Algorithms for improving the process of modeling complex systems based on big data: on the example of regional agricultural production

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Abstract. The article analyzes the sources of the development of specific mechanisms, assessing the future problems of regional agro-industry development. Agro-industry as a production facility forms a complex system. In this case, as the main elements, it is suggested that the criterion of non-loss of characteristics as a result of processing information about these elements is primary. It is justified that the information system of the Big Data type, the models that describe the laws, the mechanism that enables the improvement of the models, and the algorithms that activate the mechanism are of particular importance as these sources. Researchers estimate that the mechanism that allows for the improvement of system research models is artificial intelligence, and the main problem here is the obstacles in the development of algorithms that determine the trajectory of its activity. These obstacles are explained by the complexity of the system, the lack of sufficient information to assess the importance levels of its elements, low accuracy, and the fact that the level of importance is presented differently in different sources. Taking into account that agro-industry is a complex enough system, the need to research the laws of this network requires a big data type information system, and algorithms for using artificial intelligence-based mechanisms are proposed.

1 Introduction

Today, in the context of reforms in the development of the agricultural sector in the Republic of Uzbekistan, it is aimed to achieve a high-quality and necessary amount of food supply, as well as the formation of national immunity to withstand various types of hazards expected in the future. The following potential risks can be identified and assessed:

Climate change: Climate change can have a significant impact on agriculture, including changes in temperature, rainfall patterns, and extreme weather events. Uzbekistan is already a dry country, and climate change may exacerbate this, leading to decreased crop yields and increased water scarcity [1].

Soil degradation: Soil degradation, caused by erosion, nutrient depletion, and other factors, can lead to reduced agricultural productivity over time. In Uzbekistan, soil

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degradation is a growing concern due to unsustainable agricultural practices such as monoculture and overuse of fertilizers.

Pest and disease outbreaks: Outbreaks of pests and diseases can devastate crops and livestock, leading to significant economic losses for farmers. Uzbekistan is vulnerable to outbreaks of pests and diseases due to its large agricultural sector and its location at the crossroads of several trade routes.

Market volatility: Agricultural markets can be volatile, with prices fluctuating in response to changes in supply and demand. Uzbekistan is highly dependent on exports of cotton and other agricultural products, making it vulnerable to price shocks and changes in global demand [2].

Lack of infrastructure: Inadequate infrastructure, including roads, transportation, and storage facilities, can limit the ability of farmers to access markets and sell their products. This can have a significant impact on the agricultural sector in Uzbekistan, where much of the population lives in rural areas with limited infrastructure [3].

Overall, the agricultural sector in Uzbekistan faces many challenges and risks in the coming years. Addressing these challenges will require sustained investment in infrastructure, sustainable agricultural practices, and adaptive measures to respond to the impacts of climate change.

At the same time, when such complexity is expected, there is a need to improve the methodology of systematic research. In other words, even the previous modeling principles may not be enough to calculate the medium-term forecast indicators of this network. Therefore, our scientific idea is to consider that the primary requirement of the times is to review, change and ensure the effectiveness of the usual econometric modeling strategy in terms of methodology, structure, punctuality and information.

In this case, it is necessary to take measures to organize a large database for the system, which will allow developing an unlimited number of prediction, evaluation, optimization process modeling series as information. Then it will be possible to have scientific extremum decisions, priorities.

The need for modeling in the study of complex regional systems is emphasized in many sources. Modeling methodology, their improvement, new innovative approaches are an integral part of today's research process. This aspect serves to complement the theoretical views, to increase the factual information only after the successful testing of the theoretical information in practice. Below, great attention was paid to them when choosing the research methodology.

2 Materials and methods

There has been a significant amount of scientific research on the use of big data in the modeling of agrarian networks. Some of the notable works include:

The effectiveness of analyzing the optimal management laws of production in the agrosystem based on big data systematization was justified by researchers Nabila Chergui and others (2022) [4], New approaches to multispectral imaging based on big data in the development of production processes in the agricultural network are covered in the scientific works of Charles Weiss (2019) [5], “A Cluster-Based Approach to Support the Delineation of Management Zones in Precision Agriculture” Eduardo Antonio Speranza et al (2014) [6], "Big data analytics in Agriculture" by Debdeep Bose. (2020) [7], "Data Science in Agriculture - Advancing Togetherand Benefiting Farmers”. D. Team, (2019) [8], A big data-driven model of smart agro production using the integration of modern analytics technologies can be seen in the works of S. Rajeswari (2017), [9]. Also, in the scientific works of a number of scientists, that is, Arsenovic M, et al, (2019), Mukhitdinov,

K. S et al, (2020), Ochilov, M. A. et al (2020), the production process of agricultural products is greatly A systematic analysis is given based on the data [10].

These are just a few examples of the scientific works on the use of big data in the modeling of agrarian networks. There are many other studies that explore different aspects of this topic, such as crop prediction, pest management, and supply chain optimization.

Methods such as factor analysis, correlation analysis, factor analysis, mathematical analysis, and mathematical programming were used in the research. The technology of using these methods is widely covered in sources [11-15].

3 Results

Working with big data requires powerful computing hardware. Today, the availability of modern computing systems allows solving this problem [16-19].

Of course, it is necessary to develop special algorithms for this supply (the algorithm is presented below). Based on this algorithm, we will consider the issue of improving management decisions based on the improvement of the model predicting the efficiency of the use of intellectual resources in agro-industry. Let us mark the following:

- Y – volume of production, billion soums.
- X_1 – amount of expenses for intellectual resources, million soums.
- X_2 – degree of freedom to do business in the region, in percent.
- X_3 – amount of investments in fixed capital, billion soums.
- X_4 – binary parameter (accepts values 0 or 1).

The empirical model based on these parameters is as follows (Table 1).

Table 1. Parameters and adequacy indicators calculated according to the imperial model of the volume of agro-industry production depending on intellectual resources.

Exogenous variable	Model parameters	Standard error of the model	Styudent's distribution of significance (t)	testing the null hypothesis (p)
amount of expenses for intellectual resources (X_1)	2.834181	0.625821	4.528742	0.0027
degree of freedom to do business in the region (X_2)	342.0829	135.2611	2.529057	0.0393
binary parameter (X_4)	1139.486	396.4510	2.874217	0.0238
non-exogenous element	-11055.97	4171.345	-2.650456	0.0329
coefficient of determination	0.992651	Endegen average		9076.545
smoothed coefficient of determination	0.989501	S.D. dependent var		3696.940
Fisher distribution criterion	315.1517	Autoregressiveness Test		2.042151

In our opinion, the algorithm for the formation of the information base of the "Big DATA" type in the development of network development models and priority mechanisms based on their results can be described as follows:

- Obtaining initial information from the source (in this case, information about the elements of the system that are considered the most important is received in advance).
- Perform calculations in the sserials section based on developed models (this requires the presence of pre-calculation algorithms).

- In accordance with the information received as each input, the results are recorded in the database register according to the level of reliability, importance, quality.
- The results of the newly added adequate model are included in the database according to the level mentioned above.
- Based on the updated information, new modifications of the model are developed (in this case, the model is improved only parametrically, the structural improvement is carried out only if the information transmitted by the previous model falls below the level of requirements).
- Information transmitted by modified models is recorded in the database.

This is where the repetition process begins. This iteration can continue indefinitely, according to the dynamics of the development of the network. A certain regulation can be selected as a test:

- Network development decisions are developed based on the information collected in a certain period of time.
- The perfection of these decisions is ensured based on the improvement of models.

4 Discussion

Forecast indicators and reliability intervals calculated according to the imperial model of agro-industry production volume depending on intellectual resources are presented in the following figure (Figure 1).

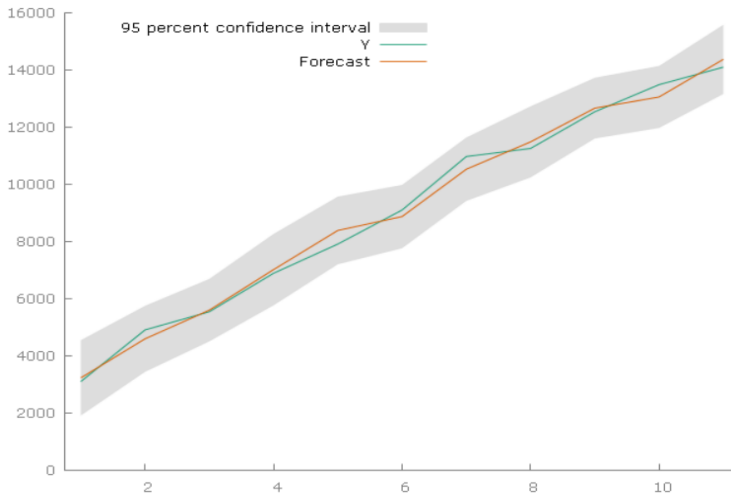

Fig. 1. Forecast line and reliability area of agro-industry production volume in the region.

In the initial case, a 1% increase in the amount of expenses for intellectual resources is accompanied by a 0.64% increase in the production volume; a 1% increase in the level of freedom to do business in the region causes a 1.49% increase; production volume will decrease by 1.22 percent without observing the trend of increase of these two factors. This was calculated based on a linear model [17, 18].

5 Conclusion

Based on the research results and some scientific sources [19-23], we draw the following important conclusions:

- In the absence of a functional link, if the density of linking the factor of influence to the main indicator is known, the possibility of increasing it according to the principle of a selected set is limited. In this case, it may not be enough to consider all combinations of choices.
- In the absence of functional linkage, if the density of linkage of an influencer to the main indicator is known, it is always possible to increase it using various mathematical operations on this factor, but this may not increase the quality and significance of the model.
- In the absence of functional connection, if the interconnection density of arbitrary two influencers of the system is known, the possibility of reducing it based on the principle of a selective set is limited. In this case, it may not be sufficient to consider all the choice combinations.
- In the absence of a functional connection, if the density of the relationship between arbitrary two factors of system influence is known, it can always be reduced using various mathematical operations on these factors, but this may not improve the quality and significance of the model.
- In the absence of functional linkage, there is an unlimited number of combined scenarios of increasing the linkage density of all selected influencers of the system to the key indicator.
- Optimal modeling of complex technological processes with many parameters requires big data. At the same time, the simplification of these information processing algorithms is of great importance, and this aspect should be the main task of developing neural rules.

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