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Application of Neural Networks to Studying the Impact of the Russian Central Bank's Monetary Policy

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***Abstract*— The paper presents analysis of the Russian Federation's monetary policy. The Central Bank's key rate is an important parameter. It is hypothesized that the key rate (KR) could be predicted by means of artificial intelligence, a perceptron, the input of which is generated by neural-network quantization. Applying the results of such "smart" analysis to predicting the CBR key rate seems appropriate.**

Keywords*— *perceptron, neural-network algorithm, digital economy, perceptron, the CBR rate, prediction.

I. INTRODUCTION

In the context of increasing market uncertainty when all kinds of risks are amplified, it is important to use artificial intelligence to study the impact of the national monetary policy.

We hereby hypothesize and prove that it is possible to use perceptron to predict the key rate (–the KR") based on quantization-identified patterns.

Analysis has shown that neural networks are important for the economy, where they are used for big data projects, pattern search [1, p. 32-34], or intelligent world GDP forecasts based on ―sft" entrepreneurship factors [2, p. 264-268], etc.

What makes this research relevant is the importance of using artificial intelligence for –smart" big data analysis in predicting the critical parameters of the Russian Federation's monetary policy. The use of artificial intelligence is an important factor that can ensure the sustainable development of the country's economy and finance, as well as stabilize the positive profitability of businesses, which is what makes it an important applied study.

II. RESEARCH MATERIALS AND METHODS

For this research, we used statistical data, macroeconomic parameters of the Russian economy, indices and indicators of the global financial system. During the study, we used such methods as a monographic method, an analytical method, quantization, a design method, and artificial intelligence, in particular a neural network (a perceptron).

Being a decision support system, artificial intelligence enables the dynamic development in the financial sector as well as the sustainable development of regional enterprises. A research team led by S.P. Sazonov has studied some aspects of regional development from the standpoint of using the opportunities of university-provided financial management. [3] From the standpoint of A.A. Polyanskaya, the competitive advantages of a regional university can be seen as factors supporting the regional development strategy. [4] N.I. Lomakin and Ye.V. Loginova analyzed the use of fuzzy algorithms and artificial intelligence in financial risk management. [5] V.A. Ekova et al proposed a systematic approach to enhance the toolset of regional development. [6] Other standpoints have been considered too, including neural network-based data quantization.

To construct a neural-network data quantization model, we chose such parameters as the actual KR, %, RTS, Brent, USD, S&P500, the consumer price indices (I_ipc), the non-consumer goods price indices (I_neprod), the consumer service price indices (I_plat), the consumer food price indices (I_prod). We decided to use the results of –smart" analysis to predict the CBR rate. The neural network was trained on data sampled in 2015-2018, see *Table 1*.

A multi-dimensional chart based on smart data processing can be used to make conclusions on whether there are any patterns determining the CBR key rate. Apparent is the

correlation of the key rate and such factors as RTS, USD, and I_plat.

Based on data quantization, the artificial intelligence computed such value intervals where patterns in these parameters were pronounced. Thus, the following key rate adjustment intervals were highlighted: (1) up to 8.25 (2) from 8.25 to 9.25 (3) from 9.25 to 10 (4) 10+.

Table 1. A fragment of the neural-network input

Дата	КС, %	PTC	Brent	USD	S&P500	I_ipc	I_neprod	I_plat	I_prod	КС(прогн), %
с 23 марта 2018 г.	7,25	1261,44	70,51	57,1658	2622	100,31	100,3	100,08	100,5	7,25
с 12 февраля 2018 г.	7,5	1285,47	65,78	56,32	2714,5	100,21	100,13	100,12	100,35	7,5
с 18 декабря 2017 г.	7,75	1154	66,87	57,61	2676	100,42	100,31	100,32	100,6	7,75
с 30 октября 2017 г.	8,25	1113	61,37	58,32	2572	100,2	100,3	99,8	100,38	8,25
с 18 сентября 2017 г.	8,5	1136	57,54	56,79	2516	99,85	100,25	100,12	99,29	8,5
с 19 июня 2017 г.	9	1001	47,92	58,94	2421	100,61	100,11	100,68	101,02	9
с 02 мая 2017 г.	9,25	1053	50,31	56,56	2411	100,37	100,15	100,35	100,59	9,25
с 27 марта 2017 г.	9,75	1113	52,83	56,26	2359	100,13	100,22	100	100,14	9,75
с 19 сентября 2016 г.	10	991	49,06	62,83	2051	100,17	100,56	100,09	99,86	10
с 14 июня 2016 г.	10,5	931	49,68	63,97	2090	100,36	100,46	100,56	100,12	10,5
с 03 августа 2015 г.	11	833	54,15	64,28	1969	100,35	100,75	101,27	99,34	11

Based on this input, we used Deductor to generate a neural network for big data quantization, see *Figure 1*.

Figure 1. Quantization results (a fragment)

Studies have shown that neural networks are important for economics, where there is need for big data processing, pattern search, etc.

At the next stage, we chose and trained a neural network (a perceptron) using these data as a training set. The perceptron was generated and trained to accurately predict the key rate using the *what if* function.

Russian scientists, we believe, have achieved the most in this respect. For instance, V.A. Vasilyev, A.F. Lyotchikov, and V.Ye. Lyalin proposed using real options as risk assessment and hedging tools for businesses in the real sector of economy. [7]

For the purpose of risk assessment and minimization, some non-Russian researchers have proposed using a wide range of tools of financial mathematics, including quantile hedging, minimum deficit risk hedging, as well as optimal quadratic hedging. [8]

Use of the Green City budget optimization NN-based algorithms for attaining sustainable regional development, particularly that of the town of Volzhsky, was covered in papers by V.A. Kabanov and L.N. Medvedeva. [9] It is important to study the dynamics of stock-exchange financial instruments.

Application of predictive modelling to assess the investment attractiveness of regions based on data quantization was studied by A.F. Moskovtsev, A.F. Kopylov, I.A. Samorodova, and S.P. Sazonov. [10] K.S. Dontsova and Yu.A. Chebotareva developed a neural-network model to plan the budget revenue of an urban district. [11]

External factors including the value of the dollar to the ruble do affect the company's financial parameters that determine the CBR rate. It seems useful to identify patterns by means of big data quantization, i.e. the input parameters to generate a set of input factors for the neural network.

III. CBR Rate Prediction Perceptron

A. *Creating the AI*

It was hypothesized that the key rate (KR) could be perceptron-predicted.

We used Deductor to find certain patterns based on processing big data by quantization input parameters; these patterns were used in the neural-network model.

Based on the analysis of parametric dynamics, we generated the ~~r~~ules" of a simple neural network and create a neural-network model, a perceptron, see *Figure 2*.

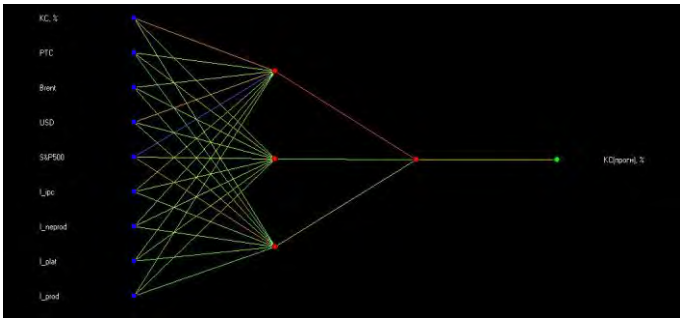

Figure 2. Perceptron graph

The *what-if* function was used to predict the CBR key rate, see *Figure 3*.

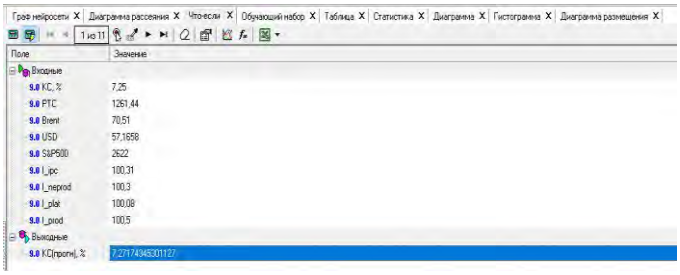

Figure 3. CBR key rate prediction

For the current economic conditions described by the input parameters of the neural-network model, the computed value was 7.2717%, which is 0.00217 points above the CBR rate. Thus, in the current macroeconomic situation, the CBR rate had to be increased by 29.23% = 0.00217/7.25*100.

IV. Results and Discussion

The created perceptron has demonstrated a high prediction accuracy.

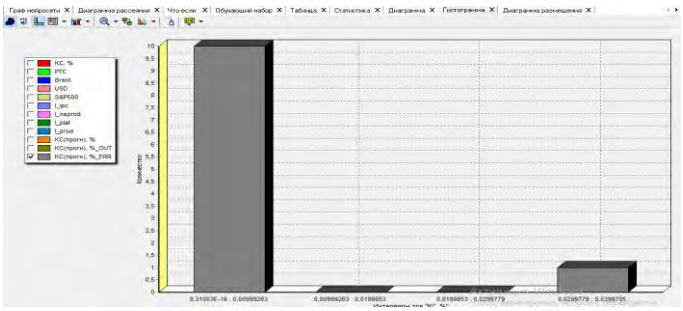

Figure 4. Interval distribution of prediction error

The neural network model used appropriate weights that had a certain effect on the output of the created AI system representing the authors' know-how.

It must be noted that AI is finding ever greater use in many applied tasks, e.g. there is an AI model to predict the stock-exchange price of a financial instrument [12], a neural network for predicting the completion of regional investment projects [13], a neural network to ensure business profitability [14], an AI system for analyzing the foreign trade turnover of Russia and Vietnam [15], AI as a tool for efficient banking operations [16], neural networks to predict the Bitcoin value [17], big data quantization of regional investment business projects [18], etc.

Of merit are studies that have produced Rospatent-patented programs, such as the neural network for market depth analysis [19], the neural network for business bankruptcy risk assessment [20], the neural network for global-economy big data quantization [21], the neural network for correlation analysis of big enterprise data in a global economic context [22], the NN-based combat stock trading robot [23], the neural network for predicting the profits of an insurance company [24], the SOM for generating an efficient investment strategy to develop the regional IT market [25].

Based on research results, we may conclude that:

- first, the hypothesis is validated as big data quantization with a neural network does identify the factors affecting the CBR key rate;

- second, the perceptron has computed a fair key rate of 7.2717%, which is 0.00217 points above the CBR rate.

A. Output of the NN-model (perceptron)

- The generated NN model is a simple model, in which weights are adjusted by backpropagation of error.
- Our analysis shows the mean error is within 5%.
- It is therefore confirmed that AI can be used to create an algorithm for calculating the predictive CBR rate value.
- The concept of ―sustainable business development" is to some extent derivative of the successful national monetary policy, where the Central Bank's key rate is of essence.

CONCLUSION

We therefore conclude that the concept of ―sustainable business development" is to some extent derivative of the successful national monetary policy, where the Central Bank's key rate is of essence.

Experience shows that AI systems are innovative tools that help make the right managerial decisions in the context of market uncertainty.

We may therefore conclude that dynamic sustainable development of a real-sector enterprise is impossible without AI. It is important to create innovative products, the AI systems for the sustainable regional development in the context of a nascent digital economy.

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