of agricultural machinery.

According to research, forecasting of the future is divided into macroeconomic and microeconomic types based on the characteristics of the studied object.

It can be operative, short-term and long-term according to the structure interval. In short-term forecasting, only quantitative changes are taken into account. Long-term forecasting is based on both quantitative and qualitative changes, and can be medium-term and long-term.

A normative forecast determines (sets) the directions and deadlines for the development of the system to achieve future goals. What changes need to be made to the influencing factors in order for the system to achieve the intended state? In other words, how can the goal be achieved?

Let's assume,

$$y = \alpha + \beta x + \varepsilon \quad (1)$$

In the observations of the model in the period ($i=1, \dots, T$).

$$\hat{y}_i = a + bx_i \quad (2)$$

We evaluated with the value of the variable x after several selections, e.g. at $x_{T+\rho}$ \hat{y}_i you can predict the corresponding value of .

$$\hat{y}_{T+\rho} = a + bx_{T+\rho} \quad (3)$$

Thus, for example, the relationship between the overall inflation rate (,%) in the economy and the increase in the monthly wage (w ,%) is expressed by the following linear equation:

$$p = \alpha + \beta w + \varepsilon \quad (4)$$

We assume that this equation evaluates to the following for the entire sampling period:

$$p = 1.0 + 0.9 * w$$

Where P and W are the annual rates of general inflation and wage inflation (in percent), respectively, and we know that wage inflation was 6% in the year after the sample. In this case, we can say that the predicted rate of general inflation is 5.8%. Of course, we need to be able to immediately compare it with the actual rate of inflation in that year and calculate the forecast error, which is the difference between the predicted and actual values.

In general, if $\hat{Y}_{T+\rho}$ - predicted value, $Y_{T+\rho}$ and if is a real value, then $f_{T+\rho}$ the prediction error is defined as:

$$f_{T+\rho} = \hat{Y}_{T+\rho} - Y_{T+\rho} \quad (5)$$

In the scientific literature, we can observe the use of various options, methods, and techniques for forecasting the level of use of agricultural machinery, the number of

- Y- total number of techniques.
- X_1 - purchase of equipment on credit (number).
- X_2 - purchase of equipment under leasing services (number).
- X_3 - the number of techniques obtained at the expense of own funds.

Using the following data of these factors, we will perform a multifactorial regression analysis.

Table 1. Values of factors affecting the regression analysis of changes in the number of agricultural techniques.

No.	Number of common techniques	The number of equipment purchased at the expense of loan funds	Number of equipment purchased through leasing services	The number of equipment purchased at the expense of own funds
	Y	X1	X2	X3
2013	73407	26426	27162	19819
2014	75125	23289	32304	19532
2015	79034	29243	32404	17387
2016	80749	33107	36337	11305
2017	86936	36513	39991	10432
2018	92434	39747	43444	9243
2019	98000	42630	45570	9800
2020	92610	40286	43063	9261
2021	84351	36694	39223	8434
2022	106646	46391	49590	10665
2023	103438	44995	48099	10344

Based on the above data, the following correlation matrix of pairwise correlation coefficients, which expresses the relationship between factors affecting the change in the total number of agricultural machinery used, was generated using the STATA program (Table 2).

Table 2. The matrix of correlation coefficients of the degree of correlation of the factors affecting the result indicator (number of common techniques).

	Y	X1	X2	X3
Y	1.0000			
X1	0.8814	1.0000		
X2	0.9091	0.9641	1.0000	
X3	-0.8012	-0.7035	-0.8442	1.0000

By generating this matrix, it is possible to determine whether there is a close relationship between adjacent factors, that is, multicollinearity. It was determined that there is no multicollinearity between the selected factors.

Accordingly, when implementing a multifactor linear regression model in the STATA program based on the above data, the following model was generated:

Table 3. Factors influencing changes in the number of agricultural machinery, regression analysis.

Y	Odds	Standard error	T statistics	P value	95% coefficient	Interval interval
X1	2.065	0.0894	90.59	0.000	19.33	20.2
X2	0.9704	0.0841	11.53	0.000	0.7763	1.167
X3	0.0075	0.0028	0.63	0.645	-0.0056	0.011
Const	1.006	17.27	-11.09	0.000	-231.5	-51.82

The analysis of this solution is as follows: 1,006 free terms are not analyzed.

The coefficient in front of X1 is 2.065 - a change in the number of equipment purchased at the expense of loan funds by one unit means an increase in the volume of total equipment by 2.065 times. - the expansion of leasing services is proportional to the technical modernization, even if it is small, and the purchase of equipment by producers from their own funds will have a positive effect on the technical modernization of agriculture in the future, even if it is small.

Accordingly, the number of agricultural machinery is a function of change

$$Y=1.006+2.065X_1+0.9704X_2+0.0075X_3$$

Also, in order to predict the future change in the total volume of agricultural machinery according to this econometric model, the following trend functions were determined for each factor affecting it:

The number and modernization of agricultural machinery has changed to different degrees over the years, that is, in some years there was a sharp increase in the volume of machinery, while in some years the growth rate decreased, since the long exploitation period of newly acquired machinery, as well as the impact of changes in the leasing markets and changes in the distribution of credit funds had a direct impact. We can also observe this situation through the coefficient of determination.

$$D = R^2 = 0.96$$

According to the results of calculations based on the substitution of real numbers obtained using the above models and formulas for the unknown numbers in the developed trend functions, a forecast of the change in the number of agricultural machinery for 2024-2027 was developed based on the dynamics of the change in the number of agricultural machinery in 2008-2021.

As is known, the coefficient of determination (R^2) in determining the general quality indicator of the multifactor linear regression econometric model is calculated using the following formula:

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2} \tag{8}$$

y_i - the resulting expected indicator; \bar{y} - arithmetic average value of the resulting indicator; \hat{y} - determined, predicted, and smoothed values of the outcome indicator; n - number of observations.

The correlation coefficient in the multifactor model is: $R=0.91$. This means that the level of correlation between the resulting factor and the influencing factors is very high. This also implies that the coefficient of determination is high: $D = R^2 = 0.96$. It follows that the above factors account for 91% of the change in the purchase and modernization of new machinery in Y-agriculture. The remaining 0.01% is due to other natural factors, along with factors not taken into account here.

The coefficient of determination shows the influence of the factors included in the model on the result indicator in percent. The indicators for all factors are expressed in values in the range [0; 1], and the closer their value is to 1, the more important the role of the factors included in the model in accurately assessing the level of the result indicator. On the other hand, in order to make it possible to compare models with different amounts

of factors and to ensure that the amount of these factors does not affect the R^2 statistic, a smoothed coefficient of determination is usually used, namely:

$$R_{\text{текис}}^2 = 1 - \frac{s^2}{S_y^2} \quad (9)$$

To determine the statistical significance and suitability of this multivariate regression model for the process under study, Fisher's F-test is taken as a basis and the following formula is used to calculate its value, namely:

$$F = \frac{R^2}{1 - R^2} * \frac{(n - k - 1)}{k} \quad (10)$$

Where: n is the number of observations; k - the number of factors in a multivariate regression equation.

In the next step, the calculated value of the F- Fisher test (Ftest) is compared with the theoretically calculated value (Ftable(α ; k ; $n-k-1$)). If Ftest > Ftable, then the used model is considered significant or adequate for the studied process. Then, the reliability of the parameters and correlation coefficients of the multivariate regression econometric model is checked based on the Student's t-test. Their values are compared with the values of the random errors using the following formula:

$$t_b = \frac{b}{m_b}; \quad t_a = \frac{a}{m_a}; \quad t_r = \frac{r}{m_r} \quad (11)$$

The random errors of the parameters and correlation coefficients obtained based on the application of the econometric model are calculated according to the following formulas :

$$m_b = \sqrt{\frac{\sum(y - \hat{y}_x)^2 / (n - 2)}{\sum(x - \bar{x})^2}} \quad (12)$$

$$m_a = \sqrt{\frac{\sum(y - \hat{y}_x)^2}{(n - 2)} \cdot \frac{\sum x^2}{n \sum(x - \bar{x})^2}} = \sqrt{S_{\text{колдик}}^2 \frac{\sum x^2}{n^2 \sigma_x^2}} = S_{\text{колдик}} \frac{\sum x^2}{n \sigma_x} \quad (13)$$

$$m_{r_{xy}} = \sqrt{\frac{1 - r_{xy}^2}{n - 2}} \quad (14)$$

The validity of the accepted hypothesis H_0 is checked by comparing the values calculated according to the Student's t-test (t-test) and the values in the table reflecting the obtained results (t-test). To do this, the reliability probability ($t_{\text{крит}}$) and the degree of freedom (α) of the factor values in the table developed on the basis of the t-test are found within the conditions. Here - ($\gamma = n - k - 1$) the number of observations, n - the number of factors.

The results obtained based on the above econometric model and its structural formulas are compared with real indicators in practice, and appropriate conclusions and recommendations are developed. The calculated R^2 determination coefficient of 0.91 indicates a strong correlation of the resulting indicator with the included factors, and the

remaining 0.09 share is not included in the calculation table and can be considered as the effect of marginal factors.

Table 4. Criteria for testing the quality and significance of a multifactor econometric model.

Multifactor correlation coefficient, R	Multifactor coefficient of determination, R-squared	Corrected R-squared	Standard error of the estimate	F-calculated	P-value	DW
0.91	0.91	0.92	10.19	11.24	0.007	1.91

The adjusted coefficient of determination equal to 0.91 and the relative closeness of R² are the levels of values that arise depending on the change in the number of factors affecting the resulting indicator.

In general, the results developed on the basis of the constructed model show that the calculated value of the F- Fisher criterion for the analysis of factors affecting the volume of gross grain production from arable land is $F_{yuc} = 11.24$, and also when the degrees of freedom are equal to $\gamma_1=7$, the value of the Fisher criterion, i.e., for the significance level $p=0.93$, $F_{жал} = 7.6$. Thus, the applied multifactor model is considered adequate and can be used to forecast changes in the number of agricultural machinery for future periods.

Also, according to this econometric model, the following trend functions were determined for each factor influencing it in order to forecast the level of change in the volume of machinery in the modernization of agriculture (Table 5).

Table 5. Trend functions of factors affecting the resulting indicator (price) in the model.

No.	Factor Name	Model View
1.	Acquisition of equipment at the expense of loan funds	$X_1=101.0336+1.83t$
2.	Acquisition of equipment through leasing services	$X_2=107.7-1.32t$
3.	Purchase of equipment at the expense of producers' own funds	$X_3= -7314.8+93.6t$

According to the results of calculations based on the substitution of real numbers obtained using the models and formulas used above for the unknown numbers in the developed trend functions, a forecast of the level of mechanization of agriculture and changes in the number of equipment for 2023-2027 was developed based on the dynamics of changes in the number of agricultural equipment during 2012-2022 (Table 6).

Table 6. Dynamics of changes in the number of agricultural machines in the future.

Years	Y number of techniques	Loaned equipment	Leased equipment	Equipment purchased at your own expense
	Y	X1	X2	X3
2012	73407	26426	27162	19819
2013	75125	23289	32304	19532
2014	79034	29243	32404	17387
2015	80749	33107	36337	11305
2016	86936	36513	39991	10432
2017	92434	39747	43444	9243
2018	98000	42630	45570	9800
2019	92610	40286	43063	9261
2020	84351	36694	39223	8434
2021	106646	46391	49590	10665
2022	103438	44995	48099	10344
2023	106265	48742	51379	6144
	yp	X1p	X2p	X3p
2024	109237	50817	53318	5102

2025	112210	52889	55258	4063
2026	115182	54963	57197	3022
2027	118155	57036	59136	1983

When the results of the table are depicted on the basis of a graph, we can describe the dynamics of changes in the level of agricultural mechanization and the number of techniques used in production in the form of the following graph. (Figure 1).

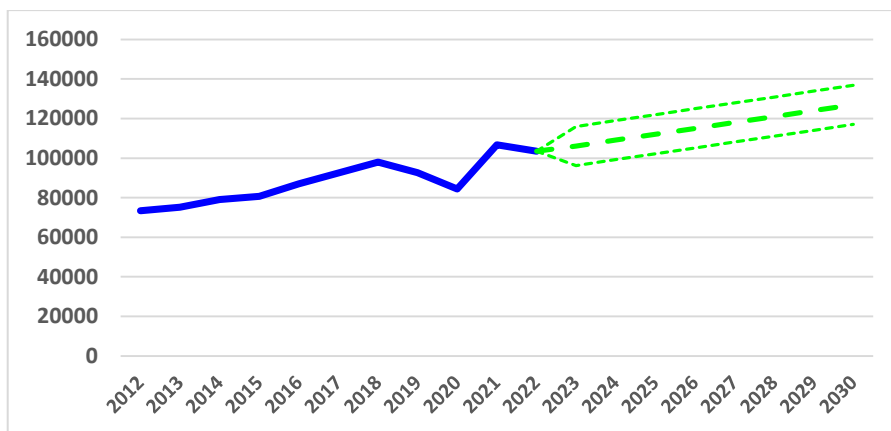


Fig. 1. Dynamics of changes in agricultural techniques.

4 Conclusion

In conclusion, it should be noted that while in 2012 more than 75 thousand pieces of equipment were used, in 2018 we can see that the number of equipment used in agriculture has increased by 25%. In the 2020s, a decrease in the growth of the number of equipment was observed, which, according to studies, is due to the decrease in the use of equipment that requires high energy consumption and relatively high costs (fuel) during this period. However, by 2023, the level of use of modern equipment was high due to the purchase of new equipment and the intensification of production in agriculture. Thus, according to the results of the analysis, in the future we can see a qualitative and quantitative increase in the number of equipment used in agriculture, with a high probability of up to 18 percent, and at least up to 5 percent. Of course, it is advisable to take into account that this process is also affected by the income of producers and the purchase prices of produced products.

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