Neural network model of interaction between real economy sector entrepreneurship and financial field under risk

Nikolai Ivanovich Lomakin
Volgograd State Technical University
Faculty of Economics and Management
Volgograd, Russia
tel9033176642@yahoo.com

Gennadiy Ivanovich Lukyanov
Volga Polytechnic Institute (branch)
Volgograd State Technical University
Faculty of Engineering and Economics
Volzhsky, Russia
valeriy_volchenko@mail.ru

Natalya Aleksandrovna Vodopyanova
Volga Polytechnic Institute (branch)
Volgograd State Technical University
Faculty of Engineering and Economics
Volzhsky, Russia
vnam@inbox.ru

Anastasia Aleksandrovna Gontar
Volgograd State Technical University
Faculty of Food Technology
Volgograd, Russia
261984@mail.ru

Elena Vyacheslavovna Goncharova
Volga Polytechnic Institute (branch)
Volgograd State Technical University
Faculty of Engineering and Economics
Volzhsky, Russia
svumato@mail.ru

Elena Vyacheslavovna Voblenko
Volgograd State Technical University
Faculty of Economics and Management
Volgograd, Russia
36_5@bk.ru

Abstract - The paper presents a developed neural network model of interaction between entrepreneurship enterprises and financial system. A hypothesis that a neural network makes it possible to simulate the interaction between complex systems and develop a profit forecast for enterprises in the real sector of the economy under risk has been put forward and proved.

Among the main research methods, monographic method, design-constructive procedure and artificial intelligence are to be emphasized. The results include the fact that the theoretical foundations of the interaction between enterprises in the real economy sector and the financial and budgetary systems have been investigated. The factors determining the profitability of the enterprises in the real sector of the economy have been considered. Main interaction dependencies between the economic and financial systems under conditions of market uncertainty have been revealed. The systems of artificial intelligence in business and other spheres have been investigated. The theoretical foundations of the financial risk analysis under conditions of uncertainty have been considered. A neural network model that makes it possible to obtain a profit forecast for enterprises in the real sector of the economy under risk has been developed.

Main conclusions that reflect the results of the study have been formulated. They consist in the fact that in modern conditions it is important to study the issues associated with the further development of entrepreneurship and the real sector of the economy as a whole in conditions of market uncertainty and risk. The studies have shown that it seems appropriate to identify patterns of interaction between entrepreneurship in the real economy and the financial and budgetary systems using artificial intelligence systems. The research has resulted in a neural network model that makes it possible to obtain a profit forecast for enterprises in the real sector of the economy under risk.

Keywords – Neural network model, interaction, entrepreneurship, economy, financial sphere, financial risk, market uncertainty.

I. INTRODUCTION

The relevance of the study lies in the fact that in modern conditions, it is important to study the theoretical foundations of the artificial intelligence systems being applied in entrepreneurship and enterprises of the real economy, as well as to predict the profits of enterprises in risk.

Many Russian and western scientists devoted their work to the study of the problems raised. For example, Baranov E. F. and Bessonov V. A. investigated the issues of the Russian economic transformation, balance of the financial and economic system and sustainable growth in modern conditions [1]; Medvedev D. A., exploring the issues of profitable work...
of enterprises in the real sector of the economy to form a growth trajectory for 2018-2024, outlined the tasks of the economic policy of Russia [2]. Improving the mechanism of fiscal policy is sure to be an important aspect of the proper operation of the financial and economic system. So, Nizhegorodtsev R. M., considering the G. B. Kleiner and M. A. Rybachuk’s point of view in their book “The systemic balance of the economy,” attempted to identify the logic of the systemic paradigm in the economy [3]. Savrukov A. N. et al., assessing the state and level of development of public-private partnership projects in the constituent entities of the Russian Federation, touches upon the issues of improving the mechanism of domestic fiscal policy [4].

Works of many scientists are devoted to the issues of balanced development of the financial and economic system. So, Stoibov M. I. et al. attempted to develop a model of the Russian financial sector on the basis of cross-country analysis [5]. The study of financial risk as the result of the reaction to the changes in the market of modern information financial technologies, as well as implementation of artificial intelligence systems is important in the conditions of growing market uncertainty. For example, Grishankin A. I. et al. developed an algorithm for managing financial risk of an enterprise based on the fuzzy method [6]; Korotina V.A. et al. suggested approaches to managing financial risk based on neural networks and fuzzy algorithms [7], Lomakin N. I. et al. dedicated their work to the issue of identifying ways of sustainable development of enterprises in the region on the basis of artificial intelligence systems [8]. Goncharova N. S. studied the problems of analyzing financial risk in the conditions of the digital economy development [9]. However, despite this, certain aspects of the problem require further research.

Studies show that in modern conditions, neural network models and artificial intelligence systems play an increasingly important role in solving the problems raised, in particular, in forecasting the implementation of regional investment projects [10], studying the systemic impact on the economy of the monetary policy of the RF Central Bank [11], developing the AI algorithm for trading with the SiH8 futures contract on the MoEx based on quantization of big data [12] and in the use of intellectual data in the evaluation of economic security [13].

The aim of the study was to propose and prove the hypothesis that a neural network makes it possible to simulate the interaction between complex regional systems and develop a profit forecast for enterprises in the real economy.

To achieve the goal, the following tasks were set and solved: to identify main factors and interaction dependencies between the economic and financial systems in the conditions of market uncertainty; investigate theoretical foundations of the use of artificial intelligence systems in business and other areas; to consider theoretical basis for financial risk analysis was; and develop a neural network model that enables obtaining a profit forecast for enterprises in the real economy sector under risk.

II. MATERIALS AND METHODS (MODEL)

Based on the statistics used and work results of the financial system, a neural network model was developed. The neural network model made it possible to obtain a profit forecast for enterprises in the real sector of the economy under risk.

The model used the following source data (Table 1).

<table>
<thead>
<tr>
<th>Key</th>
<th>RTS</th>
<th>Brent</th>
<th>S&amp;P</th>
<th>Gold</th>
<th>Sign</th>
<th>Budget</th>
<th>Leans</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 2016</td>
<td>10</td>
<td>991</td>
<td>49</td>
<td>62.83</td>
<td>2051</td>
<td>8.2</td>
<td>1.97</td>
<td>10529.4</td>
</tr>
<tr>
<td>Q1 2017</td>
<td>9</td>
<td>1001</td>
<td>47.9</td>
<td>56.94</td>
<td>2421</td>
<td>5</td>
<td>2.88</td>
<td>8442.7</td>
</tr>
<tr>
<td>Q2 2017</td>
<td>10</td>
<td>1053</td>
<td>50.3</td>
<td>56.36</td>
<td>2411</td>
<td>4</td>
<td>3.08</td>
<td>8442.7</td>
</tr>
<tr>
<td>Q3 2017</td>
<td>9</td>
<td>1053</td>
<td>50.3</td>
<td>56.36</td>
<td>2411</td>
<td>4</td>
<td>3.08</td>
<td>8442.7</td>
</tr>
<tr>
<td>Q4 2017</td>
<td>8.5</td>
<td>1136</td>
<td>57.9</td>
<td>56.79</td>
<td>2516</td>
<td>7.4</td>
<td>2.77</td>
<td>12558.5</td>
</tr>
<tr>
<td>Q1 2018</td>
<td>10</td>
<td>1117</td>
<td>51.8</td>
<td>58.32</td>
<td>2772</td>
<td>5</td>
<td>2.70</td>
<td>17343.2</td>
</tr>
<tr>
<td>Q2 2018</td>
<td>9.5</td>
<td>1136</td>
<td>57.9</td>
<td>56.79</td>
<td>2516</td>
<td>7.4</td>
<td>2.77</td>
<td>12558.5</td>
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<td>2516</td>
<td>7.4</td>
<td>2.77</td>
<td>12558.5</td>
</tr>
</tbody>
</table>

III. RESULTS AND DISCUSSION

The following results were obtained. Main factors and interaction dependencies between the economic and financial systems in the conditions of market uncertainty were studied; theoretical foundations of the use of artificial intelligence systems in business and other areas were investigated; theoretical basis for analysis of financial risk was considered; a neural network model that makes it possible to obtain a profit forecast for enterprises in the real sector of the economy under risk was developed.

The first part of the research results concerned the analysis of financial risk in the process of making a profit resulted from the entrepreneurial activity of enterprises in the real sector of the economy. Dynamics curves of the revenue made by
domestic enterprises for the period from 2015 to 2018 indicated a rather high level of instability of the final result of the Russian economy under the influence of external and internal factors. The level of risk changed temporally upward with subsequent consolidation (Fig. 1).

![Fig.1 Dynamics of profits in the real economy sector, Central Bank key rate and financial profit risk](image)

The analysis showed that the financial earnings risk of enterprises (sigma) in a chronological sequence was unsustainably increasing from the level of 0.4 from the second quarter of 2015 to a maximum of 3.1 followed by consolidation to 2.8 billion rubles, with its average value to be 2.09 billion rubles. Moreover, the declining rate of the Central Bank from 11 to 7.25% can be considered as one of the factorial signs of the consolidation of financial risk in the economic sphere.

The standard deviation is known to be defined as the square root of variance of random variable (1).

\[ \sigma = \sqrt{\text{Var}(X)} \]  

Therefore, the estimate of the standard deviation based on the biased estimate of the variance is sometimes called simply the sample variance. Moreover, the standard deviation is the mathematical expectation of squared difference between the true value of a random variable and its evaluation for a certain evaluation method. In practice, the standard deviation allows estimating how much the values in the set can differ from the mean value. The standard deviation of portfolio returns is identified with the risk of the portfolio. In technical analysis, the standard deviation is used to build the Bollinger lines and calculate the volatility. In a general sense, the standard deviation can be considered a measure of uncertainty.

A. Analysis of factors determining the performance of enterprises in the real sector of the economy

It seemed appropriate to consider the dynamics and include factors that reflect the impact of the external and internal environment over time periods, corresponding to changes in the Central Bank key rate into the neural network model, so that we could realize the patterns of the impact of decisions made in the financial sphere on the economic system, as well as the impact of the volume of loans provided by banks on the profitability of enterprises.

B. Neural network model development

- Application of the Deductor platform resulted in a neural network—a perceptron developed (Fig. 2).

![Fig.2 Perceptron graph](image)

The neural network developed allowed obtaining a profit forecast for enterprises in the real sector of the economy for the next timeframe.

- The structure of the neural network was represented by a single input layer containing such parameters as key rate (KR,%); RTS Index; price of oil (Brent, $); dollar exchange rate (UDS, rub.); US index S&P 500; consolidated profit (billion rubles); sigma or risk (\( \sigma \)); budget revenues (billion rubles); loans provided (billion rubles); and gross domestic product (GDP, billion rubles). In addition, the neural network included two hidden layers and one output with a single parameter, i.e., profit forecast (billion rubles).

C. Formation of the enterprises profit forecast based on the neural network

A) Using the “what-if” function in the Deductor platform allowed obtaining the calculated profit values corresponding to the values predicted (Fig. 3).

![Fig.3 Perceptron graph](image)

The forecast profit value was 2.0995 billion rubles that was less than the actual value of 2.5 billion rubles by 16.02%.

IV. CONCLUSIONS

The investigation claims that the study of the interaction between entrepreneurship and financial system is important in modern conditions and makes it possible to draw certain conclusions.
A. Theoretical basis for analysis of financial risk were considered.

B. Main factors and interaction dependencies between the economic and financial systems in the conditions of market uncertainty were identified.

C. Theoretical foundations of the use of artificial intelligence systems in business and other fields were investigated.

D. It was hypothesized and proven that a neural network makes it possible to simulate the interaction between complex systems and develop a profit forecast for enterprises in the real sector of the economy under risk.

E. A neural network model that enables obtaining a profit forecast for enterprises in the real economy sector under risk was developed. So, the predicted value of profit was 2.0995 billion rubles that was less than the actual value of 2.5 billion rubles by 16.02%.

Acknowledgments

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