ЭКОНОМИКА И УПРАВЛЕНИЕ ХОЗЯЙСТВУЮЩИМИ СУБЪЕКТАМИ

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DETERMINATION OF ECONOMICALLY SOUNDED AREA OF FARMING ON THE BASIS OF REGRESSION ANALYSIS

ОПРЕДЕЛЕНИЕ ЭКОНОМИЧЕСКИ ОБОСНОВАННОЙ ПЛОЩАДИ ФЕРМЕРСКОГО ХОЗЯЙСТВА НА ОСНОВЕ РЕГРЕССИОННОГО АНАЛИЗА

The article under consideration concerns farming in conditions of instability. The farming is presented as a social-economic system with peculiar proportions of its elements and relationships with other APC enterprises. To determine the model for the development of the Crimean farms, a regression analysis which presents how random variable depends on the variables (factors) X_1, X_2,…, X_k is used. Following the number of calculations, the output values of the indicators are acquired. Thus, we can calculate the desired metric using the matrix. Besides, the result of the farming area being optimal under these conditions is achieved. Based on the regression analysis performed in the MathCad program, we obtain a pool of significant indicators that, according to a given level of significance and confidence interval, to a greater extent affect the optimal farm area in the region. Statistical testing of the hypothesis of significant coefficients and their linear combination is implemented through the Fisher distribution quantile. The output values of indicators are obtained by the number of calculations. Thus, we can calculate the desired metric using a matrix. In addition, the result of the cultivation area optimal under the given conditions is achieved. To determine the optimal farm area, we propose to use regression analysis based on the dependence of Y (optimal area) on variable factors X (farm performance indicators). Regression analysis is a method for evaluating relationships between variables. We use it to assess the degree of relationship between variables and to model future dependence. Regression analysis shows how changes in the independent variables can be used to fix the change in the dependent variable. 20 farms of the Republic of Crimea were selected for the study. It is determined that the optimal area of a farm in the Republic of Crimea depends on 9 independent variables.

Keywords: farming, value, variable, matrix, crop capacity, net profit, regression, metric.

В рассматриваемой статье речь идет о фермерстве в условиях нестабильности. Представлено, что фермерство представляет собой социально-экономическую систему со своеобразными пропорциями ее элементов и взаимоотношениями с другими предприятиями АПК. Для определения модели развития крымских фермерских хозяйств используется регрессионный анализ, который показывает, как случайная величина зависит от переменных (факторов) X_1, X_2,…, X_k. Под переменными принимаются площадь угодий фермерского хозяйства, средние значения показателей деятельности фермерских хозяйств, анализируемые фермерские хозяйства по региону. На основе проведенного регрессионного анализа в программе MathCad получаем пул значимых показателей, которые в большей степени, согласно заданному уровню значимости и доверительному интервалу, влияют на оптимальную площадь фермерского хозяйства в регионе. Статистическая проверка гипотезы значимых коэффициентов и их линейной комбинации реализована через квантиль распределения Фишера. По количеству вычислений получают выходные значения показателей. Таким образом, мы можем вычислить нужную метрику с помощью матрицы. Кроме того, достигается результат оптимальной в данных условиях площади возделывания. Для определения оптимальной площади фермерского хозяйства нами предлагается использовать регрессионный анализ на основе зависимости величины Y (оптимальная площадь) от переменных факторов X (показатели деятельности фермерских хозяйств). Регрессионный анализ — это метод оценки отношений между переменными. Мы его используем для оценки степени взаимосвязи между переменными и для моделирования будущей зависимости. Регрессионный анализ показывает, как по изменениям независимых переменных можно зафиксировать изменение зависимой переменной. Для проведения исследования были отобраны 20 фермерских хозяйств Республики Крым. Определено, что оптимальная площадь фермерского хозяйства в Республике Крым зависит от 9 независимых переменных.

Ключевые слова: фермерские хозяйства, стоимость, переменная, матрица, урожайность, чистая прибыль, регрессия, метрика.

INTRODUCTION

The issues of optimization in agriculture and industry have been quite acute at all times. At the present stage of digital development, the issues of optimizing the area of a farm based on regression analysis seem to be quite interesting. Professor Yu.N. Novikov [5] and his students [3] in their publications repeatedly raised the issues of optimizing the area of agricultural enterprises. Professor V.I. Safonova [8] in her monograph reveals some features of the formation of agricultural land and suggests directions for their improvement. The use of mathematical methods in decision-making in the economy was studied by such scientists as E.S. Ablyalimova and O.L. Korolev [1], K.R. Adamadeiev and N.M. Kurbanov [2], N.V. Apatova, O.N. Goncharova and V.N. Pomeranets [et al.] [5], E.V. Sidorenko and A.N. Tikhomirova [11], V.V. Khokhlov and E.I. Piskun [12]. We believe that the approach proposed by the author will complement the conducted research and lay a solid foundation in the theory of economic and mathematical modeling of the optimization of economic processes.

FORMULATION OF THE PROBLEM

Farms are a special type of entrepreneurial activity that pays a single agricultural tax. The basis for the transition to this system of taxation is the presence of income from agricultural activities of more than 70 % in relation to other income. Determining the optimal area of a farm is a constantly emerging problem that needs to be solved and the search for the optimal value. Based on research conducted by domestic scientists, we propose to carry out optimization using regression analysis methods.

METHODS

To determine the optimal farm area, we propose to use regression analysis based on the dependence of Y (optimal area) on variable factors X (farm performance indicators). Regression analysis is a method for evaluating relationships between variables. We use it to assess the degree of relationship between variables and to model future dependence. Regression analysis shows how changes in the independent variables can be used to fix the change in the dependent variable. 20 farms of the Republic of Crimea were selected for the study.

RESULTS

Farming is a social-economic system with peculiar proportions of its elements and relationships with other APC enterprises.

The market economy is based on self-payment and self-financing. Thus, enterprises are responsible for the results of management. Besides, the most important thing is the initiative, ability to find sales markets and the system of marketing in general. In the article under consideration except determining the farming space some changeable factors are foreseen.

The farm should be expanded including real land and labor resources.

The most important factor in business economics is the interconnection of farming and crop, net profit and the number of workers, etc. As a result of optimization, these interconnections should provide the land optimization on the basis of an optimal correlation of the farming indicators of grain-type farms.

Farming is a part of the state economic system, a participant in the social division of labor, which means the necessity to predict the optimal area of the economy for the specific conditions that it has: crop capacity, number of workers, the area occupied by cereals.

The most favorable criteria for solving this issue will be the optimal area of the farm.

Predicting the farm activities is a difficult and unforeseen task. Farming is not just entrepreneurial structure; it is also a way of life. A farmer is not always governed by market laws: either the demand, or the supply; the industry which he can engage depends on his attitude to work.

A farmer cannot be forced to grow a certain type of produce, it is necessary for him to be motivated for that. The current market situation does not involve planned production. Everything produced will be sold in the market, so it is difficult to predict and plan what products will be in high demand this season, what products will have an increased price, etc. There is one question that will always be facing farmers — what farming area is optimal for a particular specialization?

In the previous investigations [3], we covered the agricultural holdings of the grain type in the Republic of Crimea. We have divided the farms into three groups, according to their area, and made a conclusion that farms with different areas have various profitability for the products they produce. Thus, there is a question: what factors influence the necessity of the farming area?

To determine the model for the development of the Crimean farms, we use a regression analysis which presents how random variable depends on the variables (factors) $X_1, X_2, \ldots, X_k$.

One-way stochastic dependence is expressed by a function called a regression function or simply regression. According to our observations, we obtain the n data that correlates with values $X_1, X_2, \ldots, X_k$ and $Y = f(X_1, X_2, \ldots, X_k) + U$ where the random variable U is presented as the deviation. Based on regression analysis and assuming the theoretical values, the indicators are the following:

Y — farmland area, ha;
n — farms being analyzed;
k — average values of the analyzed farms.
Thus:
k = 1 — fixed assets of the farm, thousand, RUB.;
k = 2 — equity of the farm, thousand, RUB.;
k = 3 — revenue from sales, thousand, RUB.;
k = 4 — net profit, thousand, RUB.;
k = 5 — state support for the farm, thousand, RUB.;
k = 6 — the area occupied by the cereals sowing, ha;
k = 7 — grain yield, c / ha;
k = 8 — cost of crop production, thousand, RUB.;
k = 9 — net profit from the sale of crop products, thousand, RUB.;
k = 10 — the cost of crop products production, thousand, RUB.;
k = 11 — number of farm workers, pers.;
k = 12 — area under arable land, ha.
n = 5-8 — the farming «Agrarnoe»;
n = 9-12 — the farming «Genesis»;
n = 23-25 — the farming «Impul'se»;
n = 49-51 — the farming «Svetliy pyt'»;
n = 58-60 — the farming «Sakhalin»;
n = 67-69 — the farming «Vesta»;
n = 70-72 — the farming «Dalnyee»;
n = 73-75 — the farming «Ivushka 3»;
n = 76-78 — the farming «Don»;
n = 13-18 — the farming «Agris»;
n = 19-22 — the farming «Drugmi»;
n = 26-30 — the farming «Rostok-2»;
n = 43-48 — the farming «Yabloko»;
n = 82-85 — the farming «Ivanov»;
n = 79-81 — the farming «Pijyanikh N.V.»;
n = 31-39 — the farming «Khliborob»;
n = 40-42 — the farming «Rossia»;
n = 1-4 — the farming «Sivash»;
n = 64-66 — the farming «Rut»;
n = 52-54 — the farming «Teslik»;
n = 55-57 — the farming «Flora».

Using our observational data, we construct a value matrix based on MathCad. Then, the matrix of values from the result indicator Y will have the following form table 1.

Table 1. Matrix initial variables X *

$X^T \cdot X =$

	0	1	2	3	4	5	6	7	8	9	10	11	12
0	85	$4.804\cdot10^{5}$	$1.593\cdot10^{6}$	$2.047\cdot10^{6}$	$3.228\cdot10^{5}$	$1.831\cdot10^{4}$	$1.331\cdot10^{5}$	$2.353\cdot10^{3}$	$4.215\cdot10^{5}$	$4.189\cdot10^{5}$	$4.766\cdot10^{5}$	$5.805\cdot10^{3}$	$1.904\cdot10^{5}$
1	$4.804\cdot10^{5}$	$2.844\cdot10^{10}$	$8.942\cdot10^{10}$	$1.334\cdot10^{11}$	$1.366\cdot10^{10}$	$3.223\cdot10^{8}$	$1.187\cdot10^{9}$	$1.549\cdot10^{7}$	$4.6\cdot10^{9}$	$5.274\cdot10^{9}$	$5.54\cdot10^{9}$	$9.684\cdot10^{7}$	$1.847\cdot10^{9}$
2	$1.593\cdot10^{6}$	$8.942\cdot10^{10}$	$3.086\cdot10^{11}$	$4.377\cdot10^{11}$	$4.648\cdot10^{10}$	$9.976\cdot10^{8}$	$4.09\cdot10^{9}$	$5.424\cdot10^{7}$	$1.629\cdot10^{10}$	$1.836\cdot10^{10}$	$1.971\cdot10^{10}$	$3.342\cdot10^{8}$	$6.276\cdot10^{9}$
3	$2.047\cdot10^{6}$	$1.334\cdot10^{11}$	$4.377\cdot10^{11}$	$6.453\cdot10^{11}$	$6.694\cdot10^{10}$	$1.453\cdot10^{9}$	$5.428\cdot10^{9}$	$6.848\cdot10^{7}$	$2.15\cdot10^{10}$	$2.449\cdot10^{10}$	$2.589\cdot10^{10}$	$4.567\cdot10^{8}$	$8.424\cdot10^{9}$
4	$3.228\cdot10^{5}$	$1.366\cdot10^{10}$	$4.648\cdot10^{10}$	$6.694\cdot10^{10}$	$9.721\cdot10^{9}$	$1.56\cdot10^{8}$	$7.873\cdot10^{8}$	$9.838\cdot10^{6}$	$3.034\cdot10^{9}$	$3.307\cdot10^{9}$	$3.587\cdot10^{9}$	$5.743\cdot10^{7}$	$1.152\cdot10^{9}$
5	$1.831\cdot10^{4}$	$3.223\cdot10^{8}$	$9.976\cdot10^{8}$	$1.453\cdot10^{9}$	$1.56\cdot10^{8}$	$1.178\cdot10^{7}$	$4.256\cdot10^{7}$	$5.766\cdot10^{5}$	$1.459\cdot10^{8}$	$1.368\cdot10^{8}$	$1.661\cdot10^{8}$	$2.197\cdot10^{6}$	$5.698\cdot10^{7}$
6	$1.331\cdot10^{5}$	$1.187\cdot10^{9}$	$4.09\cdot10^{9}$	$5.428\cdot10^{9}$	$7.873\cdot10^{8}$	$4.256\cdot10^{7}$	$3.335\cdot10^{8}$	$4.019\cdot10^{6}$	$1.077\cdot10^{9}$	$1.025\cdot10^{9}$	$1.194\cdot10^{9}$	$1.31\cdot10^{7}$	$4.205\cdot10^{8}$
7	$2.353\cdot10^{3}$	$1.549\cdot10^{7}$	$5.424\cdot10^{7}$	$6.848\cdot10^{7}$	$9.838\cdot10^{6}$	$5.766\cdot10^{5}$	$4.019\cdot10^{6}$	$7.706\cdot10^{4}$	$1.439\cdot10^{7}$	$1.385\cdot10^{7}$	$1.616\cdot10^{7}$	$2.027\cdot10^{5}$	$5.651\cdot10^{6}$
8	$4.215\cdot10^{5}$	$4.6\cdot10^{9}$	$1.629\cdot10^{10}$	$2.15\cdot10^{10}$	$3.034\cdot10^{9}$	$1.459\cdot10^{8}$	$1.077\cdot10^{9}$	$1.439\cdot10^{7}$	$4.423\cdot10^{9}$	$4.065\cdot10^{9}$	$4.985\cdot10^{9}$	$5.007\cdot10^{7}$	$1.464\cdot10^{9}$
9	$4.189\cdot10^{5}$	$5.274\cdot10^{9}$	$1.836\cdot10^{10}$	$2.449\cdot10^{10}$	$3.307\cdot10^{9}$	$1.368\cdot10^{8}$	$1.025\cdot10^{9}$	$1.385\cdot10^{7}$	$4.065\cdot10^{9}$	$4.228\cdot10^{9}$	$4.609\cdot10^{9}$	$4.642\cdot10^{7}$	$1.407\cdot10^{9}$
10	$4.766\cdot10^{5}$	$5.54\cdot10^{9}$	$1.971\cdot10^{10}$	$2.589\cdot10^{10}$	$3.587\cdot10^{9}$	$1.661\cdot10^{8}$	$1.194\cdot10^{9}$	$1.616\cdot10^{7}$	$4.985\cdot10^{9}$	$4.609\cdot10^{9}$	$5.736\cdot10^{9}$	$5.682\cdot10^{7}$	$1.674\cdot10^{9}$
11	$5.805\cdot10^{3}$	$9.684\cdot10^{7}$	$3.342\cdot10^{8}$	$4.567\cdot10^{8}$	$5.743\cdot10^{7}$	$2.197\cdot10^{6}$	$1.31\cdot10^{7}$	$2.027\cdot10^{5}$	$5.007\cdot10^{7}$	$4.642\cdot10^{7}$	$5.682\cdot10^{7}$	$8.485\cdot10^{5}$	$1.807\cdot10^{7}$
12	$1.904\cdot10^{5}$	$1.847\cdot10^{9}$	$6.276\cdot10^{9}$	$8.424\cdot10^{9}$	$1.152\cdot10^{9}$	$5.698\cdot10^{7}$	$4.205\cdot10^{8}$	$5.651\cdot10^{6}$	$1.464\cdot10^{9}$	$1.407\cdot10^{9}$	$1.674\cdot10^{9}$	$1.807\cdot10^{7}$	$5.927\cdot10^{8}$

* Calculated by the author

For the regression analysis implementation, it is necessary to calculate the inverse of the analyzed data matrix X^T.

The product of the output matrix and the inverse matrix calculated using formula $(X^T \times X)\, b = X^T y$ is presented in table. To determine the estimates of the individual regression coefficients required for further calculations, we should determine the value of the indicator b (linear regression parameters).

Table 2. Definition of linear regression parameters b.

b =

	0
0	428.383
1	-0.014
2	$-7.278\cdot10^{-3}$
3	$6.535\cdot10^{-3}$
4	$3.487\cdot10^{-3}$
5	0.025
6	0.105
7	-9.688
8	-0.034
9	$2.033\cdot10^{-3}$
10	0.064
11	2.326
12	0.772

* Calculated by the author

Having calculated the estimates of linear regression parameters we calculate the residual sum of squares û.

Then, we calculate the estimate of the final variance. Variance is a measure of the deviation of a random variable values from the center of distribution. Higher variance values indicate larger deviations of the random variable values from the distribution center. The final variance is as follows: $\sigma 2 = 6{,}212 \times 10^4$.

Besides, we calculate the covariance index. Covariance is a numerical characteristic of the random variables dependence, in probability theory and mathematical statistics. The essence of covariance is that it arises because there is no result of multiplying two sets of numbers. The covariance estimate is a matrix.

For further calculations, we take the level of significance as a = 0,03. The level of significance is an assessment of certainty in its «truth» (in the sense of «representativeness of the sample»). In statistics, a value is called statically significant if it or even more extreme values are unlikely to occur. Here, the extreme is the degree of deviation from the null hypothesis.

Table 3. Product of the matrix of initial data *

$X^T \cdot X =$

	0	1	2	3	4	5	6	7	8	9	10	11	12
0	85	$5.226 \cdot 10^{5}$	$1.634 \cdot 10^{6}$	$2.347 \cdot 10^{6}$	$3.228 \cdot 10^{5}$	$3.215 \cdot 10^{5}$	$1.331 \cdot 10^{5}$	$3.942 \cdot 10^{6}$	$4.215 \cdot 10^{5}$	$4.189 \cdot 10^{5}$	$4.766 \cdot 10^{5}$	$5.805 \cdot 10^{3}$	$1.904 \cdot 10^{5}$
1	$5.226 \cdot 10^{5}$	$3.015 \cdot 10^{10}$	$9.099 \cdot 10^{10}$	$1.349 \cdot 10^{11}$	$1.378 \cdot 10^{10}$	$2.787 \cdot 10^{9}$	$1.223 \cdot 10^{9}$	$4.045 \cdot 10^{10}$	$4.717 \cdot 10^{9}$	$5.395 \cdot 10^{9}$	$5.663 \cdot 10^{9}$	$9.883 \cdot 10^{7}$	$1.916 \cdot 10^{9}$
2	$1.634 \cdot 10^{6}$	$9.099 \cdot 10^{10}$	$3.104 \cdot 10^{11}$	$4.595 \cdot 10^{11}$	$4.645 \cdot 10^{10}$	$9.667 \cdot 10^{9}$	$4.123 \cdot 10^{9}$	$1.399 \cdot 10^{11}$	$1.638 \cdot 10^{10}$	$1.847 \cdot 10^{10}$	$1.982 \cdot 10^{10}$	$3.36 \cdot 10^{8}$	$6.342 \cdot 10^{9}$
3	$2.347 \cdot 10^{6}$	$1.349 \cdot 10^{11}$	$4.595 \cdot 10^{11}$	$7.031 \cdot 10^{11}$	$7.159 \cdot 10^{10}$	$1.487 \cdot 10^{10}$	$6.073 \cdot 10^{9}$	$2.157 \cdot 10^{11}$	$2.522 \cdot 10^{10}$	$2.857 \cdot 10^{10}$	$3.046 \cdot 10^{10}$	$5.154 \cdot 10^{8}$	$9.437 \cdot 10^{9}$
4	$3.228 \cdot 10^{5}$	$1.378 \cdot 10^{10}$	$4.645 \cdot 10^{10}$	$7.159 \cdot 10^{10}$	$9.721 \cdot 10^{9}$	$1.865 \cdot 10^{9}$	$7.873 \cdot 10^{8}$	$2.66 \cdot 10^{10}$	$3.034 \cdot 10^{9}$	$3.307 \cdot 10^{9}$	$3.587 \cdot 10^{9}$	$5.743 \cdot 10^{7}$	$1.152 \cdot 10^{9}$
5	$3.215 \cdot 10^{5}$	$2.787 \cdot 10^{9}$	$9.667 \cdot 10^{9}$	$1.487 \cdot 10^{10}$	$1.865 \cdot 10^{9}$	$2.798 \cdot 10^{9}$	$8.645 \cdot 10^{8}$	$2.978 \cdot 10^{10}$	$3.314 \cdot 10^{9}$	$3.117 \cdot 10^{9}$	$3.712 \cdot 10^{9}$	$3.424 \cdot 10^{7}$	$1.122 \cdot 10^{9}$
6	$1.331 \cdot 10^{5}$	$1.223 \cdot 10^{9}$	$4.123 \cdot 10^{9}$	$6.073 \cdot 10^{9}$	$7.873 \cdot 10^{8}$	$8.645 \cdot 10^{8}$	$3.335 \cdot 10^{8}$	$1.044 \cdot 10^{10}$	$1.077 \cdot 10^{9}$	$1.025 \cdot 10^{9}$	$1.194 \cdot 10^{9}$	$1.31 \cdot 10^{7}$	$4.205 \cdot 10^{8}$
7	$3.942 \cdot 10^{6}$	$4.045 \cdot 10^{10}$	$1.399 \cdot 10^{11}$	$2.157 \cdot 10^{11}$	$2.66 \cdot 10^{10}$	$2.978 \cdot 10^{10}$	$1.044 \cdot 10^{10}$	$3.649 \cdot 10^{11}$	$3.764 \cdot 10^{10}$	$3.56 \cdot 10^{10}$	$4.159 \cdot 10^{10}$	$4.589 \cdot 10^{8}$	$1.318 \cdot 10^{10}$
8	$4.215 \cdot 10^{5}$	$4.717 \cdot 10^{9}$	$1.638 \cdot 10^{10}$	$2.522 \cdot 10^{10}$	$3.034 \cdot 10^{9}$	$3.314 \cdot 10^{9}$	$1.077 \cdot 10^{9}$	$3.764 \cdot 10^{10}$	$4.423 \cdot 10^{9}$	$4.065 \cdot 10^{9}$	$4.985 \cdot 10^{9}$	$5.007 \cdot 10^{7}$	$1.464 \cdot 10^{9}$
9	$4.189 \cdot 10^{5}$	$5.395 \cdot 10^{9}$	$1.847 \cdot 10^{10}$	$2.857 \cdot 10^{10}$	$3.307 \cdot 10^{9}$	$3.117 \cdot 10^{9}$	$1.025 \cdot 10^{9}$	$3.56 \cdot 10^{10}$	$4.065 \cdot 10^{9}$	$4.228 \cdot 10^{9}$	$4.609 \cdot 10^{9}$	$4.642 \cdot 10^{7}$	$1.407 \cdot 10^{9}$
10	$4.766 \cdot 10^{5}$	$5.663 \cdot 10^{9}$	$1.982 \cdot 10^{10}$	$3.046 \cdot 10^{10}$	$3.587 \cdot 10^{9}$	$3.712 \cdot 10^{9}$	$1.194 \cdot 10^{9}$	$4.159 \cdot 10^{10}$	$4.985 \cdot 10^{9}$	$4.609 \cdot 10^{9}$	$5.736 \cdot 10^{9}$	$5.682 \cdot 10^{7}$	$1.674 \cdot 10^{9}$
11	$5.805 \cdot 10^{3}$	$9.883 \cdot 10^{7}$	$3.36 \cdot 10^{8}$	$5.154 \cdot 10^{8}$	$5.743 \cdot 10^{7}$	$3.424 \cdot 10^{7}$	$1.31 \cdot 10^{7}$	$4.589 \cdot 10^{8}$	$5.007 \cdot 10^{7}$	$4.642 \cdot 10^{7}$	$5.682 \cdot 10^{7}$	$8.485 \cdot 10^{5}$	$1.807 \cdot 10^{7}$
12	$1.904 \cdot 10^{5}$	$1.916 \cdot 10^{9}$	$6.342 \cdot 10^{9}$	$9.437 \cdot 10^{9}$	$1.152 \cdot 10^{9}$	$1.122 \cdot 10^{9}$	$4.205 \cdot 10^{8}$	$1.318 \cdot 10^{10}$	$1.464 \cdot 10^{9}$	$1.407 \cdot 10^{9}$	$1.674 \cdot 10^{9}$	$1.807 \cdot 10^{7}$	$5.927 \cdot 10^{8}$

* Calculated by the author

Table 4. Covariance matrix *

$K =$

	0	1	2	3	4	5	6	7	8	9	10	11	12
0	$4.258 \cdot 10^{3}$	$-1.036 \cdot 10^{3}$	-0.011	0.023	-0.034	$9.935 \cdot 10^{3}$	0.199	0.019	-0.095	-0.214	0.427	-17.623	-2.066
1	$-1.036 \cdot 10^{3}$	$2.169 \cdot 10^{5}$	$-5.8 \cdot 10^{-6}$	$-2.829 \cdot 10^{7}$	$-1.115 \cdot 10^{-6}$	$-5.438 \cdot 10^{6}$	$2.854 \cdot 10^{-5}$	$5.381 \cdot 10^{7}$	$-2.012 \cdot 10^{-5}$	$-8.303 \cdot 10^{7}$	$2.544 \cdot 10^{-5}$	$-1.139 \cdot 10^{-4}$	$-3.965 \cdot 10^{-5}$
2	-0.011	$-5.8 \cdot 10^{6}$	$9.618 \cdot 10^{6}$	$-5.474 \cdot 10^{6}$	$2.231 \cdot 10^{-6}$	$2.424 \cdot 10^{6}$	$-5.876 \cdot 10^{-5}$	$1.062 \cdot 10^{6}$	$3.559 \cdot 10^{-6}$	$3.658 \cdot 10^{6}$	$-8.956 \cdot 10^{-6}$	$1.148 \cdot 10^{-4}$	$2.005 \cdot 10^{-5}$
3	0.023	$-2.829 \cdot 10^{7}$	$-5.474 \cdot 10^{-6}$	$4.425 \cdot 10^{6}$	$-4.428 \cdot 10^{-6}$	$-4.029 \cdot 10^{7}$	$3.683 \cdot 10^{-5}$	$-6.265 \cdot 10^{7}$	$6.512 \cdot 10^{-6}$	$-6.304 \cdot 10^{6}$	$-2.884 \cdot 10^{-7}$	$-3.44 \cdot 10^{-4}$	$-1.103 \cdot 10^{-5}$
4	-0.034	$-1.115 \cdot 10^{6}$	$2.231 \cdot 10^{6}$	$-4.428 \cdot 10^{6}$	$3.162 \cdot 10^{-5}$	$8.397 \cdot 10^{6}$	$-6.031 \cdot 10^{-5}$	$5.255 \cdot 10^{7}$	$-8.446 \cdot 10^{-6}$	$2.737 \cdot 10^{6}$	$-1.926 \cdot 10^{-6}$	$2.154 \cdot 10^{-4}$	$2.817 \cdot 10^{-5}$
5	$9.935 \cdot 10^{3}$	$-5.438 \cdot 10^{6}$	$2.424 \cdot 10^{6}$	$-4.029 \cdot 10^{7}$	$8.397 \cdot 10^{-6}$	$4.206 \cdot 10^{4}$	$-2.565 \cdot 10^{-4}$	$-1.559 \cdot 10^{5}$	$-6.91 \cdot 10^{5}$	$-3.19 \cdot 10^{-5}$	$-1.192 \cdot 10^{-4}$	$6.403 \cdot 10^{-3}$	$9.86 \cdot 10^{-5}$
6	0.199	$2.854 \cdot 10^{5}$	$-5.876 \cdot 10^{-5}$	$3.683 \cdot 10^{5}$	$-6.031 \cdot 10^{-5}$	$-2.565 \cdot 10^{4}$	$6.318 \cdot 10^{-3}$	$-1.132 \cdot 10^{4}$	$-4.847 \cdot 10^{-4}$	$1.668 \cdot 10^{4}$	$8.483 \cdot 10^{-4}$	$6.833 \cdot 10^{-3}$	$-3.28 \cdot 10^{-3}$
7	0.019	$5.381 \cdot 10^{7}$	$1.062 \cdot 10^{6}$	$-6.265 \cdot 10^{7}$	$5.255 \cdot 10^{-7}$	$-1.559 \cdot 10^{5}$	$-1.132 \cdot 10^{-4}$	$5.889 \cdot 10^{6}$	$-2.183 \cdot 10^{-5}$	$-9.145 \cdot 10^{6}$	$1.435 \cdot 10^{-5}$	$-9.376 \cdot 10^{-4}$	$3.218 \cdot 10^{-5}$
8	-0.095	$-2.012 \cdot 10^{5}$	$3.559 \cdot 10^{6}$	$6.512 \cdot 10^{6}$	$-8.446 \cdot 10^{-6}$	$-6.91 \cdot 10^{5}$	$-4.847 \cdot 10^{-4}$	$-2.183 \cdot 10^{5}$	$1.524 \cdot 10^{-3}$	$-9.256 \cdot 10^{5}$	$-1.098 \cdot 10^{-3}$	$-4.088 \cdot 10^{-3}$	$6.094 \cdot 10^{-4}$
9	-0.214	$-8.303 \cdot 10^{7}$	$3.658 \cdot 10^{6}$	$-6.304 \cdot 10^{6}$	$2.737 \cdot 10^{-6}$	$-3.19 \cdot 10^{5}$	$1.668 \cdot 10^{-4}$	$-9.145 \cdot 10^{6}$	$-9.256 \cdot 10^{-5}$	$2.197 \cdot 10^{4}$	$-2.507 \cdot 10^{-5}$	$4.167 \cdot 10^{-3}$	$-7.671 \cdot 10^{-5}$
10	0.427	$2.544 \cdot 10^{5}$	$-8.956 \cdot 10^{-6}$	$-2.884 \cdot 10^{7}$	$-1.926 \cdot 10^{-6}$	$-1.192 \cdot 10^{4}$	$8.483 \cdot 10^{-4}$	$1.435 \cdot 10^{5}$	$-1.098 \cdot 10^{-3}$	$-2.507 \cdot 10^{5}$	$1.061 \cdot 10^{-3}$	$-2.618 \cdot 10^{-3}$	$-9.563 \cdot 10^{-4}$
11	-17.623	$-1.139 \cdot 10^{4}$	$1.148 \cdot 10^{4}$	$-3.44 \cdot 10^{4}$	$2.154 \cdot 10^{-4}$	$6.403 \cdot 10^{3}$	$6.833 \cdot 10^{-3}$	$-9.376 \cdot 10^{4}$	$-4.088 \cdot 10^{-3}$	$4.167 \cdot 10^{3}$	$-2.618 \cdot 10^{-3}$	0.696	$1.179 \cdot 10^{-4}$
12	-2.066	$-3.965 \cdot 10^{5}$	$2.005 \cdot 10^{5}$	$-1.103 \cdot 10^{5}$	$2.817 \cdot 10^{-5}$	$9.86 \cdot 10^{5}$	$-3.28 \cdot 10^{3}$	$3.218 \cdot 10^{5}$	$6.094 \cdot 10^{-4}$	$-7.671 \cdot 10^{5}$	$-9.563 \cdot 10^{-4}$	$1.179 \cdot 10^{-4}$	$3.617 \cdot 10^{-3}$

* Calculated by the author

Number of degrees of freedom is n – k – 1 = 71. What we do next is calculate the confidence interval of the classical normal regression parameters ($b_{j,0}$). Confidence Interval is the interval within which a given (probable) random variable value can be expected with a given confidence probability. It is used for a more complete estimation of accuracy compared to a point estimate.

Table 5. Calculation of the confidence interval

$\left(b_{j,0} - tT \cdot \sqrt{K_{j,j}}\right) =$	$b_{j,0} + tT \cdot \sqrt{K_{j,j}} =$
321.706377	535.06039
-0.024486	-0.00366
-0.01027	-0.00429
0.003068	0.01
-0.001975	0.00895
-0.096356	0.14657
0.048076	0.16273
-13.196339	-6.18008
-0.072194	0.00461
-0.01171	0.01578
0.031724	0.09651
1.546221	3.10646
0.712863	0.83024

* Calculated by the author

Here is the tabular value of Student's quintile distribution T = 1,044.

Table 6. Calculation of the quantile of Student's distribution *

$t\phi$ =

	0
0	4.193
1	-1.411
2	-2.54
3	1.968
4	0.666
5	0.216
6	1.92
7	-2.883
8	-0.919
9	0.154
10	2.067
11	3.113
12	13.725

* Calculated by the author

To determine the adequacy of linear regression, we calculate the coefficient of determination R_2 = 0,975 and the measure of linear dependence that is the multiple correlation coefficient

R = 0,987 and empirical standard deviations sr = $2,374 \times 10^3$, Ysr2 = $7,714 \times 10^6$, sy = $1,441 \times 10^3$.

Our calculated data R is closed to 1, which indicates a close linear relationship.

With the value of the confidence interval and the above calculations, we can affirm that the final result (farmland, ha) is influenced by the following factors: fixed assets of the farm, thousand RUB. (k = 1); k = 2 — equity of the farm, thousand RUB; k = 3 — sales revenue, thousand RUB; k = 6 is the area occupied by sowing cereals, ha; k = 7 — grain yield, μ; k = 10 — costs for production of crop production, thousand RUB; k = 11 — number of farm workers, people; k = 12 is the area under arable land, ha.

However, we can statistically verify the hypotheses about the values of several coefficients or several of their linear combinations, as well as the combination of one with the other. Fisher distribution quantile with equal significance a = 0,3 is T = 1,197. The hypothesis that not all regressors in the aggregate have any effect on the regressor is rejected, because $F_f > F_T$ if F_f = 213,155.

We have calculated a data matrix for determination the predictive value of the dependent variable Xisx (table 7).

Thus, the predicted value calculated using the matrix b is $Xisx^T \times b = -1,402 \times 10^6$.

$$\sigma\ ysr = \sqrt{\sigma 2} \times \sqrt{Xisx^T \times (X^T \times X)^{-1} \times Xisx} = 4,879 \times 10^5.$$

$$\sigma\ y0 = \sqrt{\sigma 2 + \sigma ysr^2} = 4,879 \times 10^5.$$

Here, MYsr_min ≤ MYsr ≤ MYsr_max is the predictive interval of the regressor mathematical expectation, MY_min ≤ MY ≤ MY_max the interval prediction of individual value. Thereby,

$MYsr_{min} = Xisx^T \times b - tT \times sysr = -1,912 \times 10^6$.

$MYsr_{max} = Xisx^T \times b - tT \times sy0 = -8,929 \times 10^5$.

$MY_{min} = Xisx^T \times b - tT \times syo = -1,912 \times 10^6$.

$MY_{max} = Xisx^T \times b - tT \times syo = -8,928 \times 10^5$.

It is presented that the intervals are identical, which indicates the coincidence of the intervals and the completest predictive value. Thus, we have an equation of the farming area estimation which depends on 9 independent variables. Matrix will be an equation for finding the desired result (area of land).

Table 7. Matrix for determining the predictive value of the dependent variable X.

$$\mathbf{Xisx} := \begin{pmatrix} 1 \\ \mathbf{5285} \\ \mathbf{9439} \\ \mathbf{18772} \\ \mathbf{2604} \\ \mathbf{11834.4} \\ \mathbf{3523} \\ \mathbf{145256} \\ \mathbf{12799} \\ \mathbf{14533.5} \\ \mathbf{13489.9} \\ \mathbf{130} \\ \mathbf{4180} \end{pmatrix}$$

* Calculated by the author

$Y = 428{,}383 - 0{,}014\,k_1 - 7{,}278 \times 10^{-3}\,k_2 + 6{,}535 \times 10^{-3}\,k_3 + 3{,}487 \times 10^{-3}\,k_4 + 0{,}025\,k_5 + 0{,}105\,k_6 - 9{,}688\,k_7 - 0{,}034\,k_8 + 2{,}033 \times 10^{-3}\,k_9 + 0{,}064\,k_{10} + 2{,}326\,k_{11} + 0{,}772\,k_{12}$.

So, if we know the output values of the indicators, we can calculate the desired metric using this matrix. Besides, we can set inputs (which we aim to achieve or actually have) and obtain the result of the farming area that will be optimal under these conditions.

CONCLUSIONS

Thus, we have obtained a matrix for assessing the required area of land required by farms, which depends on 9 independent variables. Matrix b will be an equation for finding the desired indicator (profitability).

Thus, knowing the initial values of the indicators x, we can calculate the desired indicator y using this matrix.

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