Problems of assessing the development of animal husbandry in the context of production robotization and digitalization in Russia

M V Bochenina*, Y V Neradovskaya and E V Nesterova

1Saint Petersburg State University of Economics, 21 Sadovaja, Saint Petersburg 191023, Russia

* E-mail: m-bochenina@yandex.ru

Abstract. The article considers the research hypothesis - drive to increase the uniformity of animal husbandry development in different natural and climatic zones, due to production robotization and digitalization. The high level of technical equipment of livestock farms contributes to the reduction of regional heterogeneity. To determine the models and indicators describing the processes in agriculture, it is necessary to consider the characteristics of the object of study. The working hypothesis was evaluated using cluster analysis based on data from 84 regions of the Russian Federation based on 11 indicators reflecting financial, industry and labor characteristics. Cluster analysis showed that only 30% of farms have indicators that exceed the average level for Russia. The complex of existing problems does not allow to fully and rationally use available opportunities for the development of the livestock industry in the regions.

1. Introduction

Agriculture is a strategically important area of economic activity. Providing the population with food is one of the main state tasks, the solution of which allows ensuring food security of the country. Assessment of the current state of agriculture and forecasting its development should be based on modern design and modeling methods.

Animal husbandry is the most important industry in the economy, ensuring food security of the country, satisfying the population's need for food products containing protein and other substances necessary for the life of the human body. This determined the relevance of the study.

The degree of topic coverage is characterized by the specifics of the livestock industry. In the conditions of digitalization, increase of information obtaining efficiency, appearance of data bulk, the role of using multidimensional methods of statistical analysis and forecasting is growing.

The aim of the work is to assess the degree of animal husbandry development in the Russian Federation in modern conditions.

The object of the study is the livestock industry. The subject is the study of livestock farms homogeneity according to the main indicators of their activity.

The research hypothesis is the drive to increase the uniformity of animal husbandry development in different natural and climatic zones, due to production robotization and digitalization. The high level of technical equipment of livestock farms contributes to the reduction of regional heterogeneity. The distribution can be considered homogeneous if the distribution of farms is symmetrical with respect to the average and has a small variation.
2. Materials and methods

2.1. Sources review
In the scientific literature, works that study the complex nature of the regulation of the livestock industry and the growth of the effectiveness of its individual components, modeling the future development of agriculture through the use of multidimensional statistical methods are widely distributed.

The concept of economic and mathematical modeling in agriculture is analyzed in the works of V.N. Afanasyev, K.A. Bagrinovsky, G.V. Bespakhotny, M.E. Braslavets, A.M. Gataulin, V.A. Kardash, R.G. Kravchenko, E.N. Krylatykh, S.B. Ognivtsev, V.V. Miloserdov, P.P. Pasternak, M.M. Yuzbashev and other scientists.

The development of a system of sectoral economic and mathematical models can serve as a tool for optimizing the development of the agro-industrial complex [1]. To solve this problem, the decomposition method can be used, which is aimed at forming a set of subtasks for research that represent a common aim. Example of such blocks can be the following:
- forecast of changes in livestock and poultry, as well as their productivity;
- forecast of feed availability for livestock and poultry using the indicator of sown area and yield of forage crops;
- assessment of feed consumption in accordance with the qualitatively necessary diet for the effective use of animals;
- calculation of the resources required for the continuation of the activities of enterprises in the industry and the development of animal husbandry, and their cost.

Describing the problem of forecasting the animal husbandry development as an economic system, taking into account its specificity and complexity is possible through the use of mathematical modeling methods. The model should be considered as a flexible system that determines the values of indicators in the future under the influence of changes in a set of factors.

Researchers from China in their work [B] analyze national, global and local trends in the spatial structures of livestock and poultry farming in China. Based on clustering on three indicators - the standardized swine Index (ESP), the index of breed land pigs (PCLP) and the per capita index (PCP), they found that there is a potential uniform zoning scheme for livestock and poultry farming in China, which forms 8 clusters.

The issues of identifying trends in the location of the main sectors of livestock raising in the Central Chernozem economic region are discussed by V.F. Pechenevsky, and analysis of the condition and assessment of the factors of their development is given [3].

V.V. Rau in his work [4] investigated the trends and conditions for increasing the competitiveness of Russian livestock on an innovative basis, and in his work [5] on the example of animal husbandry, in particular beef, a number of key factors that should increase the competitiveness of Russian agricultural products when replacing imports are studied. The relationship between innovation, productivity, and agricultural sustainability is explored in the work of Ann Steensland and Margaret Zeigler, which also discusses innovation, productivity, and the Sustainable Development Goals (SDGs) [6].

The University of Newcastle upon Tyne has developed a forecast agricultural supply model to predict organizational changes in British agriculture following the UK's accession to the European Community. Special attention was paid to adjustments during the transition period at both micro and macro levels [7].

The possibilities of modern data collection technologies are application reflected in work [8], which considers the disaggregation of agricultural data at the local level, using existing modern satellite images and an entropy approach to manage different data sets.

2.2. Features of animal husbandry analysis
The agrarian economy is an open system in which the results of the implementation measures can be obtained with some delay due to the peculiarities of the production cycle, as well as the characteristic features of the industry (soil quality, livestock productivity, etc.).
The expansion of opportunities for the application of climatic, biological and environmental features of the region is associated with innovative technologies that allow to increase the degree of automation of the entire agro-industrial complex, improve quality and quantity of agricultural products through developments in the chemical and processing industries, upgrading information technology platforms and systems. Scientific research in the field of biotechnology contributes to the expansion of knowledge in the breeding and evolution of livestock and poultry to identify patterns of development of species in order to increase the efficiency of animals in the agricultural industry.

Для определения моделей и показателей, описывающих процессы в сельском хозяйстве, следует учитывать следующие особенности объекта исследования:

• instability of the external and internal environment of the industry;
• geographical and agrometeorological characteristics of the territory (presence of periods of drought, precipitation, etc.);
• seasonality of agricultural work performed;
• need for innovative solutions to optimize the use of resources (organizational and production modernization, technological innovations, etc.).

The collection and analysis of data on processes in Russian animal husbandry is associated with a number of problems:

• accepted methodology for calculating some indicators involves a combination of actual data and expert assessments.
• updated data obtained during the All-Russian Agricultural Census (conducted once every ten years) require a retrospective recalculation of livestock production indicators.
• there are relatively short time series of indicators that have become available due to ongoing digitalization.
• confidentiality of primary statistical data. Information is not published if it is determined for less than three farms. For this reason, a large amount of actual data may fall out of the researcher’s field of view.
• lack of unity of classification features of farms categories in statistical information systems does not allow filtering by parameters that are significant for the study.
• quite a lot of materials remain unavailable. First, it should include a large amount of data contained in paper form; second, it concerns sources that could not be digitized or identified by artificial intelligence (for example, maps); third, it implies phenomena that are not covered by observations, including due to lack of training or insufficient technical equipment (for example, analysis and monitoring of data obtained by aerial photography).
• generalized methods of data collection do not always take into account regional characteristics due to the complexity and diversity of agricultural activities in the Russian Federation over vast territories and under various climatic, financial, infrastructural and other features, which could be used in a more flexible model developed for the rapid assessment and forecast of statistical factors.

The assessment of the working hypothesis, which consists in the uniformity of livestock development in the subjects of the Russian Federation, was carried out using cluster analysis based on data from 84 regions obtained from the official website of the Unified Interdepartmental Information and Statistical System (EMISS) [9].

3. Results and discussions

With the development of the agro-industrial complex, animal husbandry shows positive dynamics. The dynamics of livestock production has been positive for the last 15 years and in 2019 the index compared to the previous period was 101.9%.

To assess the socio-economic situation in the industry under study, it was possible to form three groups of indicators that provided comparability and reliability of the results.

The first group is financial indicators that characterize the livestock industry:

• turnover of organizations (for large, medium and small organizations);
• cost of goods, products, works, services sold;
• coefficient of security of own working capital;
• share of unprofitable organizations according to accounting reports.

The second group — industry indicators:
• total livestock and poultry (live weight) produced (breed);
• milk production in farms of all categories;
• egg production in farms of all categories;
• feed consumption for livestock and poultry;
• share of animal husbandry in agricultural products.

The third group — labor indicators:
• average monthly nominal salary of agricultural workers;
• average number of employees in the livestock industry for a full range of organizations.

As a result of application of the average connection method of cluster analysis, the regions were distributed as follows:

- the first cluster included the Belgorod Region, which is one of the most successful and highly developed agricultural regions (Figure 1, a).
- the second cluster included: Bryansk region, Voronezh region, Moscow region, Leningrad region, Chelyabinsk region - developed and competitive subjects located near large settlements (Figure 1, b).
- the third cluster includes: Kursk region, Lipetsk region, Tambov region, Pskov region, Krasnodar Krai, Rostov region, Stavropol Krai, the Republic of Bashkortostan, the Republic of Mari El, the Republic of Moldova the Republic of Tatarstan (Tatarstan), the Udmurt Republic, Nizhny Novgorod region, Penza region, Sverdlovsk region, Altai Krai, Krasnoyarsk Krai, Novosibirsk region, Omsk region – regions with developed livestock industry, while cost of goods sold is significantly lower than in the first and second cluster (figure 1, c).
- the fourth cluster includes regions of the Russian Federation that are not included in other groupings (59 subjects), which have different parameters, while they are most generalized taking into account the share of unprofitable organizations in the livestock industry, the average level of remuneration and the share of livestock in the agricultural products of the subject (Figure 1, d).

Figure 1. Clustering of Russian regions according to the condition of animal husbandry in 2019.
The results of cluster analysis are shown in Table 1. It can be noted that the Belgorod region significantly exceeds the considered indicators for the Russian Federation. For most indicators, the data of the second and third groups are higher than the national average. And the values in the fourth cluster are on average lower than in Russia.

### Table 1. Clustering results: average values of the indicator in the cluster

| Indicator | Cluster first | Cluster second | Cluster third | Cluster fourth |
|-----------|--------------|----------------|---------------|---------------|
| Total livestock and poultry (live weight) produced (breed) per year (thousand tons) | 1713.7 | 432.9 | 342.5 | 77.3 |
| Milk production in farms of all categories (thousand tons) | 623.8 | 581.3 | 722.2 | 226.4 |
| Egg production in farms of all categories (million pieces) | 1658.1 | 1254.5 | 937.2 | 324.8 |
| Feed consumption for livestock and poultry (thousand tons of feed units) | 5399.9 | 2434.7 | 2331.1 | 741.0 |
| Share of unprofitable organizations according to accounting reports (per cent) | 17.0 | 30.4 | 25.5 | 25.6 |
| Average number of employees for the full range of organizations (people) | 27850.0 | 13174.6 | 13133.8 | 3382.4 |
| Average monthly nominal salary of agricultural workers (rubles) | 33306.5 | 31419.8 | 24593.1 | 25036.6 |
| Turnover of organizations (Large, medium and small organizations, million rubles) | 122474.6 | 52224.4 | 29986.7 | 7069.6 |
| Coefficient of security of own working capital (per cent) | 22.4 | -39.7 | -38.2 | -6.2 |
| Cost of goods, products, works, and services sold (million rubles) | 120315.5 | 44580.8 | 24338.6 | 4931.8 |
| Livestock production in agricultural products in actual prices (per cent) | 65.2 | 57.0 | 51.3 | 55.7 |

The obtained characteristics indicate the uneven development of the regions. The reasons for this result are the large territory of the state, climatic and geographical features, different infrastructure, financial opportunities, as well as historical background. After the collapse of the USSR, agricultural producers faced a crisis situation, without centralized state support, it was difficult to maintain output volumes and ensure business profits. At the present stage, problems in increasing the production of livestock products are observed even in those subjects where there are favorable conditions for agriculture. Costs associated with the expenses for food supply provision, the poor state of technological resource, limited access to markets, lack of socio-economic development of rural areas, and as a result lack of qualified personnel – the factors that have a negative effect and is manifested in increased production costs, unattractive salaries, increased debt load of the organizations. The complex of existing problems does not allow to fully and rationally use available opportunities for the development of the livestock industry in the regions. This assessment of the industry allows to identify pain points, assess the scale of the problem of heterogeneity in the animal husbandry development.

### 4. Conclusions

In the course of the work, the need to take into account the instability of the external and internal environment of the animal husbandry industry, the need for innovative solutions was established. The features of the data associated with the lack of unity of classification features of farms categories, the brevity of time series are revealed. Incomplete data due to insufficient technical equipment. Generalized methods of information collection do not always take into account regional peculiarities.

To assess the working hypothesis, which consists in the uniformity of the development of animal husbandry in the subjects of the Russian Federation, three groups of indicators were formed that ensure
comparability and reliability of the results: financial, industry, and labor. In total, clustering was carried out on 11 indicators.

As a result, four clusters were obtained. The indicators of the first cluster significantly exceed the average values for the Russian Federation. In most cases, the characteristics of the second and third clusters are higher than the national average. The indicators of the fourth cluster do not exceed the average value for Russia. Thus, there is an uneven distribution due to the insufficient level of technical progress in technological processes in animal husbandry.

References
[1] Nosonov A M 2018 Bulletin of the Moscow State Regional University, Series: Natural Sciences 3 pp 62-74
[2] Fu Q, Zhu Y, Kong Y and et al 2012 Spatial analysis and districting of the livestock and poultry breeding in China J. Geogr. Sci. 22 pp 1079–1100
[3] Pechenevskii and V F 2019 Structural Changes in the Allocation of Livestock Farming Sectors in the Central Black Earth Economic Region in the Postreform Period Stud. Russ. Econ. Dev. 30 pp 166–171
[4] Rau and V V 2011 Innovative and investment factors of increasing the competitiveness of Russian cattle breeding Stud. Russ. Econ. Dev. 22 pp 64–71
[5] Rau and V V 2009 Global food crisis and prospects for animal production in Russia Stud. Russ. Econ. Dev. 20 pp 23–30
[6] Steensland A and Zeigler M 2021 Productivity in Agriculture for a Sustainable Future (The Innovation Revolution in Agriculture Springer, Cham)
[7] Davey B and Hazell P B R 1976 Adjustment in British Farm Production, Agriculture and the State Trade Policy Research Centre (London)
[8] Xavier A, Fragoso R, de Belém Costa Freitas M and et al 2019 An Approach Using Entropy and Supervised Classifications to Disaggregate Agricultural Data at a Local Level J. Quant. Econ. 17 pp 763–779
[9] Unified Interdepartmental Information and Statistical System (EMISS) 2020, https://fedstat.ru free