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Research Article

Strategic Parameters to Improve Dairy Production Efficiency

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ABSTRACT:

The rationale of the study is that the current economic changes in Russia necessitate the search for reserves and determination of parameters to improve the production efficiency. In this regard, this paper is aimed at identifying the conditions for improving dairy production efficiency, as well as developing strategic parameters to improve it. The main research method is economic and mathematical modelling that allows for a comprehensive and systematic approach to evaluation factors that have an impact on dairy production efficiency and developing recommendations to improve it. The paper presents two optimization scenarios to improve milk production efficiency in the region under study. One of them is aimed at increasing revenues and production volumes, and the other is aimed at increasing profit and profitability. Different parameters of efficient production were identified for the organizations under study depending on their type and size. It was determined that the choice of the scenario for improving efficiency depends on specific objectives and development trends. The paper has a practical value for agricultural organizations in terms of the identification of strategic parameters to improve milk production efficiency.

Keywords: efficiency, profitability, profit, optimization, production.

Introduction

Milk production occupies a large share in the gross agricultural output, and its economic efficiency largely determines the efficiency of the whole agricultural industry.

Meanwhile, the efficiency of agricultural organizations is affected by current changes in the Russian economy.

The current situation and trends in milk production are a decrease in efficiency, an increase in production costs and prices, a general trend towards a reduction in cow numbers.

In recent years, Russia is steadily focused on import substitution of foods and food production resources. A particular attention is focused on milk production.

The decreased pressure of imports forces milk producers to find reserves for improving production efficiency. However, some organizations are unable to promptly respond to the fast-changing environment, and their efficiency declines despite the steps the government takes to improve it.

Thus, as part of an effort to provide Russia's regions with quality milk and dairy products in the amount determined by the Russian Federation Food Security Doctrine, it is necessary to search for production reserves and create an enabling environment for increasing economic efficiency of milk production.

Theoretical, practical and methodological foundations of production efficiency were reflected by many Russian and international researchers. Works of the following international scholars are worth mentioning: M. Castells, C. R. McConnell, J. S. Mill,

A. Smith, D. Khan, J. A. Schumpeter.

Among Russian researchers, the milk production efficiency was addressed by K. Kh. Abulaev, A. I. Altukhov, V. A. Antashov, M. Z. Bor, E. Yu. Bondareva, A. S. Bulatov, G. A. Goncharenko, V. P. Gruzinov, A. Yu. Gusev, N. Ya. Kovalenko, V. G. Larionov, S. Yu. Lyapina, M. D. Magomedov, I. A. Minakov, T. A. Mikhaleva, I. P. Nikolaeva, G. A. Petraneva, I. S. Sandu, I. M. Surkov, A. V. Ulezko, O. M. Fokina, I. M. Chetvertakov and others.

However, a number of issues still remain to be explored, and some provisions are still debatable. These include the study of the reserves for improving milk production efficiency, the study and systematization of the factors that shape the conditions for its production, the substantiation for ways of increasing the economic efficiency of regional milk producers.

MATERIALS AND METHODS

Over the recent years, a number of steps have been taken in the Russian Federation towards the sustainable development of internal production of food and raw materials.

Those steps mostly concern agricultural production, and particular attention is focused on milk production. The reason for such attention is the decline in production of several product categories and a decline in cow numbers throughout the country (Zhakevich 2015, 36–39).

The efficiency evaluation is based on indicators and criteria for its determination. A criterion is a key indicator by which one can judge the efficiency. An analysis of economic publications shows that there are several approaches to the definition of efficiency criteria (Igoshin 2012, 39–45).

For example, one of the commonly accepted criteria is the increase in gross milk production; however, growing volumes are not always an optimal parameter, because an inability to sell the milk, such growth would only produce a stranded cost of a large volume of product (Kovalenko 2004).

Another type of criteria is associated with meeting population demand in the products or keeping minimum production costs [Magomedov 2013).

The complexity and structural nature of efficiency in agricultural sector raise controversy and debate among many scientists regarding the criteria and indicators to evaluate it.

According to K. P. Obolensky, the criterion for agricultural production efficiency is the ratio of gross output to the costs of both human and materialized labor (Obolensky 1974).

This view is shared by E. R. Vitun. He expands the Obolensky's definition and includes there the growth value of gross income at reduced costs (Vitun 1993, 73).

L. F. Dogil suggests considering the agricultural production efficiency criterion to be the maximum value of profit per resource cost unit. High quality and productive labor is suggested to be a condition for maximizing profit (Dogil 1996, 31).

I. A. Minakov's definition might be the most accurate under current conditions: the criteria of the milk production efficiency should be the maximum effect per cost unit, or the minimum cost per output unit (Minakov 2007).

The milk production efficiency criteria should be classified according to the objects of efficiency definition. This paper suggests a general classification that includes the following levels of milk production efficiency: region, organization, industry, farms and economic activities.

These levels are similar in terms of the efficiency groups suggested by N. Ya. Kovalenko (Kovalenko 2004, 298). The classification of the milk production efficiency criteria is shown in Figure 1.

	Levels of milk production efficiency	Efficiency criterion for each level

Classification of milk production efficiency criteria	Region	Growing milk production volumes, greater food independence in milk and sufficiently meeting the population demand for milk and dairy products
	Organization	Maximum profit per milk production cost unit or per conditional head, maximum profit per conditional head; profitability of milk production
	Industry	Reduced milk production cost; better quality of milk, provision of milk for young stock and other industries.
	Farms	Increased cow productivity; loss reduction during milk transportation and storage; increased marketability.
	Economic activities	Attained goals of indivicual economic activities (scheduled, actual, project-related etc.)

** Source: author's own figure*

Figure 1. Classification of milk production efficiency criteria by efficiency levels

Thus, at the regional level, the key criterion will be greater food independence in milk and sufficiently meeting the population demand.

The milk production efficiency at the level of agricultural organizations is determined mainly by profit per milk production cost unit or per conditional head.

The efficiency criteria at the industry level are reduced milk production cost, provision of milk for young stock and other related industries (processing, etc.). The efficiency of dairy farms should be determined by the level of marketability (the ratio of sold milk to the total production volume), cow productivity and loss reduction during milk transportation and storage/processing.

The efficiency criterion for individual economic activities is the correlation of their effect to the expected results. Based on these criteria it is important to determine the indicators to evaluate the attained milk production efficiency. In agriculture, among all the factors of production (labor, land, capital and entrepreneurship), the most important is land, which characterizes not only its existence, but also the size of the organization. In view of this, the key indicator of agricultural production efficiency is revenue and profit per agricultural land area, arable land area or crops area (Tsatkhlanova 2011).

For example, in Nizhny Novgorod Oblast, milk production in 2016 was 598.2 thousand tons (Table 1), while the total milk production in the Russian Federation amounted to 30,758.5 thousand tons, which almost two times less than in 1990 (by 45%). 442 thousand tons are produced by agricultural organizations and 102.4 thousand tons by farm households. In the region under study, milk production declined within the same period by 57%, which may indicate a shortage of milk for the population and possible inefficiency of its production.

Nizhny Novgorod Oblast is a part of Volga Federal District, where farms of all categories produce 9,413.8 thousand tons of milk, which is 30% of all milk produced in Russia. The region under study accounts for 6% of the milk produced in the Volga Federal District.

Table 1. Milk production, thousand tons

Territory	1990	2016	Deviation, thousand tons	Deviation, %
Farms of all categories				
Russian Federation	55,715.3	30,758.5	-24,956.8	55.2
Volga Federal District	14,467.7	9,413.8	-5,053.9	65.1
Nizhny Novgorod Oblast	1,390.6	598.2	-792.4	43.0
Agricultural organizations				
Russian Federation	42,452.1	15,061.1	-27,391.0	35.5
Volga Federal District	10,439.5	4,835	-5,604.5	46.3
Nizhny Novgorod Oblast	1,044.3	442	-602.3	42.3
Farm households				
Russian Federation	13,263.2	13,502.6	239.4	101.8

Volga Federal District	4,028.2	3,887.6	-140.6	96.5
Nizhny Novgorod Oblast	346.3	102.4	-243.9	29.6

** Source: compiled from data of the Federal State Statistics Service*

Milk production in the region declines every year (Figure 2). According to the trend line, the average yearly decline is 28.7 thousand tons.

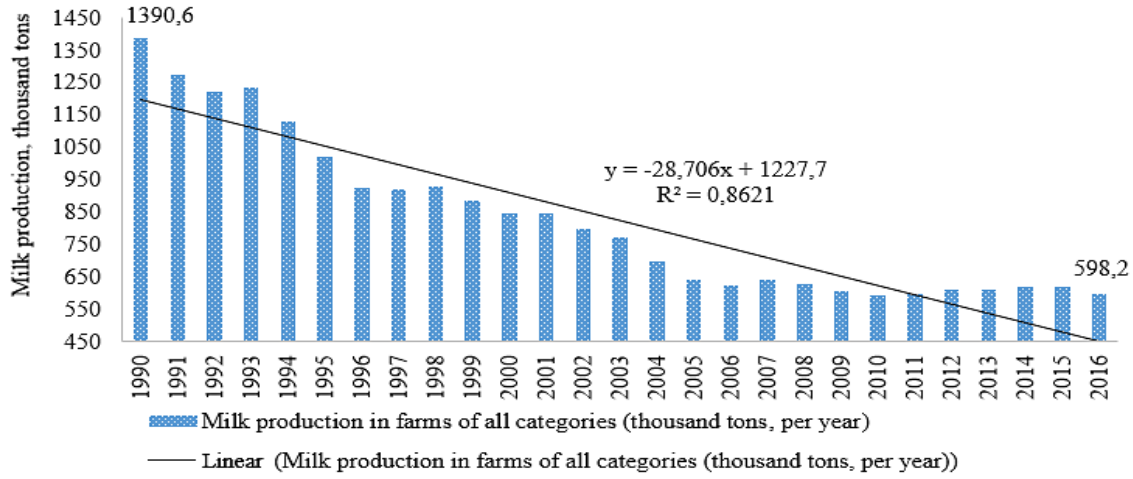


Figure 2. Milk production in Nizhny Novgorod Oblast

Sharp decreases in production can be observed since 1996. Since 2005, the value remains about 650 thousand tons of milk per year.

According to the Federal State Statistics Service, despite the decline in production, the productivity is growing (Figure 3).

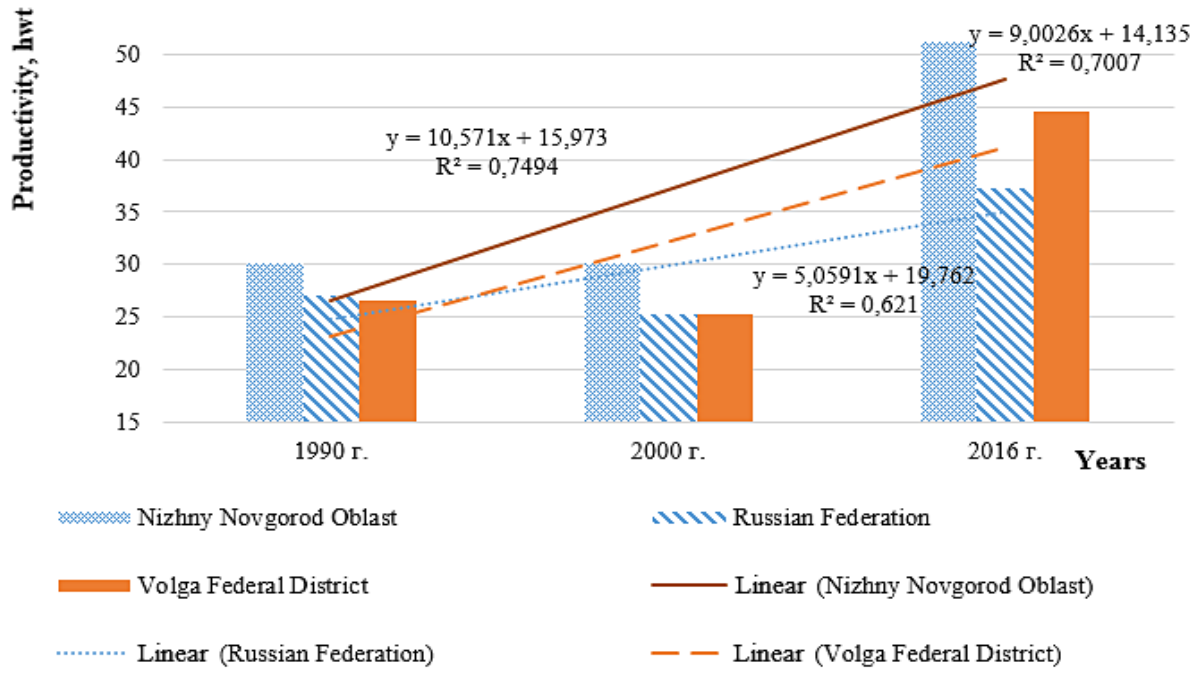


Figure 3. Productivity per head

According to the trend line, the productivity in the Russian Federation the increase is at around 9 hwt, in the Volga Federal District — at 5 hwt, and in Nizhny Novgorod Oblast — at 10.57 hwt.

The overall productivity in Nizhny Novgorod Oblast increased over the period under study by 70% (Table 2).

The reason for the decrease in production despite the increased productivity is a sharp drop in the cow numbers throughout all the territories under study.

For example, in 1990 the cow numbers in Russia were 20,556 heads, by 2000 it amounted to 12,742 heads, and by 2016 it decreased by 58.8%.

In the Volga Federal District, the cow numbers decreased by 61.2%, and Nizhny Novgorod Oblast by 74.7%.

Table 2. Cow numbers and productivity

Territory	1990	2000	2016	Deviation, %
Cow numbers, thousand heads				
Russian Federation	20,556.9	12,742.6	8,263.7	40.2
Volga Federal District	5,452.5	3,804.3	2,113.6	38.8
Nizhny Novgorod Oblast	462.4	281.7	116.8	25.3
Productivity, hwt				
Russian Federation	27.1	25.3	37.2	137.3
Volga Federal District	26.5	25.3	44.5	167.9
Nizhny Novgorod Oblast	30.1	30.1	51.2	170.3

** Source: compiled from data of the Federal State Statistics Service*

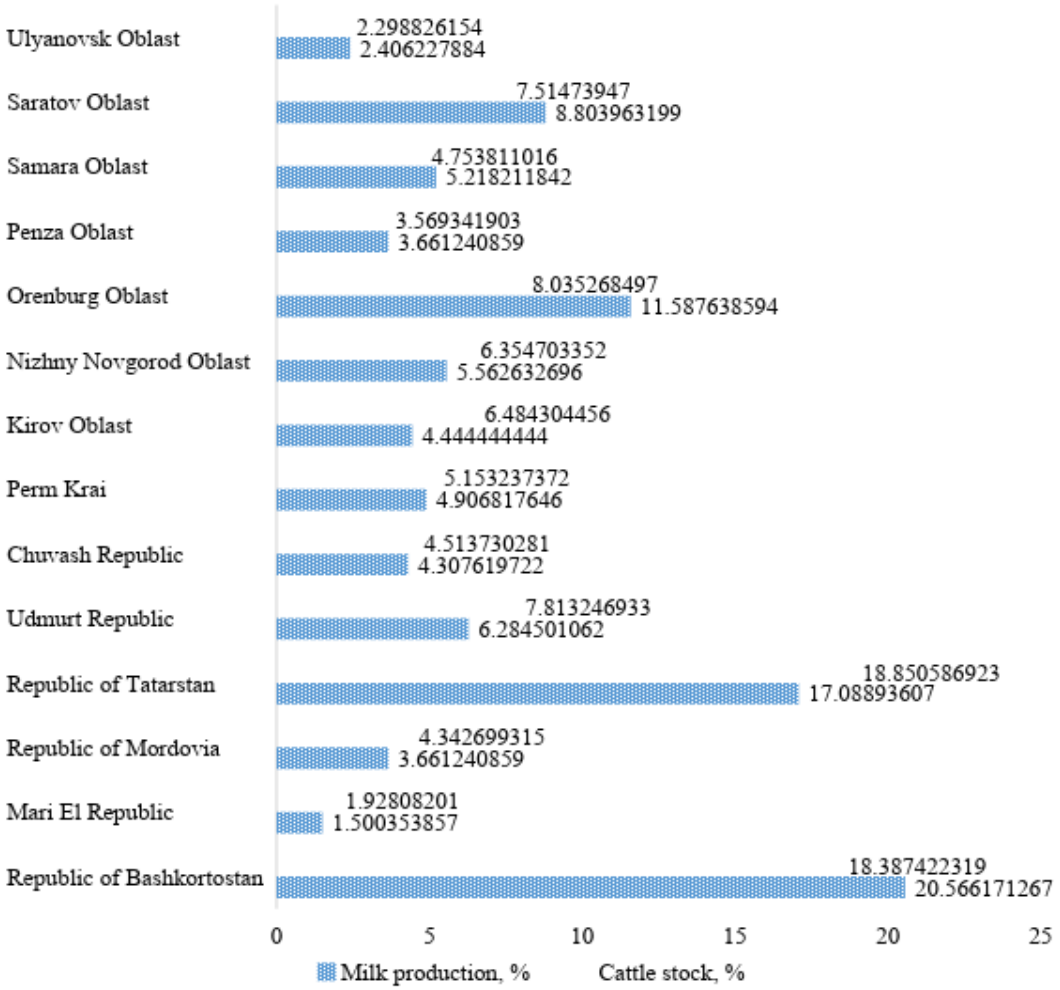
The development of any region is closely linked to neighboring territories. Nizhny Novgorod Oblast is a region within the Privolzhsky Federal District, which occupies about 6% of Russia's territory (more than 1 million sq. km.).

More than 30.2 million people live in the District, which accounts for more than 20% of Russia's population. The district's share in Russian gross domestic product exceeds 15%.

The Volga Federal District is one of the most populous Russian territories and is a leading federal district in producing many agricultural products.

An important role in the economy of the district is played by the food and processing industries, which are largely provided with agricultural products and have a high consumer demand (2020 Strategy of Social and Economic Development of the Volga Federal District, 2011).

Milk production in the Volga Federal District is an important component of social and economic development. Dairy cattle breeding is usually concentrated in agricultural organizations and, on a limited scale, in farm households and farming enterprises. Cattle stock is distributed in the Volga Federal District unevenly. It is most concentrated in the Republics of Bashkortostan and Tatarstan and Orenburg Oblast (Figure 4).



** compiled from data of the Federal State Statistics Service*

Figure 4. Share of the Volga Federal District regions in the total cattle numbers and milk production in 2016, %

The key factors in the existing distribution of livestock are availability of forage crops areas and natural forage lands and favorable natural conditions for production.

Nizhny Novgorod Oblast has 6.35% of the District's cattle and produces 5.6% of its milk.

Economics differentiate extensive and intensive the factors of production development.

The extensive factors include increasing the amount of resources used in production: in dairy cattle breeding the role of an extensive growth factor is played by increasing the numbers of dairy cows.

The intensive factors include factors affecting the increase in production in a qualitative manner. With regard to dairy cattle breeding, such factor will be increased productivity per head of the dairy herd (Ilysheva 2011).

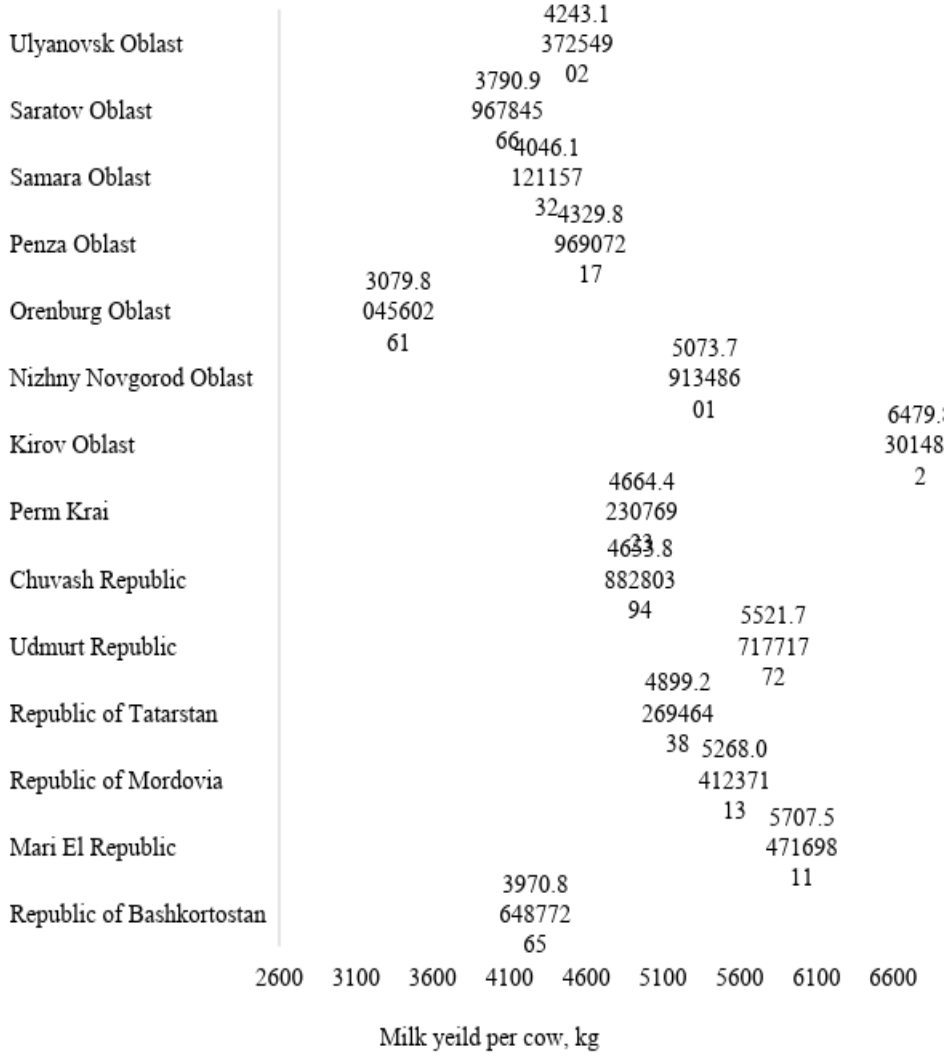
Figure 5 shows that the highest productivity of dairy herd was recorded in Kirov Oblast and the Mordovia and Udmurtia Republics.

Orenburg Oblast, Republics of Bashkortostan and Tatarstan that produce a large share of milk in the Volga Federal District have lower productivity in relation to other regions, and therefore they can be described as following the extensive development model, which is based on increasing the number of livestock. This is due to the large pasture areas and availability of organizations' production facilities.

In 2016, Nizhny Novgorod Oblast ranked 6th in Volga Federal District in cow numbers and gross milk yield, and 5th by the productivity per head of the dairy herd.

The area of Nizhny Novgorod Oblast accounts for 7%, and the population — for 12% of Volga Federal District.

Agriculture is a well-developed sector of the regional economy.



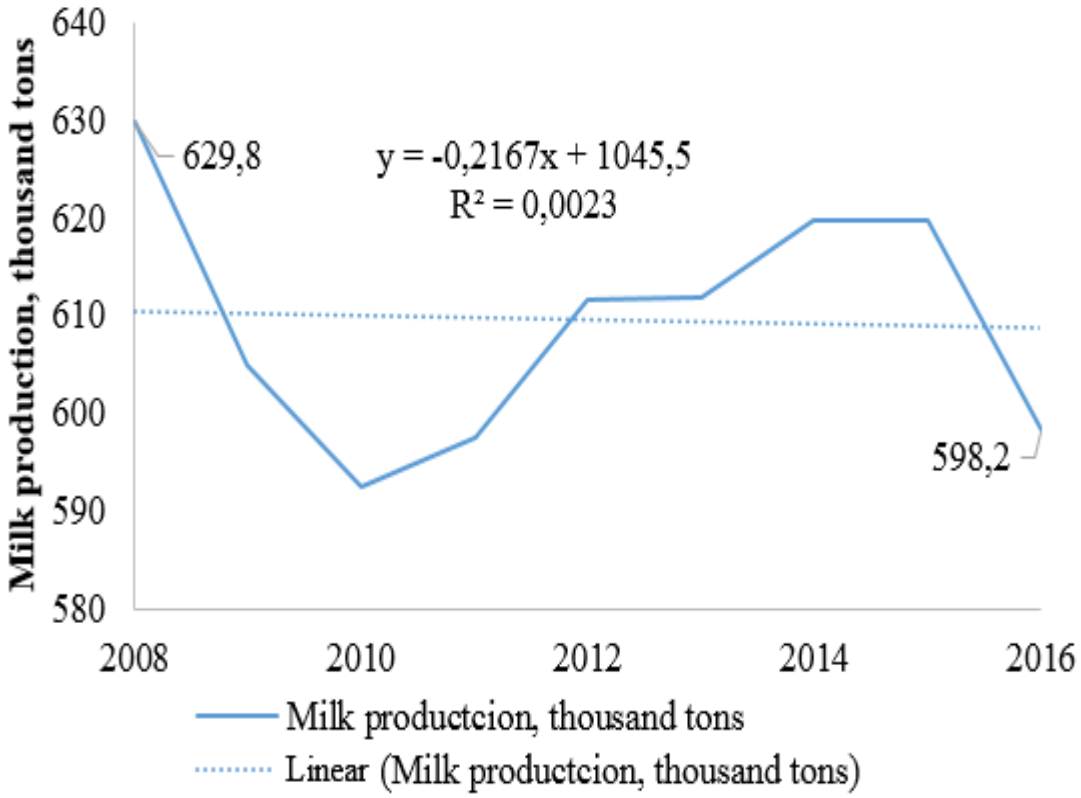
** compiled from data of the Federal State Statistics Service*
Figure 5. Cow productivity in Volga Federal District in 2016, kg

Rye, wheat, oats, barley, buckwheat, sugar beet and fiber flax are mostly grown. Onion and potatoes are also cultivated. Beef-dairy and dairy cattle breeding is well developed (Nizhniy Novgorod Oblast ranks 14th in Russia in milk production), as well as pig breeding, poultry farming.

Greenhouse complexes cultivate about 12 thousand tons of off-season vegetables. In 2009, 1.5 million tons of grains were harvested — more than the region can consume.

Home produced meat is not sufficient to meet the public demand, so meat is imported from Argentina and other countries (Official site of the Ministry of Agriculture and Food Resources of Nizhny Novgorod Oblast 2016).

Nizhny Novgorod Oblast has 6.35% of the cow numbers in farms of all categories in Volga Federal District and produces 5.6% of its milk. A statistical analysis of the time series of gross milk yield (Figure 6) shows that milk production is currently subject to a decrease, as indicated by the trend line (reduction of about 0.2167 thousand tons per year).



** compiled from data of the territorial body of state statistics for Nizhny Novgorod Oblast*
Figure 6. Milk production in Nizhny Novgorod Oblast, thousand tons

A strong decline was observed until 2010. After that, a growth was recorded until 2015, but in 2016 milk production decreased almost to the 2010 level.

And although in recent years the government takes steps to promote the industry and improve its efficiency, they are not enough to steadily increase the milk production.

According to the Office for National Statistics, In January — September 2017, farms of all categories produced 469.6 thousand tons of milk. Compared with the same period last year, milk production decreased by 0.3%.

Efficiency eventually sums up into the result of economic activity. For milk producers and commercial organizations, the key result is gaining profit from milk sales.

Profit is generated as the difference between the cost of milk production and the revenues from its sales. The study determined that the average profitability of milk production in municipal districts of Nizhny Novgorod Oblast is 16.98%.

It should also be noted that in 4 districts of Nizhny Novgorod Oblast, milk sales are unprofitable.

Among all municipal districts, 7 were reported in the study to have the highest profitability of milk production: Bogorodsky, Bolshemurashkinsky, Vadsky, Dalnekonstantinovsky, Knyagininsky, Krasnooktyabrsky and Urensky. The maximum profitability of 45.5% was observed in the Krasnooktyabrsky District, which is 45.3 percentage points higher than in 2012 (Figure 7). This data suggests that in 2012 — 2016, the efficiency of milk production and sales grew significantly in the district. Such a change can be attributed mainly to the fact that the volume of the forage resources sharply increased (from 25.1 hwt of forage units of harvested forage per head to 35.1 hwt of forage units). It should be noted that Dalnekonstantinovsky and Vadsky districts also rank among the highest in profit from the milk sales (Figure 8).

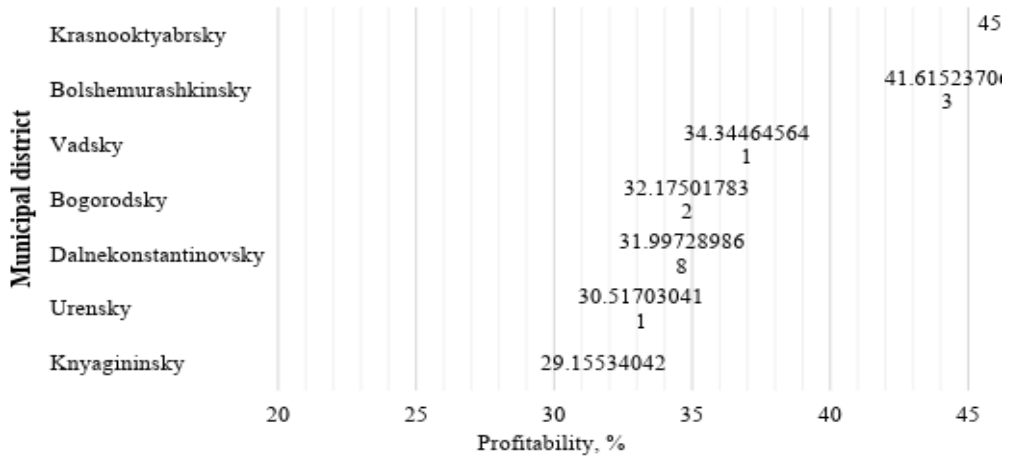


Figure 7. Districts of Nizhny Novgorod Oblast with highest profitability of milk production in 2016, %

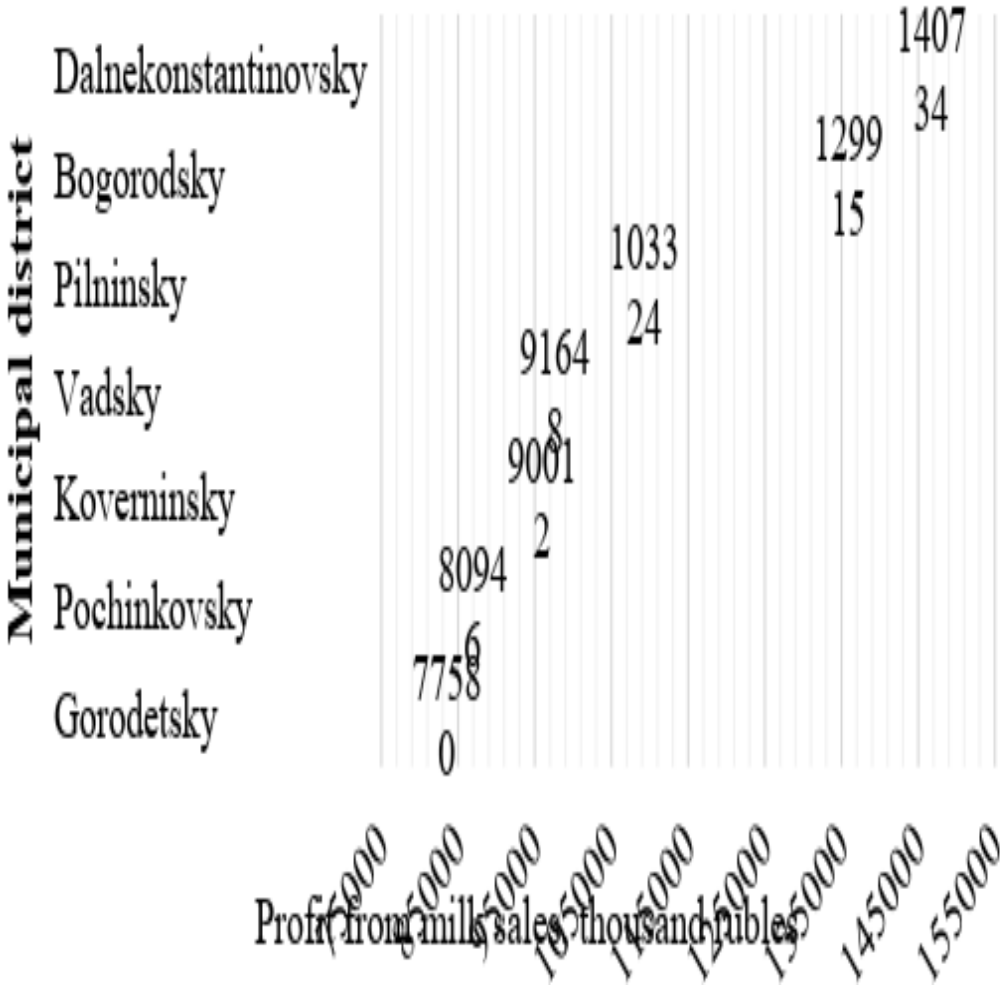


Figure 8. Districts of Nizhny Novgorod Oblast with the highest profit from the milk sales in 2016, thousand rubles.

The largest profit from the milk sales was gained in the Dalnekonstantinovsky district (140,734 thousand rubles). This district is also a leader in terms of milk production in 2016 (the same trends can be observed in 2015). In the period under study, the profit from the milk sales greatly decreased in several districts, which negatively affected the dairy cattle breeding efficiency (Figure 9).

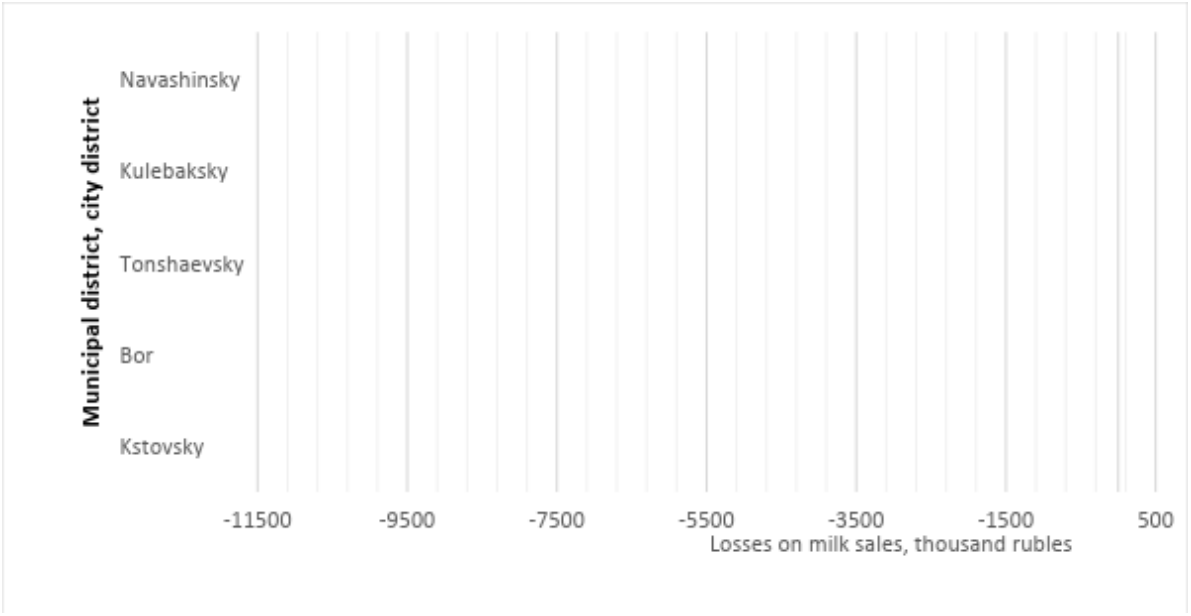


Figure 9. Level of deviation of profit in 2016 from 2012 in municipal districts of Nizhny Novgorod Oblast, %

In Kstovsky district, in 2012–2016 the profit dropped by 41%. Kulebaksky district suffered an 89% reduction in profit.

The loss from the milk sales increased by 97% in the Bor district and by 48% in Tonshaevsky district.

A review of the data on the sale prices of 1 kg of milk showed that the highest price was in Voskresensky district: 29.7 rubles per 1 kg of milk (Figure 10).

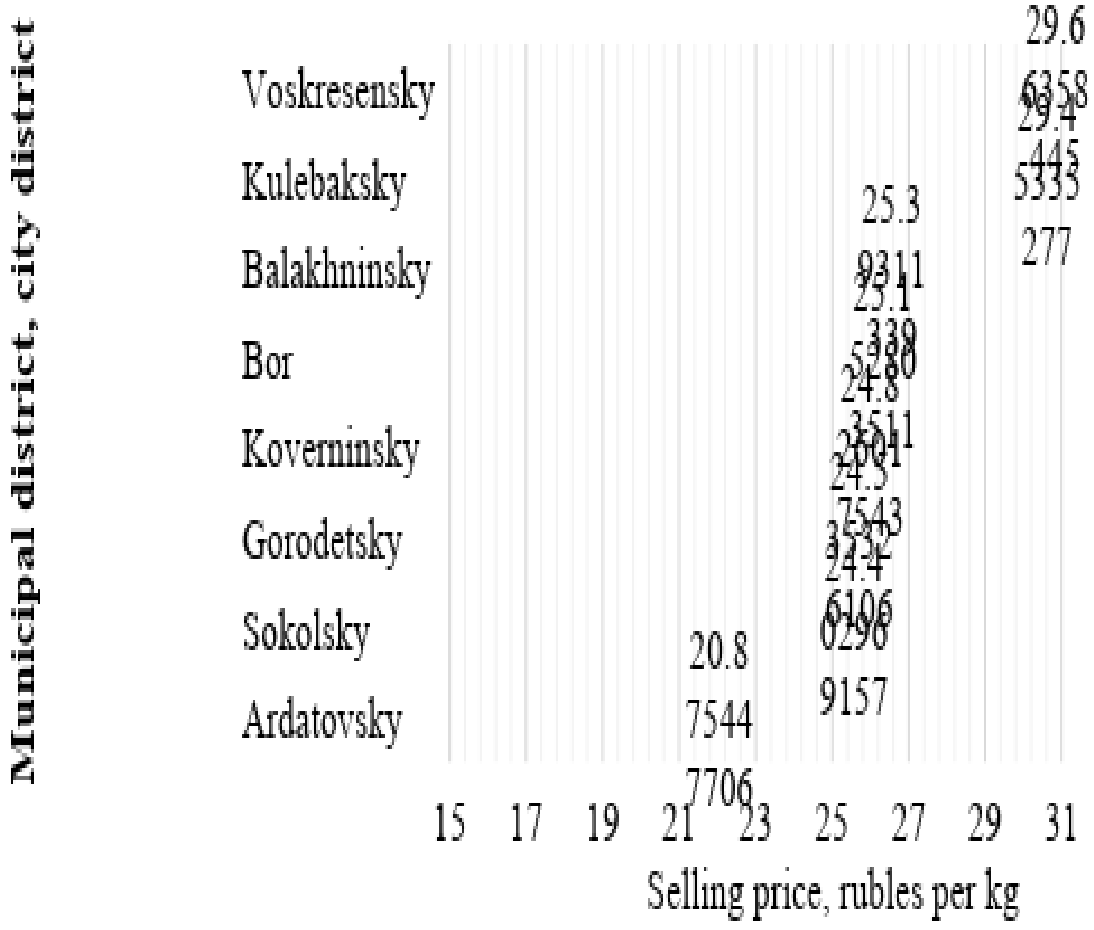


Figure 10. Districts of Nizhny Novgorod Oblast with the highest sale price of 1 kg of milk, RUB

As it was found earlier, despite the highest sale price for milk, the profit in this municipal district decreased by 83,000 rubles.

That said, based on a comprehensive analysis of the current state of milk production in Nizhny Novgorod Oblast, it is important to note that steps are currently required to reduce the lag between the production and consumption of milk and to reduce its production costs. To determine such measures and their subsequent efficiency, it is necessary to have an understanding of the further development of the industry and the reserves of increasing the efficiency of milk production.

RESULTS

The study determined that milk production efficiency in agricultural organizations of the region under study shows a mild tendency to improve.

In particular, in larger farms with cow numbers of 520 heads and more, a higher profit is generated per conditional head than in organizations with a smaller dairy herd.

Based on this, it is important to determine the parameters of achieving optimal milk production efficiency in organizations.

Economic and mathematical modelling is often used to determine the optimal values of such parameters. This method allows to find the quantities of required resources, to identify reserves for increasing milk production efficiency, and, as a result, to make rational managerial decisions.

To find the parameters for increasing the efficiency of milk production, an economic and mathematical model was developed in this study for optimizing the commercial activities in organizations involved in dairy cattle breeding in Knyagininsky district (Nizhny Novgorod Oblast): OOO AP Solovyovskoe , ZAO Pokrovskaya Sloboda, SPK Bolsheandreevsky, OOO AP Knyagininskoe, OOO Ananye.

Milk production in these organizations amounts to 57,105 hwt, the dairy cow number is 1,767 heads. The absolute leader in milk production and the number of livestock is OOO AP Solovyovskoe: 29.9% and 29.7% respectively of the group under study (Table 3, Figure 11, Figure 12).

Table 3. Parameters of the group under study

Indicators	OOO Agropredpriyatie Solovyovskoe	
	Units	%
Cow number, heads	525.0	29.7
Productivity per head, hwt	32.5	-
Milk produced, hwt	17,082	29.9
Indicators	ZAO Pokrovskaya Sloboda	
	Units	%
Cow number, heads	453.0	25.6
Productivity per head, hwt	36.0	-
Milk produced, hwt	16,310	28.6
Indicators	Agricultural production co-operative Bolsheandreevsky	
	Units	%
Cow number, heads	160.0	9.1
Productivity per head, hwt	32.5	-
Milk produced, hwt	5,200	9.1
Indicators	OOO Agropredpriyatie Knyagininskoe	
	Units	%
Cow number, heads	304.0	17.2
Productivity per head, hwt	41.6	-
Milk produced, hwt	12,652	22.2
Indicators	OOO Ananye	

	Units	%
Cow number, heads	325.0	18.4
Productivity per head, hwt	18.0	-
Milk produced, hwt	5,861	10.3

** Source: compiled from data of the territorial body of state statistics for Nizhny Novgorod Oblast (Nizhny Novgorod Oblast, Statistical Year Book 2016)*

The milk is sold directly in Knyaginino to OAO Knyagininskoe Moloko, and also to Nizhny Novgorod to Wimm-Bill-Dann (Nizhny Novgorod branch) at an average price of 19.35 rubles per 1 kg of milk.
It should also be taken into account that all organizations in the district are distributed evenly and are equidistant from the district center Knyaginino (except for OOO AP Knyagininskoe, which is located in Knyaginino town).

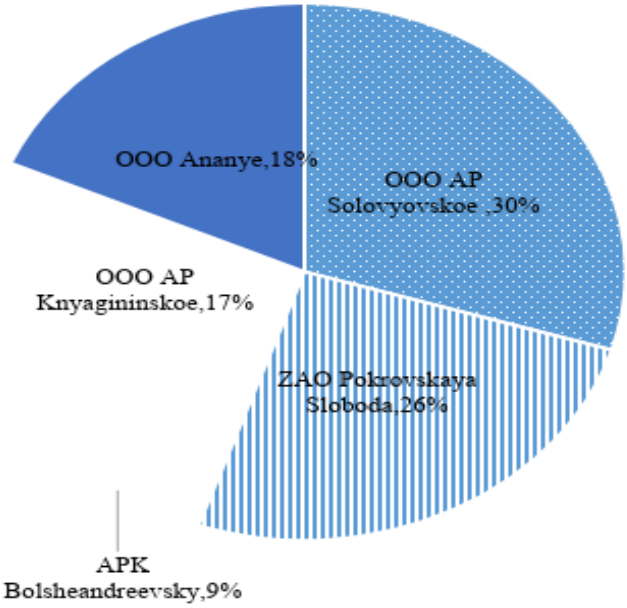


Figure 11. Breakdown of the cow numbers in the group under study

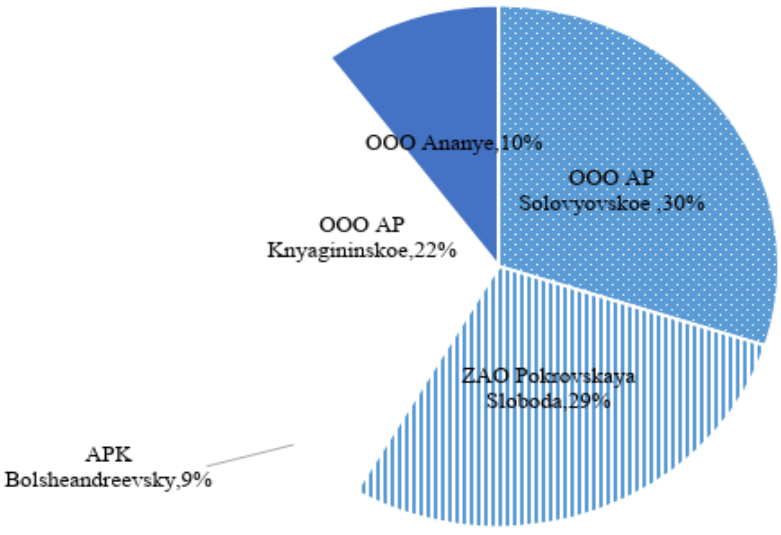


Figure 12. Breakdown of milk production in the group under study

The productivity per head of the dairy herd in the group under study does not exceed a value of 41.6 hwt per year, which is low compared to the average regional value.

In OOO Ananye, the productivity is 18 hwt, in OOO AP Solovyovskoe and SPK Bolsheandreevsky — 32.5 hwt, in ZAO Pokrovskaya Sloboda — 36 hwt per head of the herd, and in OOO AP Knyagininskoye the productivity established at the level of 41.6 hwt.

It should be noted that OOO AP Knyagininskoe and OOO AP Solovyovskoe have the highest selling price of milk: 20.6 rubles per kg (Figure 13). The lowest selling price is offered by SPK Bolsheandreevsky: 17.83 rubles. ZAO Pokrovskaya Sloboda and OOO Ananye rank in the medium range with prices slightly lower than the group average.

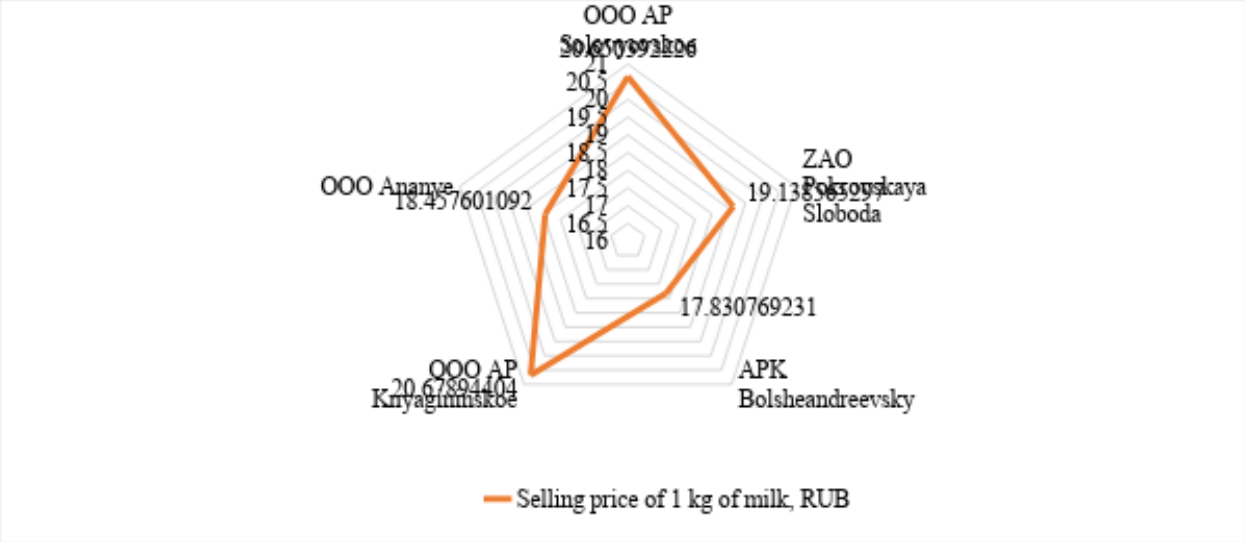


Figure 13. Distribution of the selling price of 1 kg of milk in the group under study

This affects the distribution of profits per conditional head (Figure 14).

The leader in this indicator is OOO AP Knyagininskoye with a profit of 18,64 thousand rubles per head (gross profit — 5,667 thousand rubles). This indicator at OOO AP Solovyovskoe and OOO Ananye is at almost the same level: 10,42 and 10,58 thousand rubles respectively.

The profit per head of the herd at SPK Bolsheandreevsky and ZAO Pokrovskaya Sloboda is 7,34 and 7,52 thousand rubles respectively.

In the latter case, the gross profit from the milk sales in ZAO Pokrovskaya Sloboda is three times higher than that in SPK Bolsheandreevsky, which indicates a less efficient use of the dairy herd.

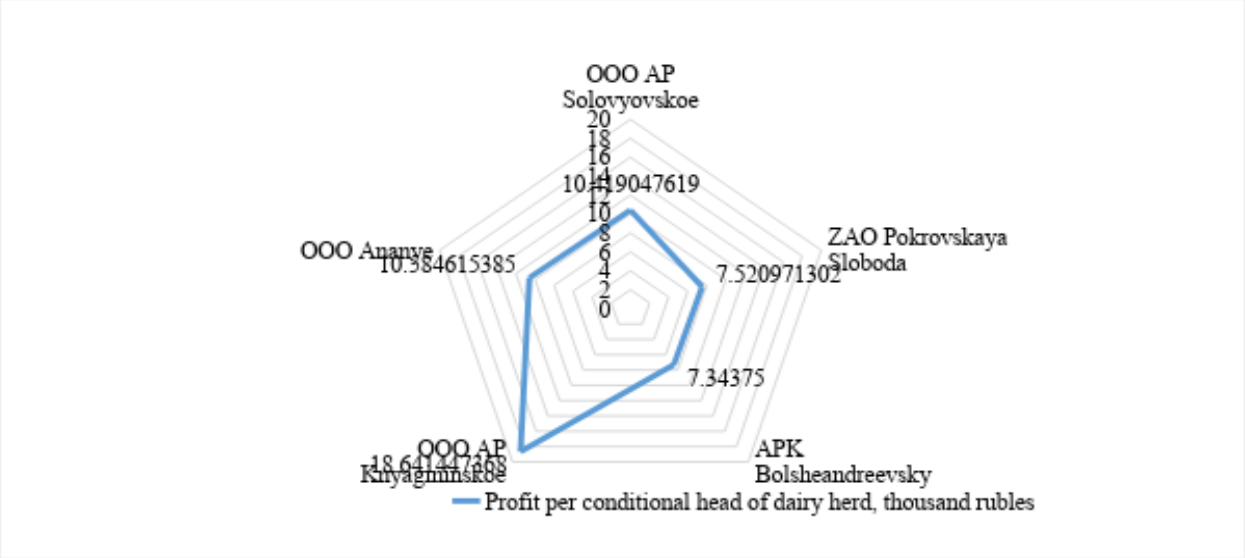


Figure 14. Distribution of sales profit in the group under study

The profitability parameter differs in the group (Fig. 15). For example, the highest profitability can be observed in OOO Ananye, which produces 10% of the total milk volume in the group.
This organization offers a lower selling price compared to the average of the group and ranks first by the efficiency of milk production.

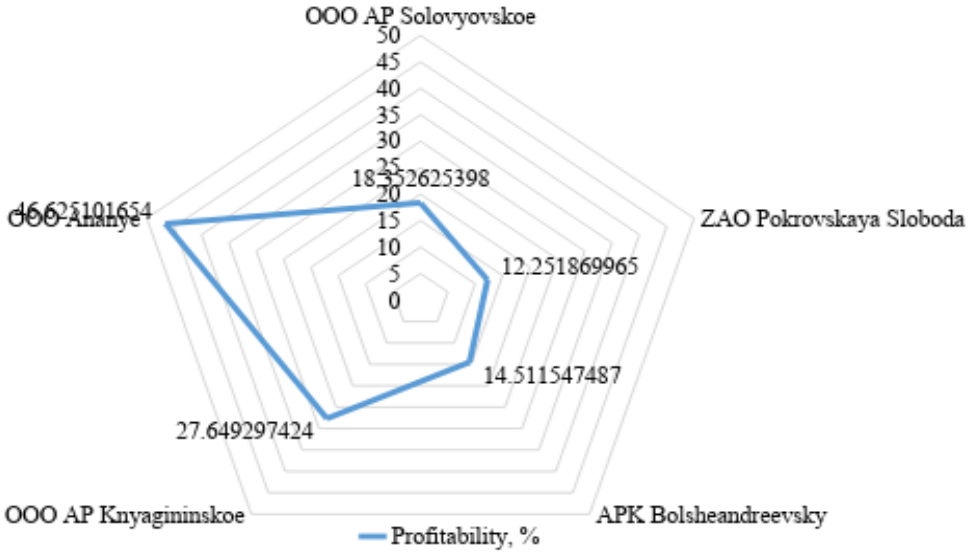


Figure 15. Distribution of profitability of milk sales in the group under study

In Knyagininsky district, the level of efficiency and the proportion of the milk volume indicates that it is produced in an inefficient manner.
Both profitability and milk production volumes are low. The review of profitability and profit indicators includes the cost of 1 kg of milk in the organizations under study (Figure 16).
OOO Ananye has the lowest cost of 1 kg of milk — 15.6 rubles, which is a key factor in generating profit from the milk sales. The cost at SPK Bolsheandreevsky is also low, but given the low selling price, it generates less profit.
The highest cost is observed at OOO AP Solovyovskoe and at ZAO Pokrovskaya Sloboda — 17.4 and 17 rubles respectively. OOO AP Knyagininskoe ranks in-between among the companies (16.2 rubles).

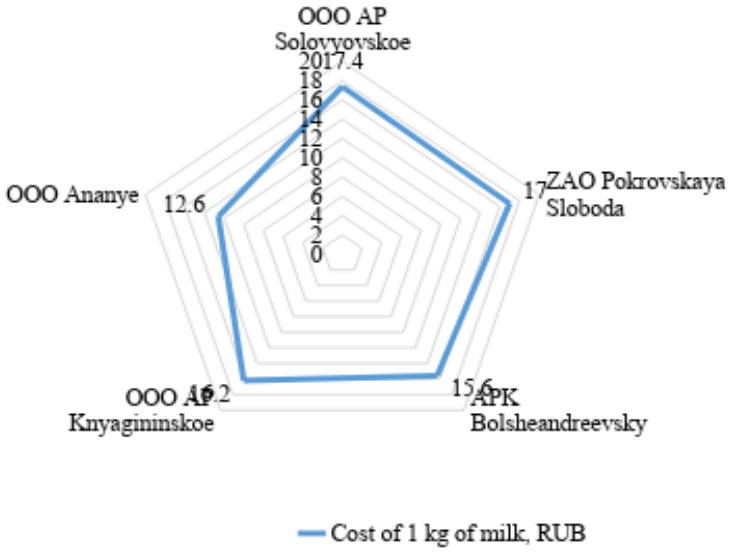


Figure 16. Distribution of cost of 1 kg of milk in the group under study

Based on the reviewed parameters of the group under study, it can be noted that in these organizations, with equal conditions for milk sales, there is a potential to improve the efficiency through adjusting the cost and the selling price.

To determine the priorities for the development of dairy cattle breeding in Knyagininsky district, an economic and mathematical optimization model was developed.

Optimization was carried out by means of Microsoft Excel. The model covers the organizations involved in dairy cattle breeding in Knyagininsky district. The modelling was carried out for the following objective functions:

$$Q \rightarrow max; \quad (1)$$

$$P_Q \rightarrow max; \quad (2)$$

$$P_r \rightarrow max; \quad (3)$$

$$ROS \rightarrow max, \quad \text{where: (4)}$$

Q — milk production volume;

P_Q — cost;

P_r — profit;

ROS — profitability.

The model was developed based on the information sources about activities in the organizations under study. The indicators under study include:

- Actual cow numbers, heads;
- Actual milk production volume, hwt;
- Productivity per head of the herd, hwt;
- Nutritional value of harvested forage, hwt of forage units;
- Man-hours worked (actual);
- Milk selling price, RUB (actual);
- Agricultural land area, ha (actual);
- Actual cost price of milk, thousand rubles;
- Actual profit per 1 conditional head of dairy herd, thousand rubles;
- Actual revenue, thousand rubles.

The following general optimization model was developed:

$$\{F(\partial X, t, z) \rightarrow max\ 0 \leq \partial X \leq \partial X_{max}\ t_{min} \leq t \leq t_{max}\ z_{min} \leq z \leq z_{max}\ \partial X, t, z \geq 0 \quad ,$$

where: (5)

F — optimization function;

∂X — change in size of the dairy herd, heads;

t — man-hours worked;

z — value of harvested forage, hwt of forage units

∂X_{max} is determined based on the amount of free cash in the economic system (it is divided by the average cost of 1 cow in the region).

In the absence of free cash, this value equals 0. tmin is determined based on the minimum possible

labor cost for dairy herd management, tmin is based on the maximum possible number of workers involved in dairy cattle breeding.

tmin was calculated based on the minimum necessary forage energy value for a given herd, tmin— maximum possible amount of harvested forage, given that the average yield of 1 ha of forage land in the region is 4.19 hwt of forage units.

Areas of the land used in organization are taken as a constant. Revenue, profit and profitability were taken as the optimization value. The following ratios were obtained:

$$Q(X,t,z) = -2529.8 + 34.3(X + \partial X) + 5.8t + 0.59z\,; \quad (6)$$

$$P_Q(X,t,z) = -5394,8 + 53,6(X + \partial X) + 50\partial X + 21,2t + 1,15z\,; \quad (7)$$

$$P(Q) = 18.3 + 0.0000066Q, \text{ where:} \quad (8)$$

Q — the amount of milk produced;

P_Q — the cost of the produced milk;

P — the unit price of the produced milk.

The optimization results are shown in Tables 4, 5, 6 and 7.

It should be taken into account that in the developed models, two focus areas for optimization were considered.

The first (strategy A) is to maximize the amount of milk produced and proceeds (this method implies significant investment in the cow numbers). The second (strategy B) is to maximize profit per 1 conditional head of dairy herd and profitability.

It should be noted that the organizations under study have a significant potential for increasing the amount of produced milk. In addition, the calculations show that an increase in milk production by 40% will have the most positive effect on their efficiency.

It is also noteworthy that ZAO Pokrovskaya Sloboda is the most promising for investing in the number of livestock.

Solving the function determined the optimal parameters for the strategic development for companies in Knyagininsky district involved in milk production, namely: parameters which enable to maximize the amount of milk production, the revenues from its sales, the profit per conditional head of dairy herd and profitability.

The results of optimization of milk production volume (Table 4) in Knyagininsky district showed that there is a strategic potential to increase it by 67,081 hwt.

To achieve this goal it is necessary:

− In OOO AP Solovyovskoe, to maximize the use labor resources and to increase the number of livestock by 110 heads, which at a productivity of 32.54 hwt will ensure a total increase in the milk production volume by 16,163.85 hwt;

− In ZAO Pokrovskaya Sloboda, to increase the cow number by 68 heads and man-hours worked to 158.76. This can ensure to achieve a significant increase in milk production (more than twice), and the nutritional value of harvested forage should be 43,809 hwt of forage units;

− In SPK Bolsheandreevsky, to increase the dairy herd by 23 heads in order to maximize the amount of produced milk.

It is also worth mentioning that OOO AP Knyagininskoe is similar to OOO AP Solovyovskoe by its parameters.

It should increase its livestock by 113 heads, which can provide an increase in production by 6,816 hwt, at the nutritional value of harvested forage of 11,572 hwt of forage units.

Table 4. Optimization results in maximizing milk production (focus area A)

Organization code / indicator	1	2	3	4	5
Cow number, heads	525.00	453.00	160.00	304.00	325.00
Free cash, thousand rubles.	5,470.00	3,407.00	1,175.00	5,667.00	3,440.00
Change in the cow numbers, heads	109.00	68.00	23.00	113.00	68.00
Productivity, hwt	32.54	36.00	32.50	41.62	18.03
Nutritional value of forage resources, hwt of forage units	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Labor cost, man-hour	180.32	158.76	25.48	150.92	70.56
Man-hours worked (min. constraint)	25.48	19.60	9.80	27.44	11.76
Man-hours worked (max. constraint)	180.32	158.76	25.48	150.92	70.56
Constraint of hwt of forage units (minimum)	22,028.21	1,984,14	6,321.80	11,571.64	1,423.50
Constraint of hwt of forage units (maximum)	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Milk produced, hwt (actual)	17,082	16,310	5,200	12,652	5,861
Milk produced, hwt (model)	33,245.85	42,089.90	7,621.52	19,468,24	21,761.24
Change in milk production volume, hwt	16,163.85	25,779.90	2,421.52	6,816.24	15,900.24

** Organizations: 1 — OOO AP Solovyovskoe, 2 — ZAO Pokrovskaya Sloboda, 3 — SPK Bolsheandreevsky, 4 — OOO AP Knyagininskoe, 5 — OOO Ananye*

** Source: compiled from data of the financial statements of the selected companies*

OOO Ananye should also invest in the number of cows and monitor the quality of the forage resources: its nutritional value at the level of 44.9 hwt of the forage unit per head will ensure a significant increase in the volume of milk. The largest increase in milk production volume is observed in ZAO Pokrovskaya Sloboda and in OOO AP Solovyovskoe, which have the largest size of livestock in the group. Despite the high productivity in OOO AP Knyagininskoe, with the constraints considered, the increase there will amount to 10% of the total volume. Optimization of the maximum quantity of produced milk and optimization of the maximum revenue from its sales are attributed to the strategy A.

Given the characteristics of optimal milk production values, it is noteworthy that for all organizations, high deviations from the actual levels are attainable. The same applies to the maximum revenues in the group under study (Table 5).

Table 5. Optimization results in maximizing revenues (strategy A)

Organization code / indicator	1	2	3	4	5
Cow number, heads	525.00	453.00	160.00	304.00	325.00
Change in the cow numbers, heads	109.00	68.00	23.00	113.00	68.00
Nutritional value of forage resources, hwt of forage units	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Labor cost, man-hour	180.32	158.76	25.48	150.92	70.56
Produced, hwt	33,245.85	42,089.90	7,621.52	19,468,24	21,761.24
Man-hours worked (min. constraint)	25.48	19.60	9.80	27.44	11.76

Man-hours worked (max. constraint)	180.32	158.76	25.48	150.92	70.56
Constraint of hwt of forage units (minimum)	22,028.21	1,984,14	6,321.80	11,571.64	1,423.50
Constraint of hwt of forage units (maximum)	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Cost, thousand rubles	63,389.15	80,042.43	13,431.58	39,219.44	41,012.17
Revenues, thousand rubles (actual)	35,275.00	31,215.00	9,272.00	26,163.00	10,818.00
Revenues, thousand rubles (model)	68,653.99	80,554.02	13,589.75	40,258.27	40,166.02
Change in revenues, thousand rubles	33,378.99	49,339.02	4,317.75	14,095.27	29,348.02

** Organizations: 1 — OOO AP Solovyovskoe, 2 — ZAO Pokrovskaya Sloboda, 3 — SPK Bolsheandreevsky, 4 — OOO AP Knyagininskoe, 5 — OOO Ananye*

** Source: compiled from data of the financial statements of the selected companies*

Optimization of the parameters of the companies in Knyagininsky District, aimed at finding the maximum revenue from the sale of milk, determined that the amount of potential revenues in ZAO Pokrovskaya Sloboda is 80,554.02 thousand rubles, which is the largest value for the group (an increase of 49,339.02 thousand rubles).

Throughout the whole group, the increase in revenues is caused by the increase in milk production volumes, which is attributable to the adjustments of the selected constraints. Due to the optimization, in OOO AP Solovyovskoe, the revenue from milk sales will amount to 68,653.9 thousand rubles, in SPK Bolsheandreevsky — 13,589.7 thousand rubles, in OOO AP Knyagininskoye — 40,258.27 thousand rubles and in OOO Ananye — 40,266.02 thousand rubles.

It is also noteworthy that the increase in revenue implies maximum possible production increase mainly by increasing the cow numbers in all organizations.

The next optimization strategy (strategy B) is to identify the parameters at which the maximum profit per conditional head and the maximum profitability can be obtained in the selected group (Tables 6 and 7).

In the model, there is a potential to increase the maximum profit from milk sales in Knyagininsky district by 16.39 thousand rubles per conditional head of the herd.

To attain this target, the following parameters are necessary:

- The cow numbers should be taken as a constant;
- To use labor costs by the minimum constraint in all organizations;
- In ZAO Pokrovskaya Sloboda, at an unchanged selling price of milk, its volume should be reduced by 2,022.73 hwt, which will make it possible to restrict the growth of milk cost given the minimum labor costs for its production;
- To increase the milk production volume in OOO AP Solovyovskoe by 11,528.85 hwt, thereby increasing the profit per conditional head by 9.15 thousand rubles. In SPK Bolsheandreevsky, the profit will grow by 0.82 thousand rubles per conditional head, if the production volume is increased by 1,541.38 hwt. Any further increase will lead to a decline in profit.

Table 6. Optimization results in maximizing profit (strategy B)

Organization code / indicator	1	2	3	4	5
Cow number, heads	525.00	453.00	160.00	304.00	325.00
Change in the cow numbers, heads	0.00	0.00	0.00	0.00	0.00
Nutritional value of forage resources, hwt of forage units	22,029.21	1,984,14	6,321.80	11,572.64	1,423.50
Labor cost, man-hour	25.48	19.60	9.80	27.44	11.76

Milk produced, hwt (actual)	17,082	16,310	5,200	12,652	5,861
Milk produced, hwt (model)	28,610.85	14,287.27	6,741,38	14,877.83	9,522.08
Change in production volume, hwt	11,528.85	-2,022.73	1,541,38	2,225.83	3,661.08
Man-hours worked (min. constraint)	25.48	19.60	9.80	27.44	11.76
Man-hours worked (max. constraint)	180.32	158.76	25.48	150.92	70.56
Constraint of hwt of forage units (minimum)	22,028.21	1,984,14	6,321.80	11,571.64	1,423.50
Constraint of hwt of forage units (maximum)	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Cost, thousand rubles	48,811,33	21,613.63	10,714.54	24,891.78	13,933.33
Selling price of 1 kg of milk, RUB	20.65	19.14	17.83	20.68	18.46
Revenues from milk sales, thousand rubles	59,082.54	27,343.78	12,020.40	30,765.77	17,575.48
Profit per conditional head, thousand rubles (actual)	10.42	7.52	7.34	18.64	10.58
Profit per conditional head, thousand rubles (model)	19.56	12.65	8.16	19.32	11.21
Change in profit, thousand rubles	9.15	5.13	0.82	0.68	0.62

** Organizations: 1 — OOO AP Solovyovskoe, 2 — ZAO Pokrovskaya Sloboda, 3 — SPK Bolsheandreevsky, 4 — OOO AP Knyagininskoe, 5 — OOO Ananye*

** Source: compiled from data of the financial statements of the selected organizations*

In OOO AP Knyagininskoye, the maximum profit will be attained at the optimal milk production volume of 14,877.83 (has to be increased by 2,225.83 hwt). In OOO Ananye, there is a potential of increasing profit by 0.62 thousand rubles if the production volume of 9,522.08 hwt is attained.

Profitability optimization was carried out in strategy B (Table 7). Based on the results of maximization for this indicator, the following parameters were identified:

− Under the existing constraints, an increase in profitability is only possible in ZAO Pokrovskaya Sloboda;

− A disproportionate increase in profits and revenues, as well as the cost of increasing the livestock during optimization, cannot increase the profitability of the other companies.

When considering the two optimization strategies, companies need to make a priority choice: either increasing production and making the profit in the future, or increasing profits from the existing production resources.

Table 7. Optimization results in maximizing profitability (strategy B)

Organization code / indicator	1	2	3	4	5
Cow number, heads	525.00	453.00	160.00	304.00	325.00
Nutritional value of forage resources, hwt of forage units	22,028.21	1,984,14	6,321.80	11,571.64	1,423.50
Labor cost, man-hour	25.48	19.60	9.80	27.44	11.76
Man-hours worked (min. constraint)	25.48	19.60	9.80	27.44	11.76
Man-hours worked (max. constraint)	180.32	158.76	25.48	150.92	70.56
Constraint of hwt of forage units (minimum)	22,028.21	1,984,14	6,321.80	11,571.64	1,423.50

Constraint of hwt of forage units (maximum)	22,029.21	43,809.34	6,322.80	11,572.64	17,646.36
Revenues, thousand rubles (actual)	35,275.00	31,215.00	9,272.00	26,163.00	10,818.00
Revenues, thousand rubles (model)	59,081.32	27,343.78	12,020.40	30,764.55	17,575.48
Change in revenues, thousand rubles	23,806.32	-3,871.22	2,748.40	4,601.55	6,757.48
Profit per conditional head, thousand rubles (actual)	10.42	7.52	7.34	18.64	10.58
Profit per conditional head, thousand rubles (model)	19.56	12.65	8.16	19.32	11.21
Change in profit, thousand rubles	9.15	5.13	0.82	0.68	0.62
Profitability, % (actual)	18	12	15	28	47
Profitability, % (model)	17.38	20.96	10.86	19.09	20.72
Change in profitability, p.p.	-0.62	8.96	-4,14	-8.91	-26.28

** Organizations: 1 — OOO AP Solovyovskoe, 2 — ZAO Pokrovskaya Sloboda, 3 — SPK Bolsheandreevsky, 4 — OOO AP Knyagininskoe, 5 — OOO Ananye*

** Source: compiled from data of the financial statements of the selected organizations*

Modelling outcome in two strategies are shown in Table 8.

Table 8. Strategic parameters for the development of organizations involved in milk production in Knyagininsky District in two focus areas

Organization	Production volume, hwt		Revenues, thousand rubles		Profit per conditional head, thousand rubles		Profitability, %	
	Model value	Deviation from the actual value	Model value	Deviation from the actual value	Model value	Deviation from the actual value	Model value	Deviation from the actual value
Focus area A								
OOO AP Solovyovskoe	33,245.9	16,163.9	68,654.0	33,379.0	8.30	-2.11	7.7	-10.3
ZAO Pokrovskaya Sloboda	42,089.9	25,779.9	80,554.0	49,339.0	0.98	-6.54	0.6	-11.4
SPK Bolsheandreevsky	7,621.5	2,421.5	13,589.7	4,317.7	0.86	-6.48	1.2	-13.8
OOO AP Knyagininskoe	19,468,2	6,816.2	40,258.3	14,095.3	2.49	-16.15	2.6	-25.4
OOO Ananye	21,761.2	15,900.2	40,166.0	29,348.0	-2.15	-12.74	-2.1	-49.1
Strategy B								
OOO AP Solovyovskoe	28,610.3	11,528.3	59,081.3	23,806.3	19.56	9.15	17.4	-0.6
ZAO Pokrovskaya Sloboda	14,287.3	-2,022.7	27,343.8	-3,871.2	12.65	5.13	21.0	9.0
SPK Bolsheandreevsky	6,741.4	1,541.4	12,020.4	2,748.4	8.16	0.82	10.9	-4.1
OOO AP Knyagininskoe	14,877.2	2,225.2	30,764.6	4,601.6	19.32	0.68	19.1	-8.9
OOO Ananye	9,522.1	3,661,1	17,575.5	6,757.5	11.21	0.62	20.7	-26.3

Strategy A has a potential to significantly increase milk production volumes and revenues from its sales in the group under study, but profit and profitability are low compared to actual values. In OOO Ananye, if this strategy is chosen, a loss of 2.12 thousand rubles per conditional head will be observed

(the actual value is 10.58 thousand rubles), and, accordingly, the profitability will decline by 25.4 percentage points.

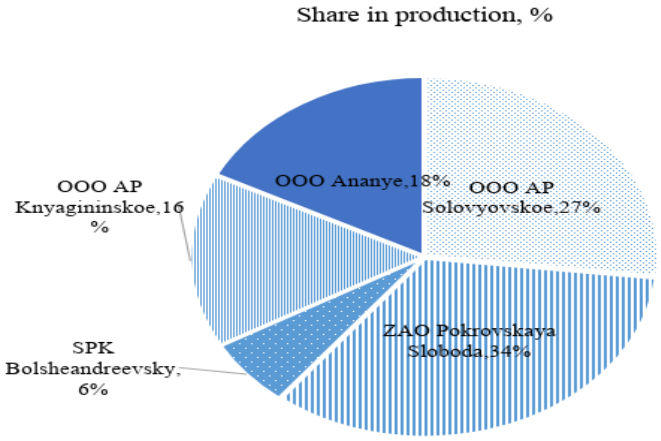
In OOO AP Solovyovskoe that ranks first in the group by actual indicators, the decline in profit per conditional head will amount to 2.11 thousand rubles given the increase in production volume by 16,163.9 hwt.

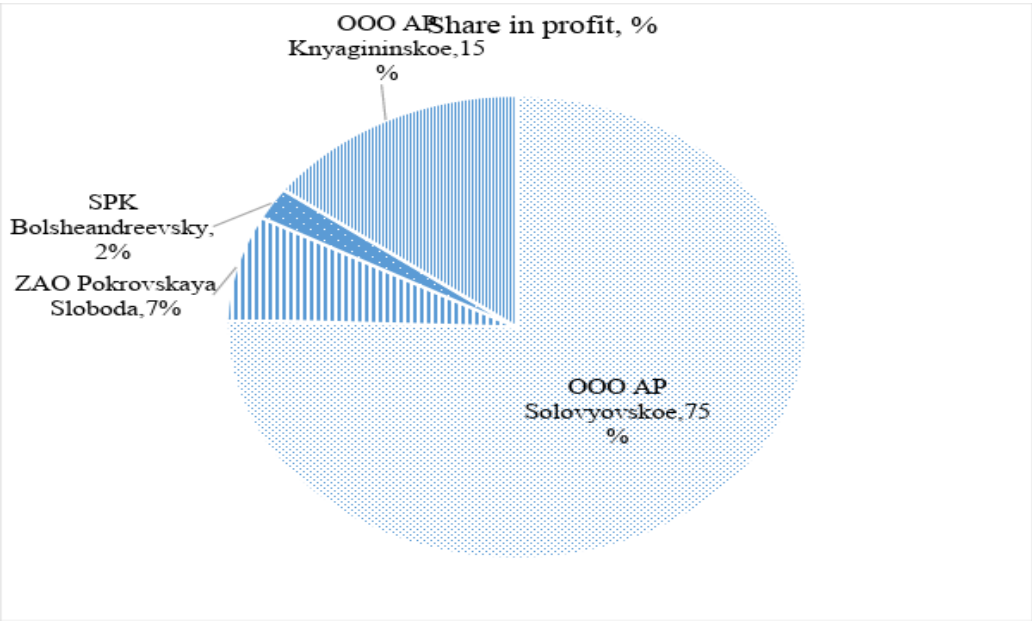
Strategy B is characterized by an increase in profits per conditional head of the dairy herd, and in OOO AP Solovyovskoe and ZAO Pokrovskaya Sloboda the increase is significant: by 9.15 and by 5.13 thousand rubles respectively.

Optimization according to this strategy also leads to increase in the production volume and revenues (except for ZAO Pokrovskaya Sloboda).

The choice of development strategy depends on the company's individual strategic goals, but the milk production efficiency at the district level is put together by the performance indicators of the group under study.

Figure 17 shows the shares of each organization in the optimization indicators for strategy A; and Figure 18 shows the same for strategy B.





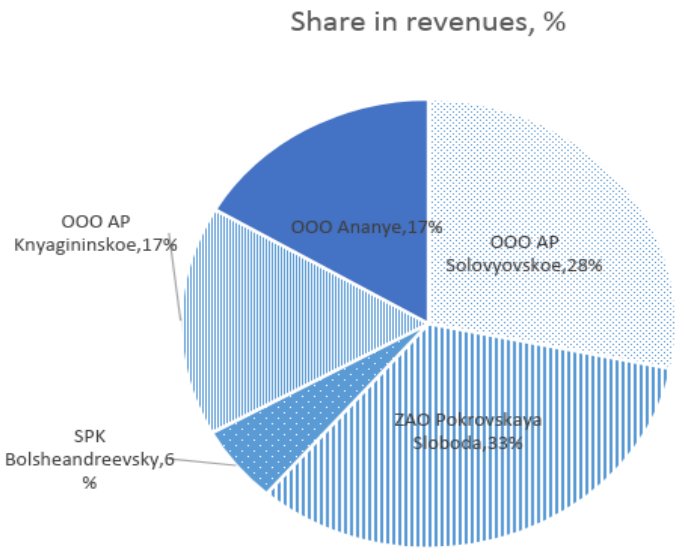
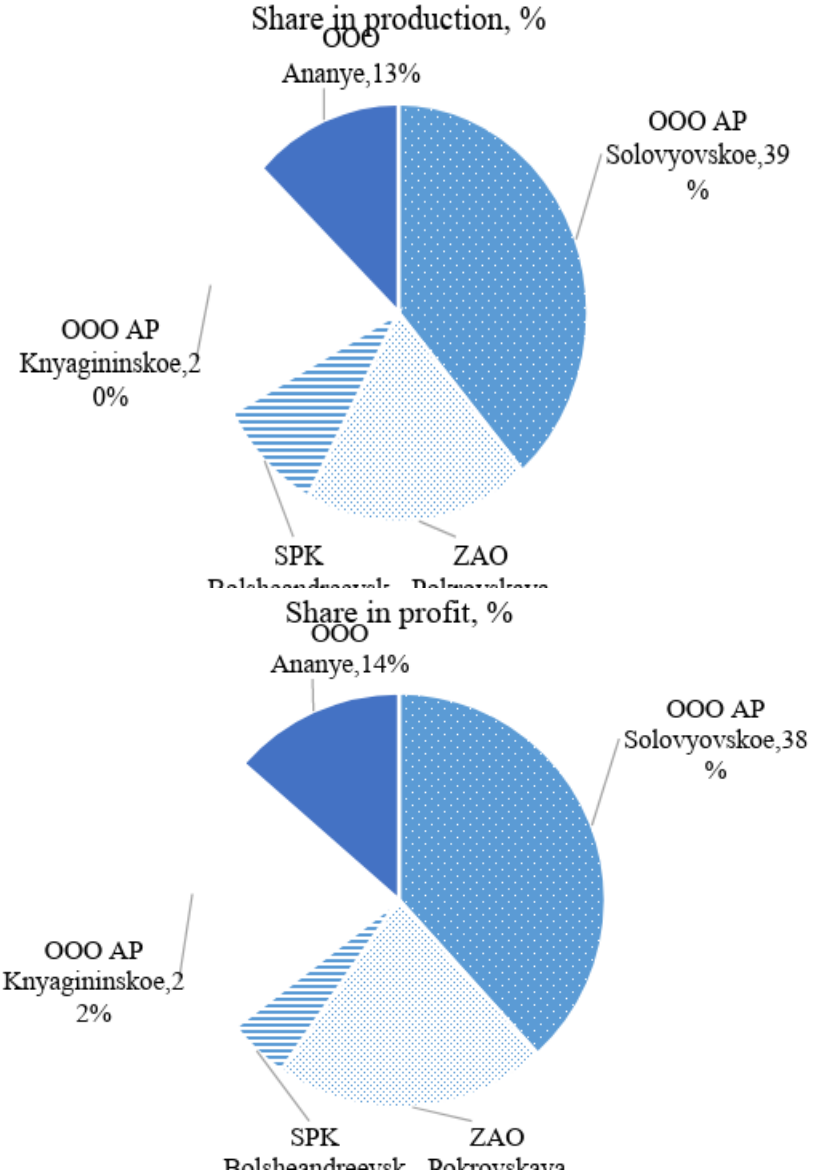


Figure 17. Distribution of values of key indicators if development strategy A is adopted



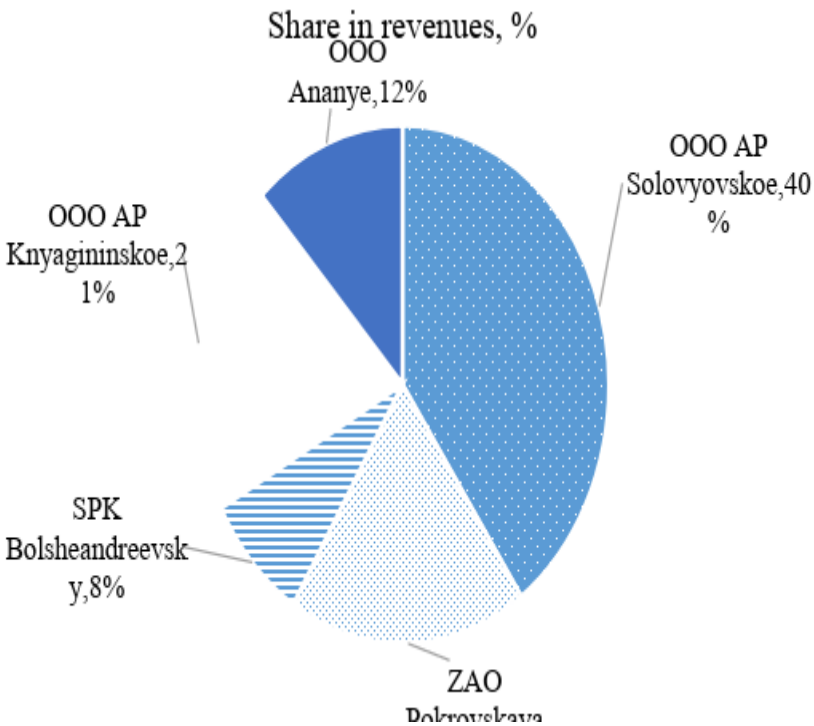


Figure 18. Distribution of values of key indicators if development strategy B is adopted

If the first strategy is adopted, ZAO Pokrovskaya Sloboda will become the leader in milk production — 34% of the total production volume.

Also, this organization will rank first in revenues (33%), but at the same time, the gross profit from the milk sales will amount to only 7%, which is lower than the actual level.

The company will be followed by OOO AP Solovyovskoe in milk production volume (27%). Solovyovskoe will also collect 28% of the total revenues.

It is noteworthy that if this development strategy is chosen, the company will earn the largest profit: 5,264.8 thousand rubles (slightly less than the actual level). If the development strategy B is adopted, the largest profit will be generated by OOO AP Solovyovskoe: 38% of the total profit in the district.

Solovyovskoe will also earn the largest amount of revenues (40% of the total group revenue) and rank among the top companies in the production volume: 39%.

At the same time, OOO AP Knyagininskoe will rank the second in all the other indicators: profit — 22%, revenues — 21% and production volume — 20%.

SPK Bolsheandreevsky and OOO Ananye will have smaller shares regardless of the development strategy. Bolsheandreevsky has a smaller cow number than other organizations in the group.

Therefore, its share in production under development strategy A will amount to 6%, and the share of profits under development strategy B — 9%.

OOO Ananye, under the same conditions, is capable of producing 17% of the total milk volume in the district and earn 13% of the profit in the group under study.

Thus, while optimizing the commercial activities in the companies under study, two development strategies were identified, which are aimed at maximization production volumes and revenues, and maximization of profit and profitability.

The optimization results allowed to conclude that the most beneficial strategy for OOO AP Solovyovskoe is increasing the profit from the milk sales and for ZAO Pokrovskaya Sloboda — to increase the milk production, which will generate large profits in the future.

The above companies rank the highest in terms of profit growth per conditional head of dairy herd under strategy B — an increase of 9.15 and 5.13 thousand rubles respectively. For the other

organizations, the optimal strategy will be any strategy given that it becomes the goal of their strategic development and ensures maximization of milk production efficiency.

DISCUSSION

The analysis of milk production efficiency in municipal districts of Nizhny Novgorod Oblast established that the average cow productivity is slightly more than 5,000 kg, the average production profitability is 16.98% at this productivity. Monitoring of milk production volumes established that in 2008–2016, this indicator showed negative trends, and its stabilization and a slight growth only began in 2012.

This research involved economic and mathematical modelling of the strategic development parameters for organizations involved in milk production in Knyagininsky district (Nizhny Novgorod Oblast).

In the course of the modeling, two optimization strategies were considered. The first of those involved increasing the milk production volume and the revenues from its sales; the second implied increasing profits per conventional head and profitability in the agricultural organizations.

CONCLUSION

The economic and mathematical modelling determined that the production volume and revenues maximization strategy provides the potential of a significant increase in these indicators across the entire group of companies.

In particular, it was established that the most beneficial strategy for ZAO Pokrovskaya Sloboda is the strategy of maximizing the production volume, at which profitability will remain at a sufficient level.

For OOO AP Solovyovskoe, the optimal strategy will be increasing the profits, which will also keep a sufficient level of milk production.

For the other companies in the group under study, choice of strategy depends on individual strategic development goals. With regard to milk production efficiency for municipal districts of Nizhny Novgorod Oblast, it is noteworthy that they should stick to the strategy where the parameters are optimized for increasing the production volumes.

Thus, practical implementation of the provisions suggested in this thesis research can contribute to increasing the efficiency of milk production, and can also ensure a more reasonable use of resources based on current development factors, which eventually will have a positive impact on the socio-economic situation in the region.

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