Management system for development of the dairy industry in the context of digitalization

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Abstract. This study covers the problem of managing the development of the dairy industry. One of the tasks is the need to develop a non-standard approach to the theoretical foundations of regulation of this industry and recommendations for its practical application. The study is based on the methodology of systemic, integrated and territorial approaches using methods of economic interpretation of research results, operational and comparative analyzes. Scientific novelty lies in the theoretical substantiation of a multi-level paradoxical model of the relationship between the parameters of the dairy industry. The paradox is the hypothesis that there is a relationship between the regulatory impact and the parameters of the dairy industry, having a functional relationship with it (the correlation coefficient is close to 0), through a multi-level chain of indirect relationships of parameters that have a closer relationship with the regulator and indicators that are dependent on it indirectly. To implement the proposed hypothesis, a new mechanism of action is needed, which allows, on the basis of actual data taken from open sources, developing separate digital models of the dairy industry for the subjects of the Russian Federation. The maximum margin of error of such models shall not exceed 10 %. Based on the results of developing a digital model and testing its information and computer technology, it was concluded that it should be used in forecasting processes for the development of the dairy industry, depending on the regulatory impacts expressed by the invested amount of state support funds. Testing of the proposed theory is carried out according to the results of 3 scenarios of forecasting the development of the dairy industry in the Novosibirsk oblast for a 2-year period, calculated based on the proposed digital technology.

1. Introduction

The agro-industrial complex as a whole and the dairy industry in particular are the most important sectors for the Russian Federation and make a significant contribution to ensuring the country’s food security. At the moment, Russia ranks sixth in the world among the largest leading countries for producing and processing milk, however, it is twice as inferior to leading competitors in the productivity of dairy farming.

The reforms significantly reduced the level of consumption of milk and dairy products, including per capita. In order to eliminate the current negative situation, the dairy industry needs to be modernized, while special attention should be paid to the development of dairy farming. Additional investments are needed to solve this problem [1–2].
“It is necessary to attribute the import of cheaper similar products from other countries, primarily from Belarus to the constraining factors in the development of the dairy industry, which is ensured by the high level of state support for producers in exporting countries” [3, p.10]. Therefore, in order to eliminate the backlog of the Russian dairy industry, it is necessary to increase the effectiveness of its state regulation [4-10]. To determine the necessary level of effectiveness of state support, it is necessary to identify the mechanism of its impact on the main parameters of the dairy industry. Such a mechanism can be digital technology.

Objective: Development of a paradoxical theory of regulation of the dairy industry.

Tasks:
1. Proposal of a non-standard concept of the regulation theory of the economy sectors.
2. Based on the proposed concept, the development of a mechanism for its application on the example of the dairy industry and an algorithm for implementing the mechanism.
3. Digital technology design for the implementation of the proposed algorithm.

2. Methods and materials
The study is based upon the methodology of a systematic, integrated and territorial approaches using methods of economic interpretation of research results, operational and comparative analyzes. The study was based on information taken from the database of the National Union of Milk Producers [11].

3. Concept of dairy industry regulation
The development of a digital model required the identification of possible indicators for the dairy industry. Using the methods of economic interpretation, 15 main parameters were identified [18–19] (Figure 1).

| Production, thousand tons | • X1 – milk in farms of all categories  
• X2 – trade milk |
| Cow population at the end of the year, thousands of animals | • X3 – in farms of all categories at the end of the year  
• X4 – in agricultural organizations (ACOs), peasant farm enterprises (PFEs), personal subsidiary plots (PSPs) |
| Share of brood cows, % | • X5 – in ACOs, PFEs, PSPs  
• X6 – milk and combined directions of productivity |
| Milk producing ability of cows, kg/year | • X7 – in farms of all categories  
• X8 – in ACOs  
• X9 – in PFEs  
• X10 – in PSPs  
• X11 – brood cows |
| Milk and dairy products per capita, kg/year | • X12 – production  
• X13 – consumption |
| Milk processing, t | • X14 – dairy production in terms of milk |
| Amount of funds, million rubles | • X15 – government support for the dairy industry |

**Figure 1.** Indicators characterizing the dairy industry [18–19]

To determine the possible relationship between the indicators (Figure 1), it is advisable to conduct a correlation analysis, which enables establishing not only the relationship, but also its proximity to a linear form.

The results of the correlation analysis showed a large scatter of multidirectional correlation coefficients:
• positive from 1 to 0.03.
• negative from –0.12 to –0.86.

This indicates that between the parameters of the dairy industry there is no unambiguous relationship, despite a linear relationship is observed between its individual indicators. Therefore, it is not possible to establish the relationship between the parameters using traditional methods. Thus, we proposed a paradoxical method, which involves taking into account the direct relationship between parameters where possible, and indirect where such a relationship cannot be established. Based on the a priori analysis, a hypothesis was proposed that assumes the existence of a multi-level model that, with a sufficient degree of accuracy, can describe the interaction of parameters characterizing such a diverse system as the dairy industry.

The proposed hypothesis must be tested on the actual data of the industry, at least on one of the constituent entities of the Russian Federation for at least a five-year period of time.

Based on the task, conditions and restrictions imposed when solving it, we can assume the existence of a three-level model of the following proposed configuration for the types of interaction of indicators of the dairy industry, the structure of which is shown in Figure 2.

Figure 2. A paradoxical model of the interrelation between the parameters of the dairy industry

To build an algorithm for the practical implementation of the proposed paradoxical model, the following mechanism of actions is proposed:

1. The main control parameter is singled out, by which we can influence other indicators characterizing the dairy industry. As a target function (regulator), one of the forms of financing can be chosen in the form of the volume of government support funds for the dairy industry (X15).

2. The first 14 parameters shown in Table 1 are selected as being researched for possible effect. These parameters are selected because of their general availability in printed and electronic information sources.

3. Initially, according to the results of the correlation analysis, parameters for which the correlation coefficient relative to the regulator (X15) is greater than 0.7 are pre-selected. We assume that these indicators should be attributed to the parameters which can be directly affected by the regulator. These indicators include parameters X4 and X11. Using the linear approximation method, a direct digital relationship is established between the selected indicators and the regulator.

4. From the parameters that fell into the category of direct, according to the table of correlation coefficients, we select the most powerful one that has an effect on the indicators remaining after preliminary selection. Parameter X4, which is called an indirect regulator in the study, is the appropriate condition for this criterion.

5. Secondarily, according to the results of the correlation analysis, parameters are preliminarily selected for which the correlation coefficient relative to the indirect regulator (X4) is greater
than 0.8. We assume that these indicators should be attributed to the parameters on which the indirect regulator can have a direct impact. Such indicators include parameters X1, X2, X5-X9 and X12. Using the linear approximation method, a direct digital relationship is established between the selected indicators and the indirect regulator.

6. The last indicators, the least dependent on direct and indirect regulators, are examined for the possibility of their interaction with the parameters of the primary indirect category. In this analysis, all restrictions are removed, and selection is carried out according to the maximum correlation coefficient of the remaining possibilities, regardless of their size and orientation. Using the linear approximation method, a direct digital relationship is established between the selected indicators and secondary indirect regulators.

4. Research result
Let us consider the work of the paradoxical model algorithm (Figure 1) based on the actual data of the Novosibirsk region for 2014–2018, which are freely available [18–19].

The final results of the multilevel correlation and functional analysis are presented in Table 1.

| Designation   | Digital model                                      | Approximation coefficient (R²) | Margin of error, % |
|---------------|---------------------------------------------------|-------------------------------|--------------------|
| 1st level     |                                                   |                               |                    |
| X4            | X4 = 0.009878 * X15 + 134.186                     | 0.759                         | 2.5 %              |
| X11           | X11 = 1.388184 * X15 + 7187.9351                  | 0.536                         | 8.3 %              |
| 2nd level     |                                                   |                               |                    |
| X1            | X1 = 6.634324 * X4 – 255.723                      | 0.774                         | 3.19 %             |
| X2            | X2 = 10.37241 * X4 – 949.852                      | 0.672                         | 8.19 %             |
| X5            | X5 = 0.467732 * X4 – 51.2205                      | 0.797                         | 8.79 %             |
| X6            | X6 = 0.492792 * X4 – 56.2171                      | 0.797                         | 9.84 %             |
| X7            | X7 = 58.20987 * X4 – 4410.82                      | 0.806                         | 4.62 %             |
| X8            | X8 = 76.64832 * X4 – 6569.93                      | 0.788                         | 5.61 %             |
| X9            | X9 = 49.55294 * X4 – 4141.81                      | 0.806                         | 5.15 %             |
| X12           | X12 = 1.64969 * X4 – 42.404                       | 0.657                         | 3.62 %             |
| 3rd level     |                                                   |                               |                    |
| X10           | X10 = 5.891 * X12 +1738.445                       | 0.305                         | 2.4 %              |
| X13           | X13 = 0.5063 * X12 + 186.7629                     | 0.472                         | 4.2 %              |
| X14           | X14 =-164.429 *X2+251345.285                      | 0.656                         | 7 %                |
| X3            | X3 = 0.00017 * X14 + 162.947927                   | 0.549                         | 1.2 %              |

5. Discussion of results
Mathematical models (Table 1) indicate that the margin of error of the equations does not exceed 9 %, which indicates the possibility of using the proposed mathematical apparatus as a tool for predicting the effects of state regulation on the main indicators of the dairy industry in the Novosibirsk region.

The adequacy of the digital model is confirmed by checking the calculation results in comparison with the actual data for 5 previous years. It showed that with the smallest relative deviation (less than 2 %) through 3 intermediate parameters, the last indicator of the second stage of the third level X3 in the algorithm is calculated, and with the largest (slightly more than 20 %) – X6.

6. Conclusion
Based on the results of developing a digital model and testing its information and computer technology, it can be concluded that the model can be used to predict the development of the dairy industry in the Novosibirsk region, taking into account the risks of the digital economy, “depending on the regulatory effect in the form of the invested amount of government support funds” [4].
The forecast results indicate that a decrease in funding will lead to a sharp deterioration of the situation in the dairy industry in the Novosibirsk region. Stabilization of government support at the previous level will only slow down its decline. This confirms the acute current underfunding of the dairy industry by state bodies. The situation may change for the better with an increase in government support at least in two times compared to current funding.

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