Analysis of prospects for the development of dairy cattle breeding in Russia: forecasts and scenarios

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Abstract. Since the import substitution policy was implemented in Russia, the production level of basic agricultural products has been gradually approaching their consumption standard. The dairy products consumption makes only 69.3% of the recommended norm, with the milk self-sufficiency ratio of the Russian Federation being 84.2% in 2018 against 90.0%. This was due to the trends of a steady decrease in the cow population, which resulted in milk production decline. The methodological basis for the problem research has been established on a set of methods of economic and mathematical modeling, involving the method for constructing scenarios and their quantitative justification. The main extrapolation method should be considered the trend modeling (linear and non-linear trends) supplemented by the expert assessment method.

1. Introduction
Reasonable forecast scenarios for the development of the domestic dairy cattle industry in Russia is particularly relevant in the context of the global transformation of external economic conditions, unfavorable situation on the domestic dairy market and breeding base of the dairy herd, an increase in the country's population and an increase in the domestic deficit of dairy products and insufficient funding for dairy subsector [1, 2].

Over the years of dramatic changes in the state regulation policy of Russian agricultural sector, i.e., the implementation of the National Project transformed into the State Program for the Development of Agriculture, the situation regarding the whole milk production has failed to be fundamentally improved [3]. So, for example, at present the level of food independence in terms of milk is much lower than other indicators determining the food security of Russia [4-6].

A set of economic policies adopted by the Government of the Russian Federation to accelerate the pace of economic development of the dairy cattle industry, including the establishment of family dairy farms and preferential loans, made it possible to stop the decline in production, but an insufficient investment activity in the industry with a long reproductive cycle of the herd and natural and biological features of the food base did not allow stabilizing the situation with respect to the cow population, fattening young farm animals and their subsequent placement in the reproductive dairy herd [6-9].
The development of the dairy market is also influenced by global consumer trends, such as increasing attention to health care, sports, an active lifestyle and a healthy diet [10]. A number of scientists note that the costs of dairy producers have increased significantly, over the past year, the operating cost index has increased by 3.5% [11]. This was due to several main factors: during the year, there were significant currency fluctuations, as well as a serious rise in the price of feed. At the same time, the price of raw materials decreased. This, of course, negatively affects the profitability of the business [12, 13].

Russian dairy industry is characterized by low elasticity of demand and supply for unique products of the industry, prevailing price disparity for milk and its products, many participants ensuring the production and processing of products, low level of technical support because of its capital intensity, and dynamism and ambiguity of the changing macroeconomic and institutional environment [14, 15, 10]. The current mechanism and volumes of state financing of the dairy cattle breeding industry are currently not sufficient for its dynamic functioning and development in Russia [16, 17]. The main problem is still the total cost of milk production in Russia – taking into account the investment component – higher than the cost in other countries [18, 19]. In the medium term, it becomes necessary to assess the manufacturability of milk production in accordance with the tasks set, and based on the indices achieved, justify the forecast parameters for the production of this strategically important type of food in the country until 2025, using the methods of economic and mathematical modeling.

2. Materials and methods
The paper proposes conceptual approaches to the development and justification of the forecast for the dairy industry based on trend modeling methods. The main method should be considered linear and non-linear trends that project past trends into the future. The trend modeling method was supplemented by the expert assessment method. Based on the calculations obtained, the most probable values of the forecast parameters for the development of the dairy industry were determined.

The extrapolation of time series that reflected the development trends of the dairy industry in agricultural production cannot always ensure the reliability of the indices predicted; therefore, several methodological approaches should be used simultaneously to evaluate trend parameters based on various curvilinear and rectilinear dependencies.

Trend calculations of the studied economic processes were carried out using linear, logarithmic, power and exponential models; their functions can be presented as follows:

\[
\text{linear model is } Y = a + bx, \\
\text{exponential model is } Y_t = ab^t, \\
\text{power model is } Y = a_0x_i^n, \\
\text{logarithmic model is } Y = b = a\ln x, 
\]

The forecast parameters were:

- milk production in various categories of farms, thousand tons;
- composition of the cow population according to the categories of farms, %;
- proportion of milk produced by a certain category of farms in the total volume of all categories of farms, %, calculated by the formula:

\[
P = \frac{O_c}{O_a} \times 100\%,
\]

where \(P\) is the proportion of products of a certain category of farms in the total volume of all categories of farms;
\(O_c\) is overall milk produced by a certain category of farms (thousand tons);
$O_a$ is overall milk produced (thousand tons) in farms of all categories, i.e., agricultural enterprises, farms, and households.

The trend modeling results of all the dependencies above in relation to the studied time series were assessed according to economic, mathematical and statistical criteria of reliability and accuracy, using expert methods. Based on the calculations, the best possible values of the number and structure of the farm livestock and total volume of milk production were determined in terms of multistructurality.

3. Results and discussion

One of the main features of domestic dairy cattle breeding is that in the period of great changes in the agricultural sector of the economy, including the food embargo policy, the milk industry headed the priority direction of agricultural development. However, the rate of milk production was markedly inferior to the growth rate of meat and egg production for the period 2013-2018 (Table 1).

| Year | Product | Meat (in slaughter weight), th. tons | Milk, million tons | Eggs, billion pcs |
|------|---------|-------------------------------------|-------------------|-----------------|
| All categories | | | | |
| 2013 | | 105.4 | 94.0 | 98.5 |
| 2014 | | 105.9 | 100.4 | 100.9 |
| 2015 | | 105.6 | 99.6 | 101.8 |
| 2016 | | 103.5 | 99.7 | 102.4 |
| 2017 | | 104.7 | 101.3 | 103.0 |
| 2018 | | 103.0 | 101.4 | 100.2 |

* Compiled by the authors according to Federal statistic service (the Russian Federation).

Despite the government measures to reduce the import dependence on milk – a strategically important food, – an unprecedented reduction in the cow population was registered (Table 2), which is the main deterrent to economic growth in the industry.

Over the past 5 years, in the whole country, the number of dairy herds has decreased from 8430.9 thousand head in 2013 down to 7942.6 thousand head in 2018 (or 5.8%). The highest rates of decline in the number of farm animals were registered in households over the study period (by 13.4%).

| Indicator | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2018 to 2013, % |
|-----------|------|------|------|------|------|------|-----------------|
| All categories | 8430.9 | 8263.2 | 8115.2 | 7966.0 | 7950.6 | 7942.6 | 94.2 |
| Agricultural enterprises | 3532.5 | 3439.3 | 3387.4 | 3359.5 | 3315.7 | 3283.3 | 92.9 |
| Households | 3879.9 | 3766.0 | 3621.9 | 3426.8 | 3400.2 | 3360.8 | 86.6 |
| Farms | 1018.5 | 1058.0 | 1105.9 | 1179.7 | 1234.7 | 1298.5 | 127.5 |

* Compiled by the authors according to Federal statistic service (the Russian Federation).

In the small agricultural business, competitive enterprises are being established due to the National Project and the State Programs implemented. In particular, the most widespread program is the grant support for farmers, starting business, family livestock farms and agricultural consumer cooperatives. The priority of the grant programs was the development of dairy farming, as the most capital-intensive industry, requiring considerable financial investments. By virtue of the program, farmers purchased highly productive farm animals, machinery and livestock equipment [5, 16], as well as land plots and
industrial premises. So, for the period 2013-2017, the number of farm animals in farms of Russia increased by 21.2% [1].

Studies showed that in the context of the food embargo aimed at maximal satisfying the population’s needs for domestic food products, there is an increase in the country’s food security by basic types of food, including milk (figure 1) [12, 14].

Figure 1. Threshold value and dynamics of milk production in the Russian Federation for the period of 2013-2018*.

Despite the government protectionism, the level of food independence of the country with respect to milk amounted to 84.2% in 2018 against 90.0% indicated in the Federal program. The shortage of milk and dairy products was compensated by imports [18, 19].

The consumption level of milk and dairy products was only 69.3% of the recommended standards (figure 2), which is an indicator of the limited economic availability of food caused by depreciation of the money income of the population during the period of macroeconomic instability in the country.

Calculated by the authors according to Federal statistic service (the Russian Federation).

Insufficient consumption of livestock products causes low calorie intake and its unfavorable structure, reduces the quality of life of the population, and negatively affects the life expectancy and health of the population.

To stabilize the situation and ensure the steady functioning of the dairy cattle industry in the future, there is a need to justify methodological approaches to a forecast for milk production based on a set of methods of economic and mathematical modeling that are studied fragmentarily in certain areas of scientific research.
Figure 2. A comparative assessment of the production and consumption of milk and dairy products in Russia per capita per year with the standard for 2013-2018*.

According to the forecast, in the medium term, Russia will experience an unprecedented downward trend in the cow population from 7.942.6 thousand a year in 2018 to 7.750.4 thousand head in 2025 (or 2.4%) (Table 3).

Because of insufficient investment climate in the industry, a considerable reduction in the cow population is expected from 3283.3 thousand head in 2018 to 3137.8 thousand head in 2025 (or 4.4%) in agricultural enterprises.

Active government support aimed at the development of family dairy farms in the medium term will not stimulate an increase in the cow population in farms in 2025. According to forecast estimates, the cow population may decrease by 3.5% in comparison with 2018.

The specific gravity of farms in the composition of cow population will be constant in 2025. Traditionally, the largest share of the cattle stock of 43.3% is expected to be concentrated in households by 2025. The share of agricultural enterprises in the dairy herd will slightly decrease from 41.3% in 2018 to 40.6% in 2025 (Figure 3).

The reduction in the total cow population is primarily caused by the unprofitableness of milk production because of prevailing disparity in prices for products of the industry and processed products, unsatisfactory condition of the breed composition of the herd, poor availability of balanced feed, and obligatory availability of agricultural land for the dairy cattle breeding industry.

Table 3. Forecast of the number of cows by categories of farms in Russia for 2025, thousand heads.

| Years | The farm category | | | |
|-------|------------------|-------------|-----------------|-----------------|
|       | All categories   | Agricultural| Households      | Farms           |
|       | of farms         | enterprises |                 |                 |
| Actual values | | | | |
| 2004  | 10244.1          | 4670.2      | 5207.0          | 366.9           |
| 2005  | 9522.2           | 4282.0      | 4827.1          | 413.2           |
| 2006  | 9359.7           | 4077.1      | 4805.3          | 477.3           |
| 2007  | 9286.4           | 3974.5      | 4784.0          | 527.9           |
Innovative technologies in feeding and keeping farm animals, as well as renewal of the gene pool and breeding base are now feasible for large agricultural enterprises, which has a positive effect on the productivity of cows (Table 4). Therefore, in the medium term, due to the high productivity of cows, a large proportion of milk production of 16891.3 thousand tons (Table 5) or 57.7% of the gross output (Figure 4) will fall on agricultural enterprises.

**Table 4. Dynamics of the average annual milk yield per 1 cow in Russia for 2013-2018, kg**

| Indicator          | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2018 to 2013, % |
|--------------------|-------|-------|-------|-------|-------|-------|-----------------|
| Milk yield per cow |       |       |       |       |       |       |                 |
| Agricultural enterprises | 4519  | 4841  | 5140  | 5370  | 5660  | 5945  | 131.6           |
| Farms              | 3323  | 3450  | 3465  | 3499  | 3628  | 3463  | 104.2           |
| Households         | 3496  | 3501  | 3500  | 3484  | 3518  | 3689  | 105.5           |
| All categories of farms | 3893  | 4021  | 4134  | 4218  | 4368  | 4492  | 115.4           |

*Compiled by the authors to Federal statistic service (the Russian Federation).*
Table 5. Forecast for milk production in Russia by farm categories for 2025, thousand tons a.

| Year | Category | All categories | Agricultural enterprises | Households | Farms |
|------|----------|----------------|--------------------------|------------|-------|
|      |          | Actual values  |                          |            |       |
| 2004 |          | 31861.2        | 14374.7                  | 16581.5    | 905.0 |
| 2005 |          | 31069.9        | 14000.7                  | 16088.4    | 980.8 |
| 2006 |          | 31339.1        | 14134.9                  | 16081.4    | 1122.8|
| 2007 |          | 31984.2        | 14162.8                  | 16537.7    | 1283.7|
| 2008 |          | 32225.7        | 14246.2                  | 16604.2    | 1375.3|
| 2009 |          | 32315.1        | 14494.8                  | 16403.4    | 1416.9|
| 2010 |          | 31507.8        | 14313.2                  | 15719.9    | 1474.7|
| 2011 |          | 31204.3        | 14395.0                  | 15295.0    | 1514.3|
| 2012 |          | 31196.8        | 14752.4                  | 14737.4    | 1707.0|
| 2013 |          | 29865.3        | 14046.5                  | 14031.5    | 1787.3|
| 2014 |          | 29995.2        | 14365.0                  | 13728.2    | 1902.0|
| 2015 |          | 29887.5        | 14718.0                  | 13158.6    | 2010.9|
| 2016 |          | 29787.2        | 15061.2                  | 12552.0    | 2174.0|
| 2017 |          | 30184.5        | 15673.7                  | 11854.9    | 2375.4|
| 2018 |          | 30611.2        | 16245.3                  | 11854.9    | 2511.0|
|      | Estimated values |              |                          |            |       |
| 2025 |          | 29290.9        | 16891.3                  | 9085.1     | 3314.5|
| 2025 to 2018, % |          |                |                          |            |       |
| 2018, % |          | 95.7           | 104.0                    | 76.6       | 132.0 |

a Developed by the authors according to the study results.

In the future, financial support for the dairy cattle breeding will stimulate an increase in milk production in farms from 2511.0 thousand tons in 2018 to 3314.5 thousand tons (by 32.0%). The share of small agribusiness can grow to 11.3% in 2025.

![Figure 4](image-source) Figure 4. Forecast structure for milk production for 2025 by farm categories, %.

However, the structure of milk production in various categories of farms is different. In the Northwestern, Central, Ural and Volga Federal Districts, by 2025, agricultural dairy cattle breeding enterprises will retain their priority; their share in the structure of milk production will amount to 84.9; 76.4; 56.5; and 52.5%, respectively (figure 5).
Other federal districts will have distinctive milk production structures with respect to farm categories. In the medium term, milk production in households will not stimulate a tendency of economic growth, but it will help to prevent a decline in the quality of life in rural areas and preserve its historical appearance.

Due to a reduction in the cow population, the whole milk production may decrease by 4.3% in 2025 compared to 2018, which will not enable achieving food independence in terms of this strategically important product.

To calculate the volume of milk production in the country per capita for the period up to 2025, the scenario forecasting method used the Rosstat data on the forecast population of the Russian Federation for the period up to 2025. According to the Rosstat forecast for 2025, the possible estimated population of the Russian Federation may amount to 146.6 million people according to the “average case forecast,” 150.4 million people according to the “high case forecast,” and 144.2 million people according to the “low case forecast [6, 10]. Comparing the forecast for milk production with scientifically based standards of milk consumption, we highlighted three scenarios of food self-sufficiency of the population of the Russian Federation with milk, i.e., basic, optimistic and pessimistic scenarios.

The developed forecast scenarios indicated that in the medium term, the level of food self-sufficiency in milk will not be achieved by 2025 despite accelerated import substitution policy implemented in the food sector of Russia (figure 6).

Base scenario I predicated on the population size of the Russian Federation in 2018 suggests that in 2025 the ability of agriculture to provide the country's population with milk will make 61.5% of the standard.

Optimistic scenario II calculated on the positive dynamics of an increase in the country's population in the medium term from 146.8 million people in 2018 to 150.4 million people in 2025 (by 2.5%) suggests that by 2025 the food self-sufficiency in milk will be achieved for 59.9% of the standard (figure 6).

Pessimistic scenario III, providing for the reduction of the population of the Russian Federation to 144.2 million people by 2025 that is lower by 1.8% than in 2018. The forecast showed that in 2025 the volume of milk production per capita will be 65.2% of the standard (figure 6).

|                | Agricultural enterprises | Farms | Households |
|----------------|--------------------------|-------|------------|
| Nort.          | 27.5                     | 19.5  | 53.0       |
| Sibe.          | 39.7                     | 15.5  | 54.8       |
| Ural.          | 56.5                     | 5.2   | 38.3       |
| Volg.          | 52.5                     | 8.4   | 39.1       |
| Far.           | 12.8                     | 14.2  | 75.0       |
| Sout.          | 27.4                     | 8.7   | 63.9       |
| Cent.          | 76.4                     | 5.4   | 18.2       |

Figure 5. Forecast for the milk production structure by farm categories by federal districts of the Russian Federation for 2025, %*.
Figure 6. Forecast for production and consumption of milk per capita in the Russian Federation in 2025.

According to calculations, in 2025 the shortage of milk production will be 18379.4 thousand tons according to the baseline scenario, 19113.4 thousand tons according to the optimistic scenario, and 17894.9 thousand tons according to the pessimistic scenario.

4. Conclusion
In the medium term, reserves for growth in milk production can be activated through the development of the dairy sub-sector of livestock production, involvement of unused especially productive agricultural lands in the market, expansion of measures of government regulation and support of economic entities of all forms of farming of livestock production, as well as maintaining solvent demand for the products of the industry on the part of the population through the development and implementation of food aid programs for poor people.

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References
[1] Golubev A V 2017 New trends in the development of the agrarian economy of Russia Economics of agricultural and processing enterprises 3 8-12
[2] Khramtsov A G 2019 New technological paradigm of the Russian dairy industry: formation principles under globalization Foods and raw materials 7(2) 291-300
[3] Minakov I A and Nikitin A V 2019 Agricultural market development: Trends and prospects International Journal of Innovative Technology and Exploring Engineering 9(1) 3842-4
[4] Boldyreva I A, Andryushchenko O G, Nikitaeva A Yu, Udalova Z V and Rudash J 2017 The agricultural production and food industry development trends in the context of food security of Russia Journal of environmental management and tourism 8(20) 642-7
[5] Vorozheykina T 2018 Threats to food security: will there be milk in Russia? Economics of
agriculture in Russia 3 43-7

[6] Poluskina T M 2013 Modern Russia agrarian polity in the context of globalization In world of scientific discoveries Series B 1 105-19

[7] Golubev A V, Golubeva, A A and Smoleninova N A 2018 Challenges and prospects for the development of the agri-food complex of Russia Economics of agricultural and processing enterprises 8 12-9

[8] Bogovioz A V, Ragulina Yu V, Shkodinsky S V and Babeshin M A 2017 Food security factors Agricultural Economics of Russia 2 2-7

[9] Ushachev I, Maslova V and Chekalin V 2017 Economic problems of import substitution in the conditions of scientific and technological development of the agro-industrial complex of Russia Agro-industrial complex: economics management 11 4-11

[10] Kholodova M A and Kholodov O A 2009 Justification of forecast scenarios for the development of the meat and food subcomplex of the agro-industrial sector of the region (Russia: Persiansky) p 172

[11] Minakov I A and Sytova A Yu 2018 The role of regional agribusiness in food security of the country Economics of agricultural and processing enterprises 7 28-31

[12] Pechenevsky V F and Snegirev O I 2018 Prediction of the location of livestock production in the region Economics of agricultural and processing enterprises 11 43-7

[13] Kuznetsov V V, Tarasov A N and Dunaev V L 2006 Improving forecasting the development of regional agribusiness using methods of economic and mathematical modeling (Russia, Rostov on Don, D: VNIIEiN) p 152

[14] Belova T N 2019 Import substitution in the agri-food sector Economy of the region 15(1) 285-97

[15] Bashmachnikov V F, Drokin V V and Zhuravlev A S 2018 Involvement of peasant farms in solving the problems of import substitution Regional Economy 14(2) 663-75

[16] Douphrâte D I, Hagevoort G R, Nonnenmann M W, Jakob M and Kinsel M 2013 The Dairy Industry: a brief description of production practices, trends, and farm characteristics around the world Journal of Agromedicine 18(3) 187-97

[17] Li W X, Chen C C S and French J J 2012 The relationship between liquidity, corporate governance, and firm valuation: evidence from Russia Emerging Markets Review 13(4) 465-77

[18] Sagatgareev R M, Mazhara E N, Fomina E A, Zykov O A and Chernov A N 2019 Production capacities of Russian agricultural organizations: Assessment and forecast Journal of Environmental Treatment Techniques 7(3) 522-30

[19] Raskaliyev T H, Yesmagulova N D and Digilina O B 2019 Integration and development of the dairy regions in the Eurasian economic union: trends, problems and prospects Economy of Region 15(1) 547-60

[20] Kolpakova E A and Popova S A 2015 Evaluation of food self-sufficiency in the region Scientific and methodical electronic journal Concept 13 936-40