Development of methodological tools for forecasting the activities of agricultural organizations to ensure food security in the region

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Abstract. The study of the issues of forecasting the activities of agricultural organizations in modern conditions is necessary and relevant. Development of forecasting tools in the management system of modern agricultural organization has a significant impact on improving the efficiency and effectiveness of its production and economic activity. In our opinion, the methodology of assessing the sustainability and effectiveness of agricultural organizations should be aimed at combining static and dynamic approaches, which is demonstrated in the present study. In economic practice, the possibility of managing the factors of socio-economic phenomena determines the need to measure their relationships. Multifactor correlation and regression analysis allows to estimate the measure of influence on the studied result indicator of each of the factors included in the model at a fixed position of other factors, as well as at any possible combinations of factors with a certain degree of accuracy. Correlation and regression analysis allows taking into account influence of various factors in forecast calculations. The research allows to create the forecasting variants of economical-mathematical models of activity of enterprise that allows to choose the trajectories of the most effective economic development. As an analysis and application of forecasting tools we chose a sub-sector of agriculture of the Republic of Tatarstan - dairy cattle breeding. The analysis of dairy cattle breeding of Russia and the Republic of Tatarstan for the last 30 years is given in the article, the food security issues are considered, the multifactorial correlation-regression model of economic activity of cattle breeding enterprises of the Republic of Tatarstan is built. As a result, based on the regression equation, the average annual milk yield per 1 cow was predicted. Thus, on the basis of the obtained results, it is possible to develop further action plan to improve the production-economic activity of the enterprise and search for reserves in increasing its efficiency.

1 Introduction

Agriculture and food industry are the basis in ensuring food security of the country. Consequently, food security is important for the economy of the country as a whole, because the life, health and well-being of citizens depend on it.

In conditions of extreme economic and political instability, the problem of food security becomes the most urgent for absolutely every state.

In the medium term, food security and provision of the population of the country is one of the main directions of national security of the country. As part of this task, special normative legal acts, state programs are adopted, which determine the main directions of development of agricultural production as a strategic sector of the economy.

Over the past 30 years, agriculture in Russia as a whole has demonstrated a trend of growth in indices and volume of products produced, including through government support and implementation:

- development concepts and strategies;
- federal target programs since 1995;
- the priority national project "Development of the Agro-Industrial Complex (AIC)" in three areas: accelerated development of animal husbandry, promotion of small-scale farming and provision of affordable housing for young rural specialists (2006-2007);
- state agricultural development programs since 2008;

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– priority projects from 2016 to 2018;
– national projects since 2019, including "International cooperation and export" (one of the federal level projects "Export of agricultural products").

Dairy products are included in the list of Doctrine of Food Security of RF and the share of domestic production of milk and dairy products (in terms of milk) should be at least 90%. The annual output of milk in Russia should reach 48 million tons or not less than 90% of the Doctrine threshold - 43 million tons. According to the forecast values, in 2022 in Russia it is planned to produce 32.5 million tons of milk, which is by 24% or 10.5 million tons less than the value established by the Doctrine.

In order to solve the tasks set to ensure food security, it is necessary to continue the implementation of state programs to support and develop agriculture, and agricultural producers to improve the efficiency of their activities, including through effective management methods [1].

2 Materials and methods

To achieve the goal and objectives of the study we chose deductive and inductive methods and techniques with elements of statistical analysis. These methods make it possible to assess the degree and nature of the relationship between the result and the factors that condition it. The results of statistical analysis can be used for forecasting the results of economic activity of agricultural organizations.

The main objectives of the state in dairy cattle breeding are to ensure food security of the population of the country, increasing the productivity of farm animals, including through effective breeding methods, innovation and technological development of the industry, development of the fodder base.

Dairy productivity of cows depends on many internal and external factors. As part of the analysis, it is necessary to identify the main of them and the extent of their influence with the possibility of applying the results of the analysis in the management and forecasting of the industry.

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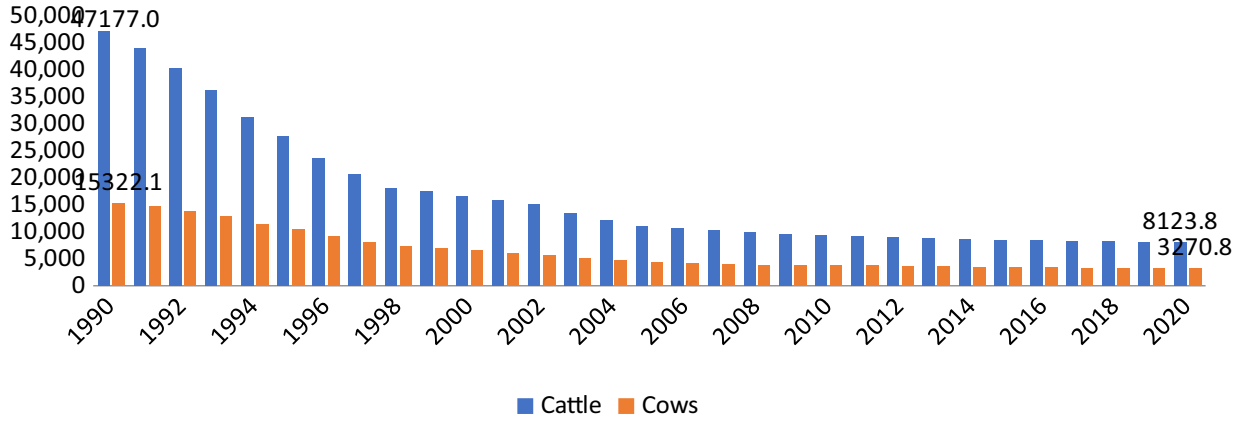

Fig. 1. The number of cattle and cows in agricultural organizations in Russia, thousand heads.

Over the period from 1990 to 2020 the number of cattle in agricultural organizations of the Russian Federation declined by 82.8%, including cows - 78.7%. Milk production decreased by 57.9% (from 42 452.1 tons to 17879.9 tons) [2].

In farms of all categories in the country the reduction of cattle in the analyzed period was 68.4%, of cows – 61.6%, the total volume of milk production decreased by 42.2% (from 55715.3 thousand tons to 32225.5 thousand tons) [2].

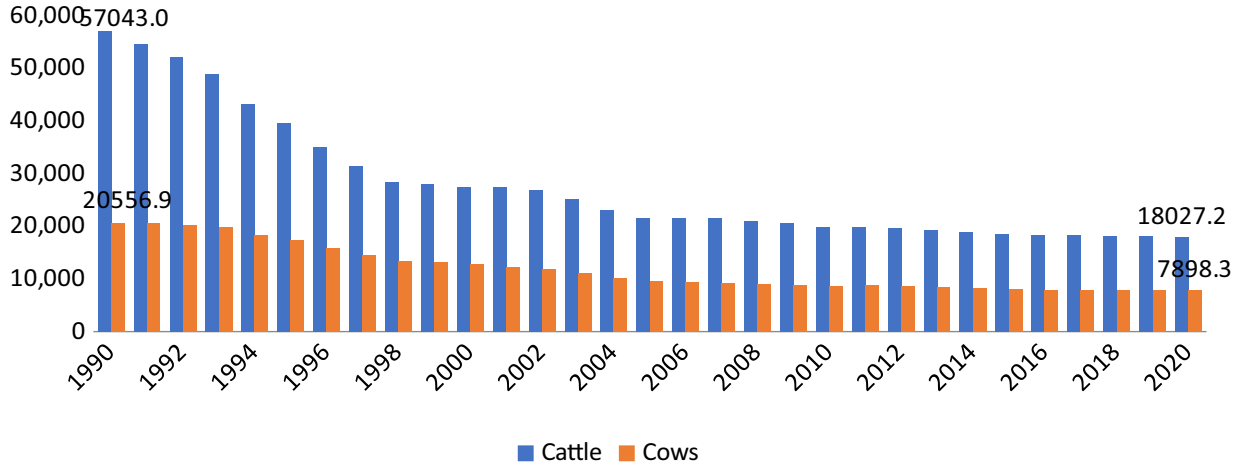

Fig. 2. The number of cattle and cows in all categories of farms of the Russian Federation, thousand heads (1990–2020).

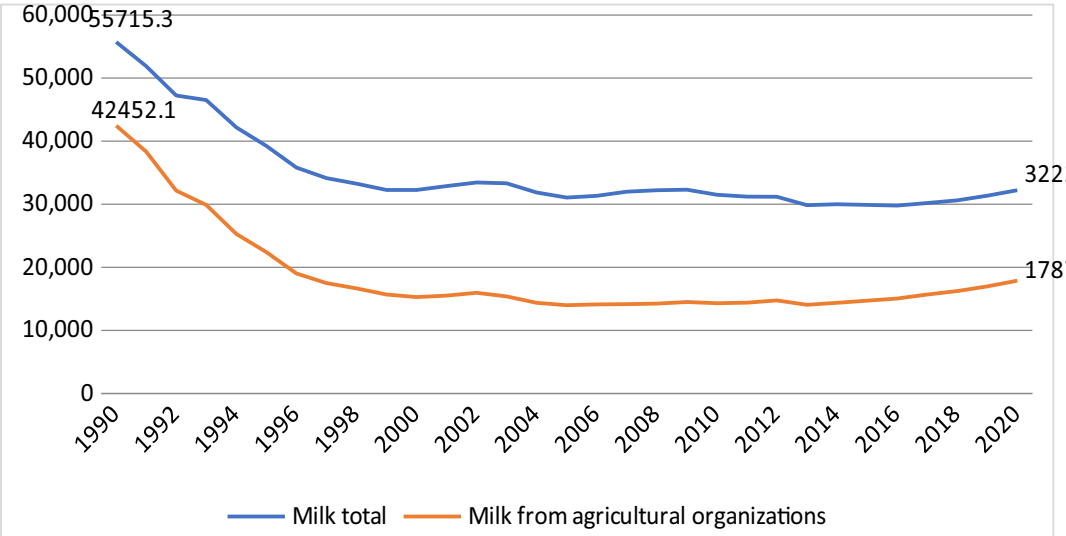

Fig. 3 - Milk production in Russia, thousand tons (1990–2020).

The processes of reducing the number of cows and providing the country's population with milk and dairy products are smoothed by intensifying milk production. The level of milk yields per cow in the country as a whole in farms of all categories during the analyzed period increased by 77.2%, in agricultural organizations – 2.4 times to 6728 kg [2].

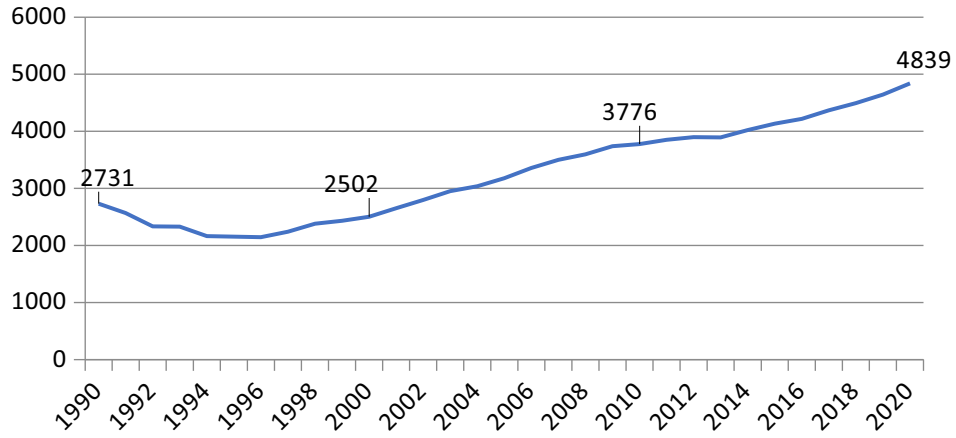

Fig. 4. Milk yields per cow on farms of all categories in Russia, kg (1990–2020).

In the Russian Federation among 85 subjects of the country only 17 regions (20%) the level of milk and dairy products production exceeds the required minimum standards of consumption (325 kg per year per person, according to the recommendations of the Russian Ministry of Health on rational norms of food consumption). The largest volume of milk production in the country in 2020 belongs to the Volga Federal District and accounts for 31% of the total Russian production. The leader in milk production in the Volga Federal District is the Republic of Tatarstan, so according to the results of 2020 the republic produced 1.9 million tons of milk, which is 2.5% more than in 2019. The share of agricultural organizations of the republic to the total production volume in 2020 was 63.1% or 1.2 million tons, which is 4.3% more than that in 2019.

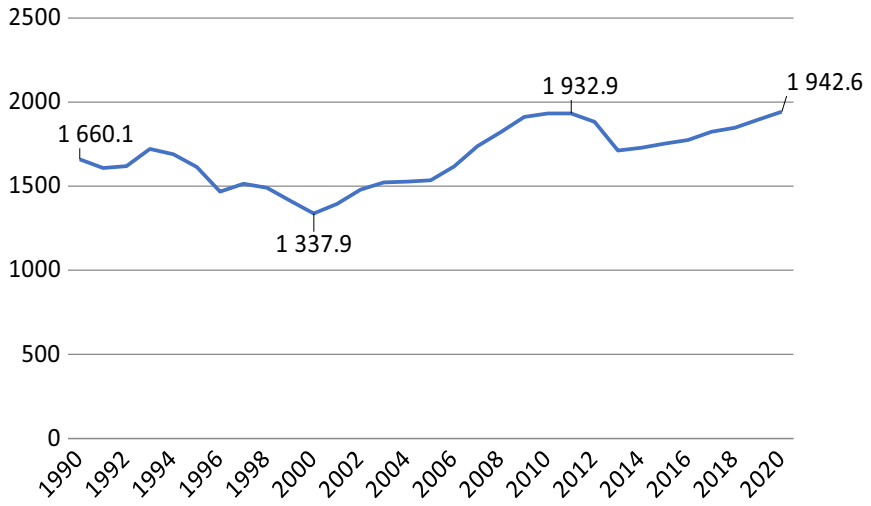

Fig. 5. Milk production in the Republic of Tatarstan, thousand tons (1990–2020).

In addition to the growth in the production of raw milk, the volume of its processing has also increased in the republic. 322.7 thousand tons of drinking milk were produced in 2020, which is 29% more than in 2019; fermented milk products – 88.8 thousand tons, an increase of 6%; cheese, cheese products and cottage cheese produced 47.9 thousand tons with an increase of 8%.

According to the Dairy Market Intelligence Center (DIA), Tatarstan leads among the regions of the country by the number of plants: there are 8 enterprises operating in RT, and in 2020, 59.3% of milk and dairy products production comes from Zelenodolsky Dairy Plant, Mamadysh Cheese and Dairy Plant and "Alabuga Sote".

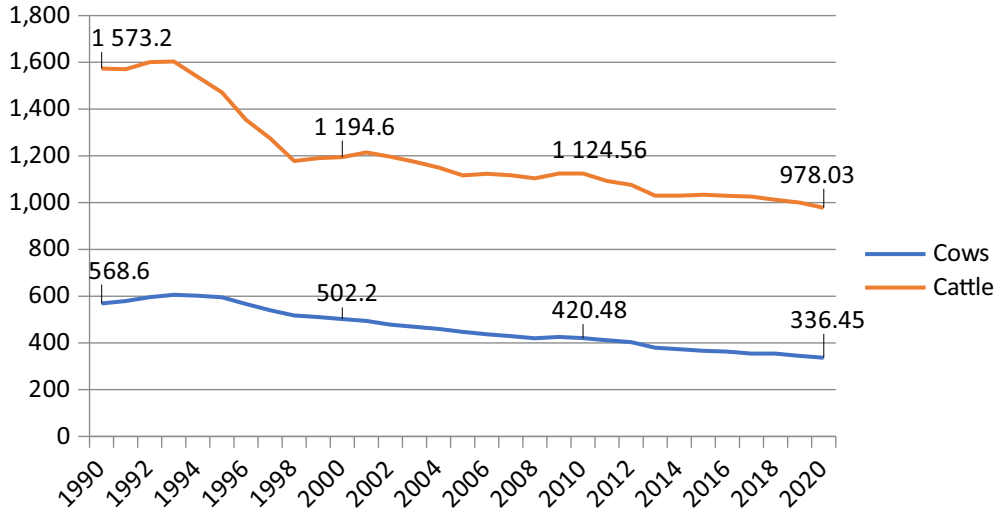

Fig. 6. The number of cattle and cows in the Republic of Tatarstan, thousand heads (1990–2020).

Despite the growth in milk production, there is a reduction in the number of cattle and cows, so for the analyzed period since 1990 the number of cows decreased by 40.8% and amounted to 336.45 thousand heads in 2020. Thus, the main factor in the growth of milk production is currently the milk productivity of cows. However, the reserve of milk production efficiency growth in the next years in Russia and in the republic will be an increase in the number of the main milking herd with a further increase in its productivity.

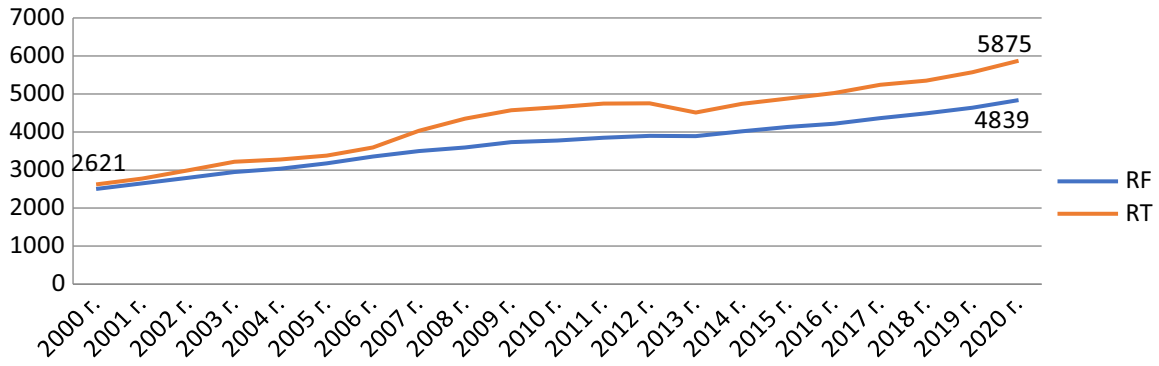

Fig. 7. Milk yield per cow in Russia and in the Republic of Tatarstan, kg.

Table 1. Large producers of milk in the Republic of Tatarstan in 2020.

Company	Volume, thousand tons	Number of cattle, thousand heads	Average yield per 1 cow, tons
JSC Agroholding «Krasny Vostok»	115.1	64.6	5.6
Ak Bars «HC JSC»	106.6	67.8	5.1
JSC «Agrosila»	67	31.9	5.8
LLC «APC Food Program» (Mamadysh)	55.4	20.8	10.9
AE Vakhitova (Kukmor)	34.3	7.9	11
LLC Management Company «AgroInvest»	31.6	9.7	6.2
LLC “Soyuz-Agro”	31	10.7	8.6
APC «Uralb» (Kukmor)	26.5	6.3	10.7
LLC «Orsis-Agro» (Nizhnekamsk)	17.8	4.2	9.7
LLC «Khuzangayevskoye»	17	10	3
LLC «Service-Agro»	12.9	5.8	7.7
LLC Agro-Osnova (Novosheshminsk)	12.5	8.2	4.2
LLC «MVP Sabinsky»	12	1.5	12.8
LLC «AF Karmaly» (Nizhnekamsk)	10.3	3.9	5.9
LLC «Nurlat Sete» (Nurlat)	9.8	5.4	5
JSC Tokarlikov (Almetyevsk)	8.9	2.9	8.9
LLC «August-Muslum»	8	12.5	5.2
LLC «Chistay-Agro» (Chistopol)	7.6	5.7	3.6
PSC JSC «TATAgrokhim»	6.3	3.3	5.6
CC Civil Code "Fortex"	6.2	2.3	6.3
AE LLC «Northern»	6	3.2	7.7
LLC AF «Chistopolskaya»	5.9	2.4	5.2
JSC «Racine»	5.6	1.1	4.1
LLC Agricultural Enterprise Lutfullin Z. R.	4.9	2.7	5.7
LLC «R-Agro» (Tatplodovoschprom)	4.4	1.9	4.4
JSC «Tatagroleasing»	3.5	1	3.7
JSC «Avangard»	3.3	2	4.3
JSC «Chelny-Khleb»	2.8	1	7
Total	633.2	300.7	X

Over the past 20 years the growth of milk productivity of cows in the republic has increased more than 2-fold and amounted to 5.9 thousand tons per year, which is associated with the improvement of the breed composition of the main herd, diet, conditions and technology of housing.

At present, the world leader in cow productivity is Israel, with an average indicator of 12 thousand tons of milk per year from one cow, which is 2 times higher than the republican value.

Let us consider the main production indicators of large producers of raw milk in the Republic of Tatarstan, which are given in Table 1.

Large producers of raw milk in the Republic of Tatarstan account for 32.6% or 633.2 thousand tons. The leaders in cow productivity are the following companies LLC LLC “MVP Sabinsky” (Sabinsky district) – 12.8

tons of milk from one cow per year, AE "Vahitova" (Kukmorsky district) – 11 tons, "APC Food Program" Ltd. (Mamadyshsky district) – 10.9 tons, "Ural" (Kukmorsky district) – 10.7 tons, "Orsis-Agro" Ltd. (Nizhnekamsky district) – 9.7 tons, Tokarlikova JSC (Almetyevsky district) – 8.9 tons [3].

Economic efficiency of dairy cattle breeding is characterized by some of the following indicators:

- average milk yield from 1 cow;
- costs per cow;
- Feed consumption per cow;
- cost of production;
- profit, level of profitability and others.

In economic practice the possibility of managing the factors of socio-economic phenomena determines the necessity to measure their interrelations.

To estimate the degree and nature of the relationship between milk productivity of cows and the factors, which determine it, we conducted correlation and regression analysis by solving the problem of multiple correlation.

For this purpose a multifactorial correlation and regression model of economic activity of livestock enterprises for 2019, covering a set of 269 units of agricultural organizations of all municipal districts of the Republic of Tatarstan was built.

The resultant (y) and factor (xi) signs are designated in this model. In economic processes, the resultant factors include indicators that directly or indirectly reflect the results of production activities. In this connection, the indicator characterizing the level of milk productivity of cows serves as an outcome factor.

Factor indicators, in turn, should reflect the level of their impact on the production process:

y – average annual milk yield per 1 head, cwt;

x1 – labor costs per 1 dairy head, thousand rubles;

x2 – cost of fodder per 1 goal, thousand rubles;

x3 – amount of subsidies per 1 goal, thousand rub;

x4 – density of cows per 100 hectares of agricultural land, heads.

Multifactor correlation and regression analysis allows one to estimate the measure of influence on the studied result indicator of each of the factors included in the model at a fixed position of the other factors, as well as at any possible combinations of factors with a certain degree of accuracy. In this case an important condition is the absence of a functional relationship between the factors.

Assessment of the parameters of the results of the solution is reduced to the comparison of obtained parameters with the norms of mathematical statistics. If the parameters meet the standards, then proceed to the interpretation of the solution results. Otherwise, the correlation and regression model is corrected by screening out observations with gross (anomalous) errors, and by excluding or replacing factor attributes according to mathematical restrictions imposed on their selection. The corrected model is used to obtain a new solution, which also evaluates the calculated parameters [4, 5, 6].

3 Results and discussion

According to the results of the solution of four-factor model, which includes 146 observation units after adjustment (Table 2), the tightness of the connection between the resultant and factor attributes selected in the correlation model is strong enough, as evidenced by the numerical value of the multiple correlation coefficient (R = 0.696).

Table 2. Four-factor correlation and regression model.

Number of observations	146				
Number of factors	4				
Result and factors	Y	X1	X2	X3	X4
Errors of correlation coefficients	0.043	0.069	0.058	0.071	0.064
Reliability of correlation coefficients	16.300	5.917	9.595	5.439	7.542
Arithmetic mean values	60.380	7.719	16.617	22.352	10.305
Mean square deviations	18.491	3.036	6.474	8.899	4.046
Coefficients of variation, %	30.625	39.333	38.960	39.814	39.263
Regression coefficients	11.157	0.818	0.808	0.635	1.483
Beta coefficients		0.134	0.283	0.306	0.325
Determination coefficients, %	48.418	16.657	30.479	14.733	23.064
Coefficients of individual determination	48.418	5.483	15.616	11.735	15.585
Multiple correlation coefficients	0.696				
Paired correlation coefficients	Y	0.408	0.552	0.384	0.480
	X1		0.404	0.082	0.414
	X2			0.282	0.396
	X3				-0.039

The absolute values of rYXj reflect the following strength of the relationship:

rYXj = 0 - no relationship;

0.00 < rYXj < 0.20 - insignificant, unreliable relationship;

0.20 < rYXj < 0.40 – weak relationship;

0.40 ≤ rYXj < 0.60 – average connection;

0.60 ≤ rYXj < 0.80 – strong connection;

0.80 <= rYXj < 1.00 – very strong relationship;

rYXj = r,00 - functional linear relationship

The error of the correlation coefficient (OR = 0.043) and the reliability of the correlation coefficient (TR = 16.300) confirm the presence of a strong relationship between the resultant and factor attributes and indicate sufficient reliability of the multiple correlation coefficient.

The interpretation of the results of the solution involves the study of coefficients of determination, regression coefficients and coefficients of separate determination.

The multiple determination coefficient (D = 48.418) characterizes the percentage measure of dependence between the factors included in the model and the result. It follows, that together the four factors of the correlation-regression model influence the change of milk productivity of cows by 48.418%, including the change of labour compensation by 5.483%, feed expenses by 15.616%, change of subsidies by 11.735%, population density by 15.585%.

The coefficients of the regression equation are the coefficients of the regression equation:

Y1 = 11.157 + 0.818x1 + 0.808x2 + 0.635x3 + 1.483x4

If we substitute the arithmetic mean values of the factor attributes – x1, x2, x3, x4 into the equation, then the calculated value of the result indicator – Y will also be the arithmetic mean.

Parameters of the linear regression equation at the factor attribute show, to what change in the average value of the resultant attribute a change in the factor attribute by one unit leads.

That is, if the average annual labor costs per 1 head are increased by 1 thousand rubles, then the average annual milk yield will increase by 0.818 ct. If the feed expenses per 1 head are increased by 1 000 rubles, then annual average milk productivity of cows will increase by 0.808 ct. The increase of the subsidies per 1 thous. rub. per 1 cow will increase the milk production level by 0.635 ct, and at the expense of the larger density of cows per 1 cow per 100 ha of agricultural land the annual average milk production will increase by 1.483 ct.

Thus, by changing the values of factor attributes it is possible to reach the maximum (or minimum) possible value of the resultant attribute. However, it is legitimate to change the factor attributes to decrease or increase only within the variation range or coefficient of variation of their arithmetic mean. Y1 = 11.157 + 0.818*1max + 0.808*2max + 0.635* max3 + 1.483*4max =

Y1 = 11,157 + 0.818*10,76 + 0.808*23.09 + 0.635*31.25 + 1.483*14.35 = 70.1 ct

It means that by changing the measure of influence of these factors, the average annual milk yield can be brought up to 70.2 centners per 1 cow, which is higher than the average level of the population under study.

It should be noted that the majority of agricultural enterprises do not use statistical methods of analysis, including correlation and regression analysis, due to the difficulties arising in the collection of digital data, their processing and interpretation. However, as this study shows, their use makes it possible to predict the value of certain basic indicators of financial and economic activity of the enterprise, taking into account the degree of influence of a number of factors on them. For a comprehensive assessment, forecasting and development of an action plan (roadmap) to improve the efficiency of financial and economic activity of an agricultural enterprise it is advisable to determine a number of key indicators with subsequent assessment of the degree of influence of certain factors on them. As an example, the study assessed and forecasted the productivity of farm animals.

In order to widely disseminate the practical application of this method in the management system of enterprises we recommend to form at the regional level the databases of the main production and financial indicators of agricultural producers (an option without naming them is possible, or to provide limited access to this information through the relevant regional ministries responsible for agriculture) [3].

4 Conclusion

The proposed tools can be used to forecast the results of the economic activity of agricultural organizations, to develop further action plans to improve the production and economic activity of the organization and to search for reserves to improve its efficiency.

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pp 687–707 (2021) https://doi.org/10.1007/978-3-030-57450-5_59