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# Application of neurointelligence technology in predicting the development of agribusiness

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**Abstract.** Neural networks have proven to be highly adaptable to various tasks associat-ed with large data sets and their processing in order to obtain new knowledge and data for subsequent planning of the development of various systems. Neural networks are used not only in the processing of large data sets, but also in the construction of predictive models. In this article, we built a neural net-work model for calculating and forecasting profit index of the agro-industrial complex (AIC) of Russia, on the basis of aggregated input factor parameters, reflecting the potential of the industries. In addition to the neural network forecast, the article builds a profit forecast using the method of regres-sion-correlation analysis, which has long been used by economists. For fore-casting purposes, the analysis of the dynamics of development of the branches of agro-industrial complex was carried out and the main factors determining their future opportunities were selected. Using the online platform Deductor Studio Academic assessed the dependence and impact of input indicators on the derived profit indicator and checking the correlation coefficients between the parameters were calculated. The obtained forecasted profit values were com-pared with the actual profit value and the difference in the accuracy of the forecasts was calculated.

## 1. Introduction

The widespread introduction of artificial intelligence technologies in all spheres of social life forces a qualitative revision of the existing approaches to planning and forecasting the future development of systems [1, 2]. Machine learning technologies, computer vision and neural networks have found application and successful practical implementation in many sectors of the economy. Agro-industrial complex industries have not been spared from these innovations either. Practice has proved successful application of neural network technologies in solving various national economic tasks [3].

In many countries, agriculture successfully uses such technologies as unmanned surveillance and monitoring of arable land, aerial land survey, robotized dairy farms, robotized poultry farms, comparing contours of arable land by machine vision, neural network-based sensors of animal and crop conditions, etc. Nevertheless, opportunities that offered by neural network technologies are quite extensive and underutilized, as evidenced by the high potential of machine learning and computer vision based on convolutional neural networks [4].

Today there are the main production sectors of the agro-industrial complex - livestock and crop production - are very responsive to changes in market demand and are steadily growing in the light of the global population growth of the Earth. However, this growth is happening today due to an extensive expansion of volumes, i.e. increase of the number of beef and dairy cattle and birds, and increase of the area of arable land, which maximizes the anthropogenic burden on the environment. A very large part of manufactured products remains unclaimed and simply turns into food waste, which also pollutes the environment. Therefore, it is necessary to accurately predict the trends in the demand for the manufactured products and actually produce "custom-made" food raw materials [5, 6].

For improving the accuracy of the forecast data, we will demonstrate and compare the features of calculations by two methods - neural network modeling and regression-correlation analysis. In our study, we compare the predicted values of the output parameter (profit) with the actual value, which will allow us to calculate the accuracy of the predictions and determine the magnitude of the deviation. Neural network analysis was compared with regression-correlation analysis, long used in practice.

## 2. Results

In Russia, a governmental project "Digital Agriculture" has been developed and approved at the level of the Ministry of Agriculture of the Russian Federation, which plans to form an integrated global digital platform for the agricultural sector, which will allow all participants in this market to provide interaction on a remote basis and will complement the information base on agricultural producers to the maximum extent possible.

This ecosystem will reduce bureaucratic barriers and enable to get answers to requests in the shortest possible time and to expand the search for partners in the agricultural markets of the country. Good funding and work with Big Data in the content of a single information window are required for the effective operation of that platform. The planned amount of funding for the project for the period 2019-2024 is presented in Figure 1.

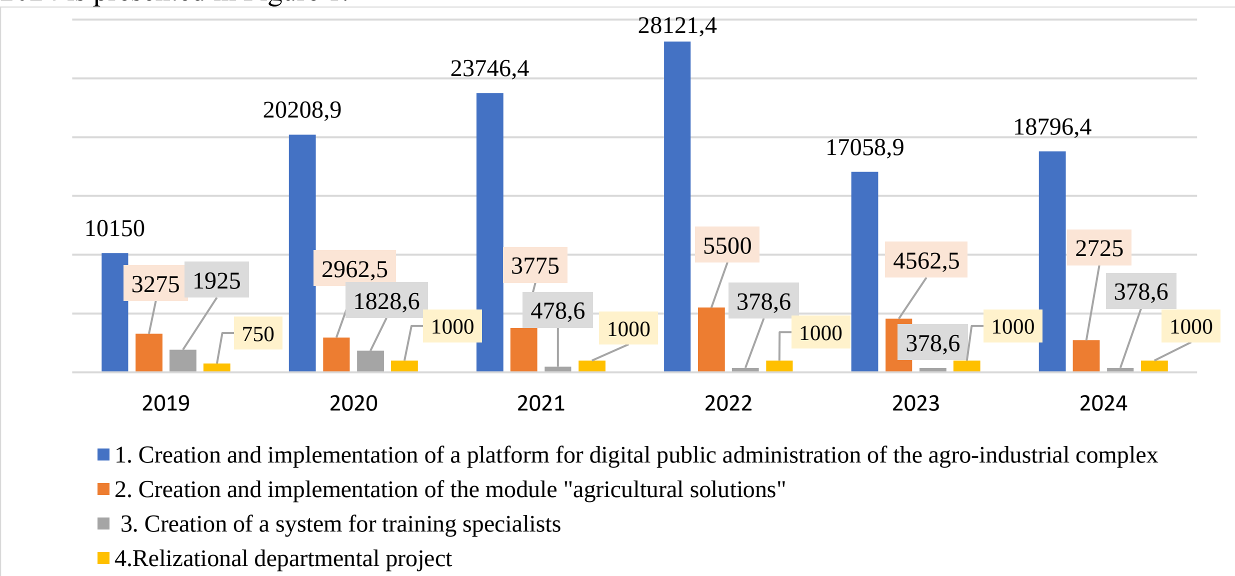


**Figure 1.** Amounts of financial support for the departmental program "Digital Agriculture" by stage of its implementation, billion rubles.

The maximum amount of funding for the construction of the innovation platform is in 2022 as, until this period, there is only preparatory work on the collection of data and the construction of forecasts of future development in the main areas of development. According to the operative data of the Ministry of Agriculture of the Russian Federation, the work of forming of the architecture of the new information eco-environment of the agricultural sector is already underway today. Certainly, the experience of application of intelligent technologies in various industries and countries will be taken into account. Such technologies as Blockchain, Big Data, Neural networks, Internet of Things, etc. have already entered our daily lives, so it is necessary to study and disclose their capabilities as much as possible [7, 8].

One of the promising applications of neural network technologies is the prediction of crop, livestock production in accordance with the dynamics of past years and economic situation factors. For today, neural networks are used in a limited mode, which is unreasonable, since as such the network is able to process a large amount of information, to learn and to produce adequate forecasts for the coming periods [9, 10]. Therefore, in our view, it is necessary to take advantage of the possibility of using convolutional neural networks in perspective planning and forecasting for the development of branches of agro-industrial complex [11, 12]. Current trends in world agriculture are dictated by the need to maximize the implementation of the existing productive capacity of the industry, which is demonstrated high resistance to external negative factors during the COVID-19 pandemic.

The neural network model will build on free online version of the Deductor Studio Academic platform. For the neural network model construction and the convenience of its calculation, we will enter the notation for the factor indicators of the input layer of neurons (I). (Figure 2).

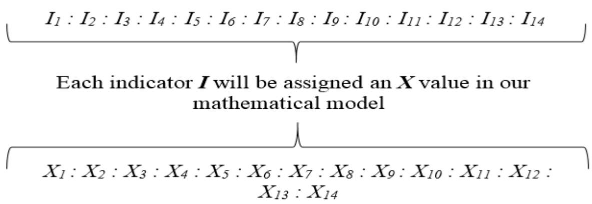


**Figure 2.** Input factor parameters of the neural network model.

Let us denote the resulting profit indicator as *I*15. We will not enter a notation for it, because it will be the required parameter in our model. Let's form the input parameters in the form of Table 1 on the Deductor Studio Academic platform.

**Table 1.** Input parameters for the construction of the forecast of the development of branches of the agroindustrial complex of Russia.

| The total sown area, ***I1*** | Cereals ***I2*** | Grain legumes, ***I3*** | Technical crops, ***I4*** | Potatoes, ***I5*** | Bahrain crops, ***I6*** | Forage crops, ***I7*** | Cattle, ***I8*** | Pigs, ***I9*** | Sheeps and goats, ***I10*** | Horses, ***I11*** | Birds, ***I12*** | Reindeers of the North, ***I13*** | Rabbits, ***I14*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75188 | 41889 | 1454 | 10900 | 2212 | 662 | 18071 | 19793 | 17251 | 21733 | 1284 | 449710 | 1626 | 2773 |
| 75188 | 41889 | 1454 | 10900 | 2212 | 662 | 18071 | 19900 | 17262 | 22726 | 1287 | 473252 | 1650 | 2970 |
| 78057 | 43847 | 1979 | 12045 | 2138 | 671 | 17377 | 19679 | 18785 | 23998 | 1287 | 495513 | 1684 | 3153 |
| 78057 | 44007 | 1979 | 12045 | 2138 | 671 | 17217 | 19272 | 19010 | 24131 | 1266 | 493945 | 1746 | 3210 |
| 78525 | 44623 | 1747 | 12232 | 2112 | 684 | 17127 | 18919 | 19451 | 24445 | 1249 | 524252 | 1651 | 3515 |
| 79319 | 45051 | 1763 | 12709 | 2128 | 694 | 16974 | 18620 | 21405 | 24606 | 1240 | 543913 | 1764 | 3749 |
| 79993 | 45451 | 1753 | 13666 | 2053 | 692 | 16378 | 18346 | 21924 | 24716 | 1216 | 550169 | 1787 | 3625 |
| 80617 | 44919 | 2898 | 13953 | 1905 | 662 | 16280 | 18294 | 23075 | 24389 | 1238 | 555827 | 1838 | 3744 |
| 79634 | 43585 | 2900 | 15174 | 1325 | 526 | 16124 | 18151 | 23726 | 23129 | 1282 | 541446 | 1779 | 3562 |
| 79881 | 44496 | 2164 | 16031 | 1255 | 518 | 15417 | 18126 | 25163 | 22617 | 1310 | 544690 | 1734 | 3587 |
| 79947 | 45721 | 2178 | 15597 | 1188 | 512 | 14751 | 18026 | 25845 | 21652 | 1302 | 5187291 | 1620 | 3587 |

The neural network must be trained. Training will take place in the program Deductor Studio Academic based on the input factor indicators and their quantitative values for the period 2010-2020. The training stages of the neural network consist of a step-by-step selection of factor indicators of the development of branches of agriculture. The output parameter will be the desired value of the F function. Input factor indicators were selected in table 1 and filled into the platform. Used software product is a powerful tool for visualization and intelligent analysis of data arrays. To build a neural network model the "Neural Network" handler was used. Each row of the table contains a training example (I1, I2, …, I14 – network input values) and the expected output value (I15).

Based on the training, the neural network builds a statistical table in which the input parameters are evaluated according to criteria such as minimum, maximum, mean, standard deviation, sum, sum of squares [13, 14].

In the program Deductor Studio Academic with the help of the data processor "Neural Network" an array of data is formed, through a neural connection. As a result of such processing, the model builds a prediction of the output parameter in a graphical interpretation. The resulting neural network was built based on input parameters (14 factor indicators and 1 derivative indicator), 3 hidden layer neurons, processing input signals, 1 output neuron (network activity). The graph of the obtained neural network is presented in Fig. 4. In the graph of the perseptron graph we can clearly see input factor parameters of the model and one output parameter I15, which is the required profit value for the future period.

11/11

| I1 | I2 | I3 | I4 | I5 | I6 | I7 | I8 | I9 | I10 | I11 | I12 | I13 | I14 | I15 | I15_OUT | I15_ERR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80617 | 44919 | 2898 | 13953 | 1905 | 662 | 16280 | 18294 | 23075 | 24389 | 1238 | 555827 | 1838 | 3744 | 243459 | 271738,982898396 | 0,00592904859732894 |
| 79993 | 45451 | 1753 | 13666 | 2053 | 692 | 16378 | 18346 | 21924 | 24716 | 1216 | 550169 | 1787 | 3625 | 300913 | 300907,496313972 | 2,24560840981871E-10 |
| 79947 | 45721 | 2178 | 15597 | 1188 | 512 | 14751 | 18026 | 25845 | 21652 | 1302 | 5187291 | 1620 | 3587 | 477567 | 476927,955169975 | 3,02753642135855E-6 |
| 79881 | 44496 | 2164 | 16031 | 1255 | 518 | 15417 | 18126 | 25163 | 22617 | 1310 | 544690 | 1734 | 3587 | 302803 | 302806,078791298 | 7,02727947372372E-11 |
| 79634 | 43585 | 2900 | 15174 | 1325 | 526 | 16124 | 18151 | 23726 | 23129 | 1282 | 541446 | 1779 | 3562 | 300015 | 271741,28333687 | 0,0059264213894258 |
| 79319 | 45051 | 1763 | 12709 | 2128 | 694 | 16974 | 18620 | 21405 | 24606 | 1240 | 543913 | 1764 | 3749 | 333336 | 333343,309305117 | 3,96076346854657E-10 |
| 78525 | 44623 | 1747 | 12232 | 2112 | 684 | 17127 | 18919 | 19451 | 24445 | 1249 | 524252 | 1651 | 3515 | 262397 | 262395,454697261 | 1,77032855251081E-11 |
| 78057 | 43847 | 1979 | 12045 | 2138 | 671 | 17377 | 19679 | 18785 | 23998 | 1287 | 495513 | 1684 | 3153 | 155925 | 131749,228421823 | 0,00433298726215943 |
| 78057 | 44007 | 1979 | 12045 | 2138 | 671 | 17217 | 19272 | 19010 | 24131 | 1266 | 493945 | 1746 | 3210 | 129062 | 131749,226120198 | 5,35346724202181E-5 |
| 75188 | 41889 | 1454 | 10900 | 2212 | 662 | 18071 | 19793 | 17251 | 21733 | 1284 | 449710 | 1626 | 2773 | 110296 | 131750,283761736 | 0,00341235939879697 |
| 75188 | 41889 | 1454 | 10900 | 2212 | 662 | 18071 | 19900 | 17262 | 22726 | 1287 | 473252 | 1650 | 2970 | 131065 | 131750,228282768 | 3,48094599388178E-6 |

**Figure 3**. Training set of factor indicators for training a neural network in Deductor Studio Academic.

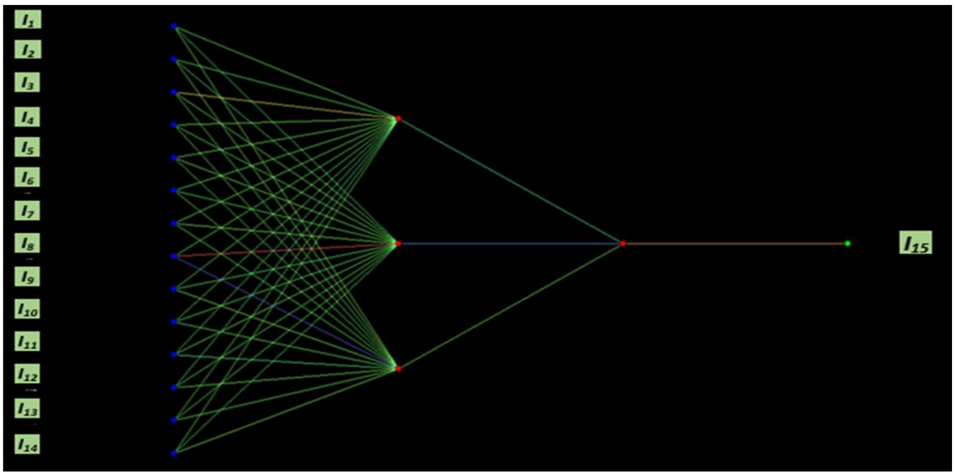


**Figure 4.** Neural network graph.

The next step in building a neuromodel is to assess the reliability of the obtained prediction. For this purpose the scatter diagram is built in the program, which also evaluates the quality of the obtained neural network [15, 16]. The scatter plot is a visual evaluation of credibility and adequacy of the obtained forecast. (Fig. 5).

The forecast will be considered reliable if the deviation of the predicted values from the general line by no more than 5%, i.e. they must be within the confidence interval. In the Deductor Studio Academic analytical platform used, the default confidence interval is assumed to be 5%. In our example, we justify the choice of input parameters by their availability in open public print sources, so the question of the feasibility of existing features and sources is closed. The scatter plot actually evaluates the difference between the calculated results of our function and the values obtained in the program. Evaluation of the scatter plot showed that after training the neural network set such values of weights and thresholds, at which the error is minimized. We can see from Figure 6 that the obtained test set is within the acceptable confidence interval. It means that the model has a high degree of reliability.

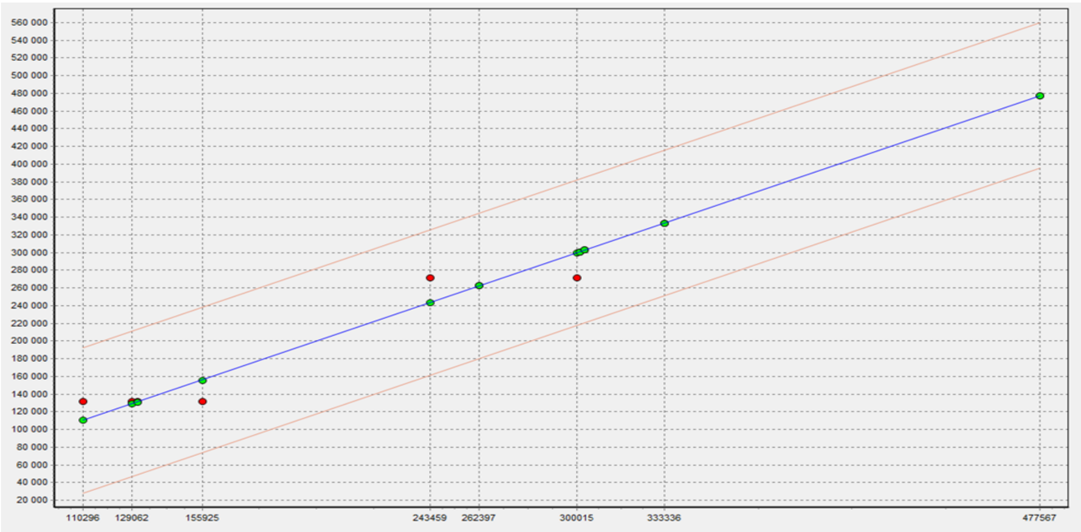


**Figure 5.** The scatter diagram built by the program.

The predicted values for the parameters of interest can be obtained by using the "what-if" function of the neural network.

The application of "what-if" function in neural network modeling allows reaching the forecast value of profit of agricultural enterprises for the perspective of 2 years. Thus, the forecast value of the parameter "Area under crops, "I1" for the second year of the last year in the sample, i.e. in 2022, was 79947 which coincided completely with the actual value in 2020. Therefore, the derived indicator "Profit, "I15" in 2022 will be 476927, which will be higher than in previous years.

In Figure 6, we selectively plotted a diagram comparing the values of the input derivative indicator I15 for the past period and the values calculated by the program with the future forecast. According to the presented graph, we can see that in fact the values of input and calculated parameters coincided over the whole analyzed period. In addition, we observe a clear upward trend of this indicator in future periods.


**Figure 6.** Diagram of comparison of parameters I15 and I15_OUT in the neural network model.

## 3. Conclusion

Russian agro-industrial complex has demonstrated its high sustainable potential for the development and growth in the volume of food production at the period of pandemic and full lockdown. The assessment of the dynamics of production of various categories of food agricultural raw materials shows us that not all sectors grew up during the period under review. The driving force of the agro-industrial complex is the poultry industry that has demonstrated a growth of 1053.46%, which actually meets all domestic needs for poultry and allows to earn additional income from export deliveries of Russian poultry. The positive dynamics of the Russian poultry industry had a positive effect on the overall financial results of the industry, which grew by 332.99% in 2020.

The neural network technology of forecasting the future value of profit of agricultural enterprises is used to demonstrate the capabilities of neural networks in calculating the cost parameters based on the input natural indicators of development. In our study 14 factor indicators of the expansion of the potential of the agroindustrial complex were selected and their impact on 1 derived value indicator of profit was assessed. Based on the results of the analysis of use the analytical platform Deductor Studio Academic, a neural network model of profit forecast for 2022 on the input parameters with the value of 476927 million rubles was built. The built model has a high stability, as all the considered parameters do not go beyond the confidence intervals of the scatter diagrams, the error values are zero in all intervals of the forecast values.

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