Advances in Economics, Business and Management Research, volume 128
International Scientific Conference "Far East Con" (ISCFEC 2020)

AI-System of Stock Exchange Trading Robot for Financial Risk Hedging

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Abstract. The article considered the theoretical basis for the calculation of financial risks, their hedging with the help of artificial intelligence. The article presents a neural network for the assessment of financial risk for atime sequence of VAR-methods with a view to mitigate it when engaging in stock exchange trade.
A hypothesis was formulated and proved that with the help of the developed AI-system that had been taught on the basis of a combined data sample with digitilized "new fluctuations" information from web-sites and time sequence candlestick charts for SiU9 US Dollar futures contracts in a 15-minute timeframe, it is possible to increase the accuracy of a futures price forecast and ensure the assessment of financial risks using the VAR-method for hedging an uncovered position with a PUT option.
As is shown by scientific research, today the majority of stock operations are conducted using trade systems, or trade robots, and their number is continuously increasing. Among trade systems, we can single out the ones using artificial intelligence (AI).
The novelty of the research results from the fact that in order to forecast the price of a futures contract, both candlestick charts parameters and size and digitilized "news fluctuations" received by Skraper programme from web-sites were used to teach the neural network. The created data set was used in the perceptron with 305 parameters in the input layer, 2 hidden layers by 100 10 parameters correspondingly and an output layer with one parameter, the target price. The perceptron was created and used on the Deductor platform, and the Python -based Skraper programme was put into Spark framework and was employed with the help of parallel calculations.
The results yielded by the neural network were analysed concerning the accuracy of the forecast of the price of a financial instrument, a SiU9 futures contract at MoEx, a Russian stock exchange, when working in a 15-minute timeframe. The hedging mechanism for an uncovered long position of a SiU9 futures was activate by buying two PUT Si-9 options with an increasing risk parameter that had been calculated using the VaR-method.
As a result of the conducted research, a neural network trade algorithm was created for speculative trading at the stock exchange with a SiU9 USD futures contract with high accuracy and minimal loss risks.

1. Introduction

The research is relevant because a hypothesis has been formulated and proved that with the help of a developed artificial intelligence system taught on the basis of a combined data sample with digitilized "new fluctuations" information from web-sites and time sequence candlestick charts for SiU9 US Dollar futures contracts in a 15-minute timeframe, it is possible to increase the accuracy of a futures price forecast, and, on the basis of the financial risk assessment with VaR-method, to use the mechanism for hedging the uncovered position of SiU9 futures by buying (and then selling) two PUT options.

The practical benefit of the research arises from the fact that financial risks are mitigated both thanks to increased accuracy of neural network forecast of a SiU9 futures and to risk hedging through buying PUT options when the relevant signal comes from the VaR-model.

Artificial intelligence systems (AISs) are important for risk hedging with a view to forecast the price of a SiU9 futures contract.

According to scientific research, today the majority of stock operations are conducted using both mechanical trade systems and digital trade robots. Experts indicate the increasing share of algorithmic trading.

2. AI-system of stock exchange trading robot for financial risk hedging

2.1. Research of assessment theoretical basis and financial risk mitigation

As is well known, the idea of getting liquidity through stock exchange operations is not new and involves considerable risk. There have been some authors who studied some aspects of the problem. For example, N.Lomakin saw stock exchange operations as a growth factor in investment activities of a company in the real sector of economy [1] and also researched issues related to the use of stock exchange trade robots in the information-focused society [2].

A group of authors headed by S.Sazonov studied some aspects of sustainable development under the conditions of risk and market uncertainty from the point of view of employing the potential of financial management [3]. A.Polyanskaya believes that competitive advantages are essential [4]. N.Lomakin and E.Loginova [5] analysed the future of fuzzy algorithms and artificial intelligence systems in risk management of the financial system in the Single Economic Space. V.Ekova, O.Maksimova, N.Lomakin have proposed to improve the system of risk management tools on the basis of systemic approach [6].

V.Vasiliev, A.Letchikov and V.Lyalin made a significant contribution into the research of financial risk management by proposing the use of real options as a tool to assess and hedge risks for companies in the real economy sector [7].

It is feasible to use the common methodology of financial risk evaluation. Actually, a risk is a variation (dispersion), and it is feasible to show it as a root-mean-square deviation.

The root-mean-square deviation is calculated applying the following formula (1)

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(r_i - \bar{r})^2}{n}}, \quad (1)$$

Where σ is the risk;

r, r_i is the return of a financial tool in a basic and i-period;

n is the number of periods

The following models are widely used for financial risk assessment, for example: VaR, SaR, GARSH, etc. In order to assess and minimize financial risks, some foreign experts introduced a broad range of financial math instruments, including the following: quantile hedging, hedging with minimum deficit risk and also squared optimal hedging [8].

In practice artificial intelligence systems are used more and more frequently in all the areas of human activities, including risk assessment, financial asset price forecasts in a time sequence, etc. For

example, sustainable development of companies in a region on the basis of neural network profit forecast model was researched by N.Lomakin, A.Polyanskaya and E.Kharlamova [9].

The trend analysis by Sengupta, S. Basak, P. Saikia, S. Paul, V. Tsalavoutis, F. Atiah, V. Ravi and A. shows that there is a possibility to single out several practical areas for Hadoop, a distributed computing environment, and convolution neural networks [10]. Faster distributed computation is another trend in the developing area [11,12,13]. Improved deep learning of convolution neural network is another important direction of development [14, 15, 16, 17].

The study of the speed of convolution by the authors [18, 19, 20] is important. We should also point out such authors as A. Serb and T. Prodromakis who researched various levels of abstraction for artificial intelligence [21]. P. Karimi, M.L. Maher, N. Davis, and K. Grace also deserve our attention; they used computing models, for example, deep learning in the computing model for concept shifts in the system of joint design creation [22].

The theoretical basis was studied for practical usage of artificial intelligence systems in big data processing [23]. Among the existing programmes, the variety of platforms and tools[24, 25, 26, 27], a wide range of tools for data analysis and machine learning was studied [28, 29, 30, 31].

The study of algorithms conducted by the authors on the basis of smart data analysis has a major significance [32]. We should also mention the research carried out by such scientists as J. Liu, S.J. Gibson and M.Osadchy, who showed that deep learning has a good productivity level, when big tagged data sets are used [33]. For example, the research by N.Udomsak on the use of computing models is noteworthy: Naive Bayes classifier and reference vector mechanism compare their abilities to make stock exchange forecasts for Thailand [34]. P. Shiralkar, A. Flammini, F. Menczer and G. L. Ciampaglia said that you should find flows in knowledge graphs to support facts checking [35].

A comparative analysis of the Hadoop platform and the Deductor analytical platform was carried out.

As is known, hedging is an insurance against financial risks through taking an opposite position on the asset in the market [36]. A trader can buy a long futures contract, for example a SiU9, and then buy two PUT options under the condition that the option strike is traded (Fig. 1).

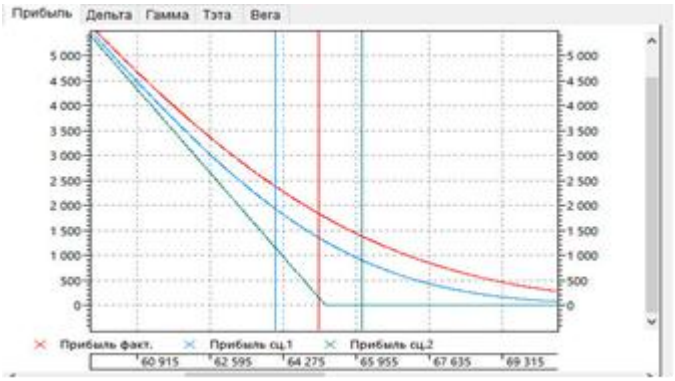


Figure 1. Hedging a risk with a PUT option.

The time sequence of quotations for a SiU9 USD contract in a 15-minute timeframe in MoEx has a moderate volatility (Fig. 2)

Figure 2. Time sequence of quotations for a SiH8 USD contract in a 15-minute timeframe.

The research has shown that it is impossible to forecast the price of a financial instrument when only history parameters of a time sequence are used. It has been shown that news, or "news vibrations," are among the factors of the external environment that affect the US dollar exchange rate.

Neural network learning used both the parameters of candlestick charts, the size and digitilized "news vibrations" were used that had been collected by the programme Skraper from web-sites. The created data set was used in the perceptron with 305 parameters in the input layer, 2 hidden layers by 100 and 10 parameters correspondingly and an output layer with one parameter, the target price.

2.2. The employed methods

The paper studied the following research methods: monography, calculation, machine data collection with the help of Scraper and further digitilization (300D vectoring) of the words with Word2Vec in Apache Spark, a framework with open initial code for distributed processing, Python software engineering, an AI-system on the Deductor platform, Big Data quantization, VaR-method for financial risk evaluation.

3. Results and discussion

3.1. Iperceptron for siu9 futures contract price forecast (AI engineering)

We believe it is feasible to identify certain patterns in the behaviour of the studied features on the basis of BigData quantization, in particular the size, a parameter of the time sequence for a SiH8 futures contract price that depends on the closing price and X300 news factor (Fig. 3).

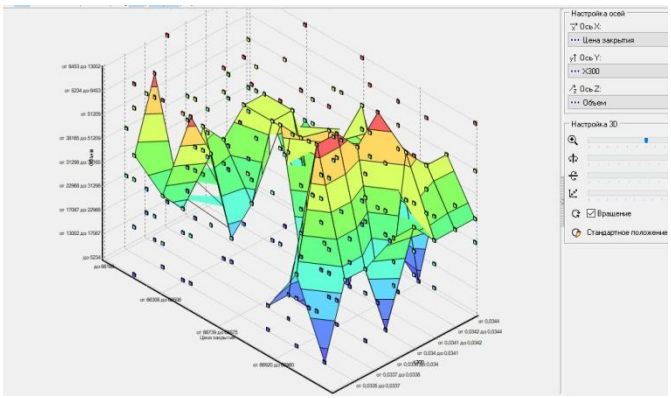


Figure 3. Results of data quantization for a SiH8 USD futures contract.

The collected data shows that there are certain non-lineal functions between the analysed factors: closing price – Pc, trade size – V, X300 indicator. It is essential to take this fact into account in an AI-system.

The programme Skraper was developed for the collection of news parameters, and its function chart is shown in Fig. 4.

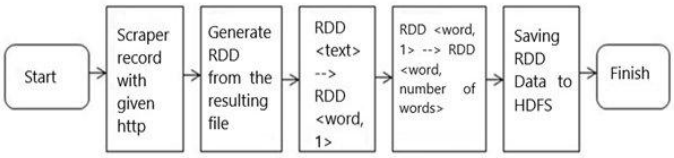
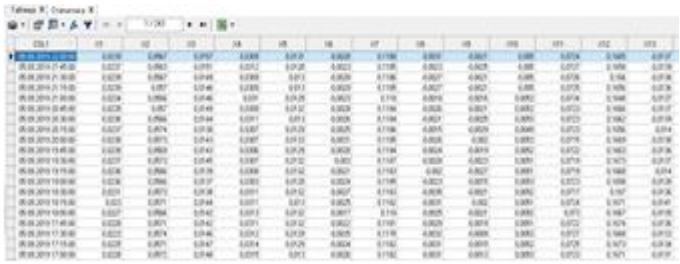


Figure 4. Function chart for data collection from news web-sites.

Words preliminary collected by Skraper from news web-sites were then uploaded into Word2vec software, and sent to the input layer of the perceptron model as 300 numeric values. These numeric values were supplemented by candlestick charts' parameters: opening price, minimal price, maximum price, closing price and the size of QUIK trade terminal. The input parameters of the model are shown below (Table 1).

Table 1. A fragment of the input data for the neural network.



After the collected data were processed, a learning (95%) and a test (5%) set for the neural network were created, and a neural network model was developed, a perceptron on the Deductor platform (Fig. 5).

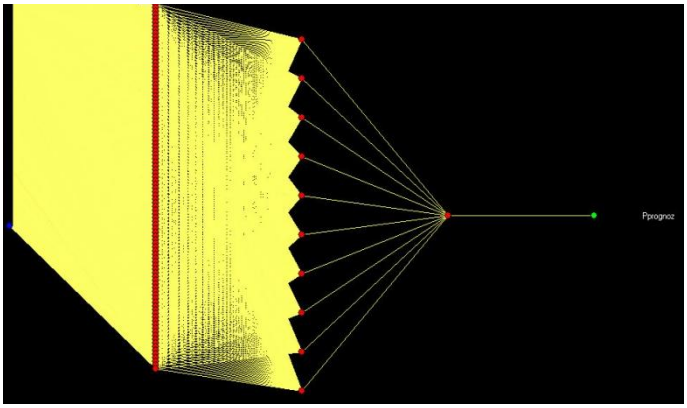


Figure 5. Perceptron graph.

An assessment of financial risks for a futures contract was carried out on the basis of a VaR-model.

3.2. The development of a VaR-model for financial risk assessments

A distribution bar chart for frequency and probability integral value are demonstrated in the chart (Fig. 6).

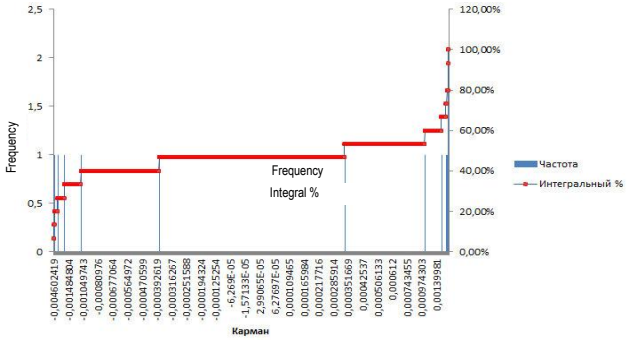


Figure 6. Chart of a VaR-model of financial risk assessment.

The fluctuations of relative values of the VaR-model risk for SiU9 for 15-minute timeframes are calculated for VaR(t+1) 0,001848603 timeframe and for VaR(t+5) 0,004128889 timeframe. However, at 99% probability of absolute losses the risk for further considered timeframes does not exceed 11.8 and 26.4 rubles correspondingly. The AI-model employed together with the hedging instrument allows to achieve a high result. For example, in the analysed period of 5 working days from 30 August 2019 4:15 pm to 5 September 2019 10:00 pm, the average profitability per one calendar day was 32.01% (less the fees).

The results of the perceptron are shown in Figure 7.

Figure 7. Deposit increment curve.

The AI system showed positive profitability for 1558 timeframes during the time of the experiment.

In order to trade one SiU9 futures contract you need to have a minimal sum on the broker account, or a security deposit, we will further refere to it as the Capital, or K=4059.35 rubles. When the algorithm was tested on the basis of historical data in the analysed period, positive margin, or profit was achieved. Profitability of the initial deposit was 32.01% per day.

The research has shown that the accuracy of the forecast is high, and deviations of the target price of SiU9 from the real ones are negligible (Fig.8).

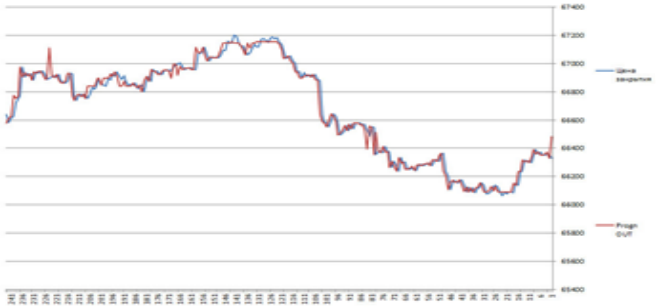


Figure 8. The curve of the target and actual SiU9 prices.

The created digital neural network model, or the perceptron, has proven its high profitability thanks to the high accuracy of the forecast for every 15-minute timeframe. For example, the error mean value (deviation forecast - actual value) was -0.48 rubles, or -0.00007 (Table 2).

Table 2. Actual and target siu9 values.

Date/Time	***Pa***	***Pt***	***(Pa-Pt)***	***Error (σ)***
05.09.19 22:00	66322	66483.54	151.54	0.2285
05.09.19 21:45	66355	66332.14	-22.86	- 0,0344
05.09.19 21:30	66360	66374.74	14.74	0.0222
…	…	….	…	…
Min	6728.9	6376.16	-92.92	-0.0138
Max	6341.9	6673.79	82.19	0.0129
Midl	6557.47	6557.00	-0.48	-0.00007

In order for the neural network to get the target price, the function "what-if" is used in the Deductor (Fig. 9).

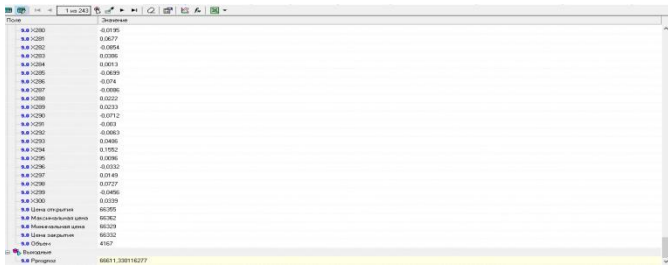


Figure 9. Calculation of the target prices using the function "what-if".

We must say that artificial intelligence systems are used more and more frequently to solve many practical problems, for example, an AI model for forecasting crypto-currencies exchange rates, for example Bitcoin [49], is employed to study the issue of risk optimization [50], etc.

We can come to the following conclusions based on the presented research.

- The formulated hypothesis was proved that with the help of the developed AI-system that had been taught on the basis of a combined data sample with digitilized "new fluctuations" information from web-sites and time sequence candlestick charts for SiU9 US Dollar futures contracts in a 15-minute timeframe, it is possible to increase the accuracy of a futures price forecast and ensure the assessment of financial risks.
- The fluctuations of relative values of the VaR-model risk for SiU9 for 15-minute timeframes are calculated for VaR(t+1) 0,001848603 timeframe and for VaR(t+5) 0,004128889 timeframe. However, at 99% probability of absolute losses the risk for further considered timeframes does not exceed 11.8 and 26.4 rubles correspondingly.
- The AI-model employed together with the hedging instrument allows to achieve a high result. For example, during the analysed 5-working day period, the income was 32.01% per one calendar day on average.

4. Conclusion

The research has shown that the following models are widely used for financial risk assessment, for example VaR, SaR, GARSH, etc. In order to assess and minimize financial risks, some foreign experts introduced a broad range of financial math instruments, including the following: quantile hedging, hedging with minimum deficit risk and also squared optimal hedging.

The practical usage shows that the study of algorithms on the basis of smart data analysis that has been conducted by the authors has a major significance.

Thus we can conclude that it is impossible to ensure dynamic sustainable development of a company without artificial intelligence systems. It is essential to create an innovative vector of sustainable development in regions on the basis of AI.

The hypothesis was proved that with the help of the developed AI system it is possible to increase the accuracy of the SiU9 futures price and ensure the assessment of financial risks using VaR-method for the purposes of hedging of the uncovered position with a PUT option. The developed AI system based on historical data yielded great results with the returns on the deposit of 32.01% per day.

5. Acknowledgments

The article has been funded by Russian Foundation for Basic Research (RFBR) "Development of innovation and investment policies as a concept of strategic economic security in agricultural organizations in the era of modern technological transformation" 19-010-00985 A.

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