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ARTIFICIAL INTELLIGENCE MODELS SUPPORTING ECONOMICAL DECISIONS COMPARED TO TRADITIONAL DECISION MAKING STRATEGIES IN THE EXAMPLE OF STOCK MARKET

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Purpose: Analysis available solutions and artificial intelligence model proposals supporting stock market decisions.
Design/methodology/approach: Analysis of technical and mathematical techniques for stock market investments. Determining the chart movement for the company over the short term.
Findings: Currently, there are many mathematical and technical solutions that effectively help investors with decision-making. The model is able to obtain information about the direction of the stock price (whether it is rising or falling) for a very short period of time.
Research limitations/implications: further development of the Long Short Term Memory model and analysis of the development of existing tools.
Practical implications: Proposing various methods of analyzing the stock exchange, so that they can help in making decisions. Proposing your own model to support stock market investments.
Social implications: Plenty of investors, consequently a large group of recipients.
Originality/value: Stock market analysis, both mathematical and technical. Moreover, a proposal of your own neural network.

Keywords: neural network, stock market prediction, investment management, technical analysis, mathematical analysis.

Category of the paper: Research paper.

1. Introduction

Investing in stock markets is not only a popular and sufficient way of earning money but it is also a determinant of company's prestige. If a company has its stocks in the market it is considered successful. Successful investors on the stock exchange primarily approach the subject of finance with cold blood and distance, and the basic goal of each stock exchange is "to buy cheap and sell dear". Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models developed by experienced brokers, including the RSI indicator, the ROC change indicator, CCI and stochastic oscillators, or the MACD curve (Anghel, 2015). These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues. In addition, the paper proposes an Long Short-Term Memory (LSTM) model for predicting stock market price. Long Short Term Memory is a specialized RNN. LSTM network can learn long term because this model use of a mechanism called gate. Consequently, this model was proposed to predict stock market prices. the model predicts the direction of the action for a short period. Future work on the project aims to develop the network to the state of predicting very low stock prices.

2. Stock a Market Analysis

The subject of voting is very common with society, we have contact at every stage of life, and at the same time it is related to the progress of its spheres. The basic operations on the accounts are performed by the given operation The world of finance and economics, we introduce ourselves and complexes. Every day new transactions, directions of development and movement in the company. Due to the high complexity of blocking metals on the stock exchange, whether it is to ensure a fairly high, it is possible without the possibility of introducing a broker. The continuous development of technology and the situation on the stock market additionally increases this threshold. Initial investors are terrified of the stock of knowledge that the beginning will be taken after treat only with a treat. Despite the many difficulties and problems they have, it is difficult to find a location on the stock exchange, you will not be discouraged. According to the data from the analysis carried out ("The analysis of stock market investments in the us", 1999-2021) the share of people participating in the session on the US stock exchange in the years 1999-2020 is more than half. The result analysis is showed on the figure 1.

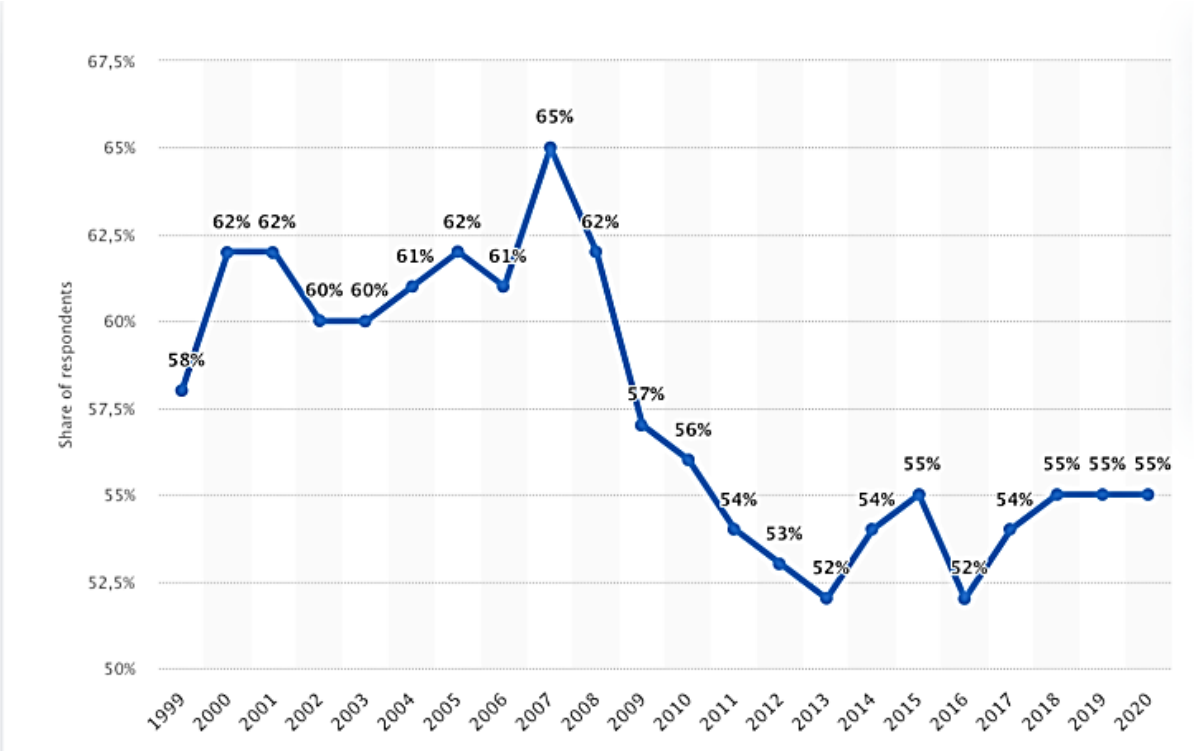

Figure 1. The analysis carried out by Statista.com about the share of people participating in the session on the US stock exchange in the years 1999-2020.

Source: The analysis of stock market investments in the us 1999-2021.

Stock prices are influenced by many factors, so predicting future prices is difficult and investments can be risky, therefore a wide area of research is predicting future stocks in the stock market. Investors must acquire not only basic knowledge about the companies in which the stocks want to invest, but also learn the basics of economics. In addition, they must learn how to draw a trend line and determine whether it is falling, upward or without clear directions of changes, what is the support and resistance point, they must understand the dependence of the price on the trading volume, so as not to make an investment mistake from the very beginning. Successful investors on the stock exchange primarily approach the subject of finance with cold blood and distance, and the basic goal of each stock exchange is "to buy cheap and sell dear". Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models (Nti et al., 2019) developed by experienced brokers, including the Relative Strength Index called RSI indicator (Alhilfi, 2019), the The Price Rate of Change (ROC change indicator), Commodity Channel Index (CCI) and Stochastic Oscillators (Wu et al., 2015), or the Moving Average Convergence Divergence (MACD curve). These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues.

One of the approaches to investing is so called technical analysis (Graham, 2006; Murphy, 2006). It bases on analyzing candlestick charts or bar Open-high-low-close charts (OHLC chart). Every candle is composed of a body and a knot. The body is either black when the price

is descending and white when its ascending. The color is important because white candles should be read from the bottom to the top whereas black candles should be read from the top. The ends of the candle inform about the opening price. The presence of a knot informs whether the price was above or below the opening value.

The simplest candle formations (Lempart et al., 2013; Bulkowski, 2011) are single figures doji or marubozu. Doji in general is the knot with a thin body. There are four types of doji star, longleg doji, gravestone doji and dragonfly doji (fig. 2). Marubozu is in fact just the body of the candle it can be black when the price is descending or white when it is ascending. Candles occurring one after another are creating a candle formation. The formations are informing whether the current trend is going to continue or is it being reversed. That is why knowledge about candle formations are the key to make an accurate investment (fig. 2).

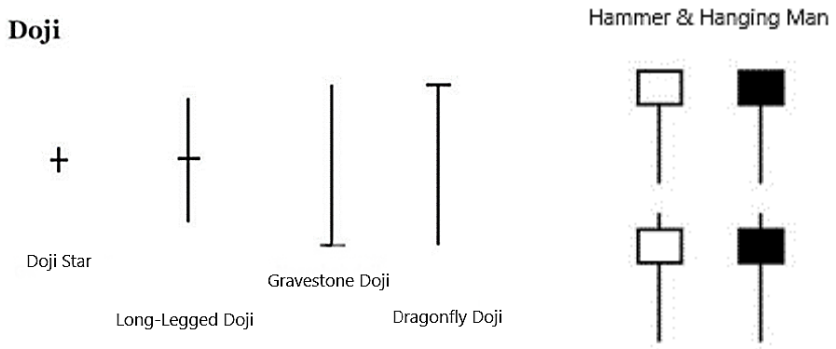

Figure 2. Example of doji and candles.

Source: Measuring and managing market risk.

Doji with a square marubozu is called the hammer when the marubozu is black and the hanging man when marubozu is white. It informs about reversing the trend. An example of more complex formation is the formation of three white soldiers or its opposite the three black crows (fig. 3). It often appears after consolidation period or a correction as three candles with the closing price higher at every candle. This formation informs about continuation of the trend.

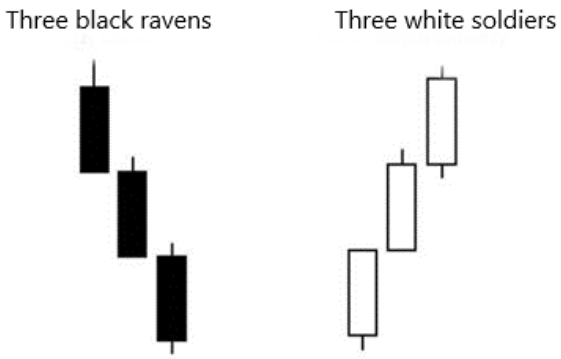

Figure 3. Architecture of Long Short Term Memory.

Source: Edukacja giełdowa.

A formation even more complicated than three white soldiers is the bull market triangle. It consists of five candles. After first white marubozu the correction is made with three smaller black candles with the closure price lower with every following candle. These three have to be in the range of opening and closure of the first. At the end there is an another white marubozu with the closure value higher than the first one. The opposite to this formation is the bear market triangle. On the other hand there is also a more scientific approach which is the mathematical analysis. The mathematical analysis (Han et al., 2021) is using a wide range of mathematical tools and operations. An example of the use of the mathematical approach is multiple regression analysis. It is a statistical technique used to analyze the relationship between a single dependent variable and several independent variables. Using this method it is important to determine these variables:

- all time low and all time high price,
- trading volume,
- market cap,
- circulating supply.

These are considered as the independent variables. Now the dependent variable which is the stock price is modeled using the values of independent variables. The seasonality analysis is another example of investing strategy. By analyzing data from few years back the investor is creating a seasonality plot. Then the statements for example "Bitcoin price reaches the highest value in may" are made. Using the set of statements the investor decides whether he is buy in or selling stocks.

3. Solution

Long Short-Term Memory (Moghara et al., 2020; Moghar et al., 2020) is a specialized Recurrent neural network (RNN). The general difference between an LSTM unit and a standard RNN unit is that the LSTM unit is more elaborate and sophisticated. A recursive neural network (RNN) is a class of artificial neural networks in which the connections between nodes form a directed or undirected graph along a temporal sequence. This allows him to exhibit dynamic behavior over time. In addition, the LSTM network possesses the gates that regulate better the flow of information inside the network. LSTM networks are useful for predictions based on time series data, also classifying, and processing. LSTM network can learn long term, because this model use of a mechanism called gate (fig. 4). Gate are learned to decide which information in the sequence should be kept and which should be erased. LSTM network has three gates; entrance, forget and exit. The three gates control the flow of information into and out of the cell, and the cell remembers values across arbitrary time periods.

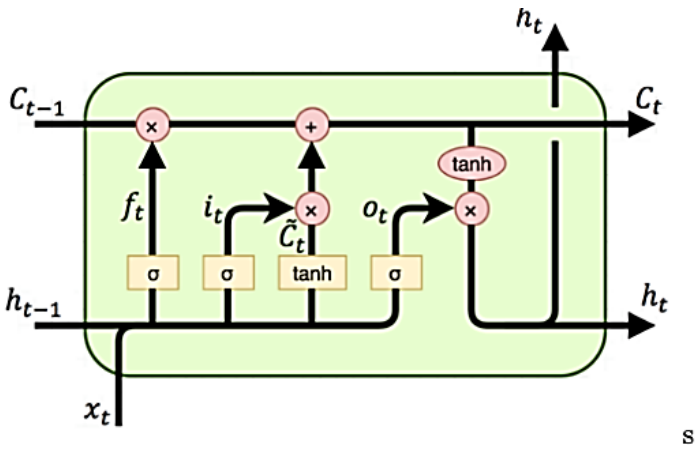

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Figure 4. Architecture of Long Sort Term Memory network.

Source: LSTM architecture.

Stock prices are defined by several different values. They are:

- Opening value - the opening price of the stock of the day,
- Closing value - The closing price of the stock of the day,
- High - The highest stock price,
- Low - the lowest stock price for the day,
- Volume - the number of shares of a security traded in a given period.

The 3-layer neural network (fig. 5) based on the Long-Short Term Memory model, calculating the future share price. Input 3D (X, y, time_steps), where:

- X - is a dataset consisting of High, Low, Close,
- y is a dataset consisting of Open,
- time steps - input price prediction period,

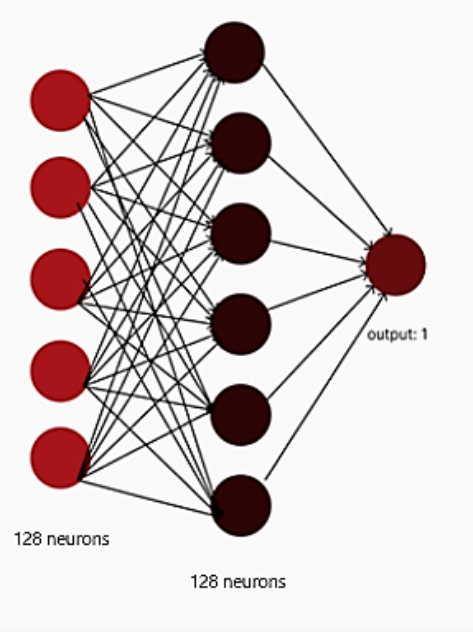

Figure 5. Scheme of the Long Short Term Memory neural network.

Source: own work.

The figure 6 presents the results of the propose neural network for Apple Inc. data. We can notice that both the proposed results and the current results of the Apple company initially drop, then rise and then they drop again.

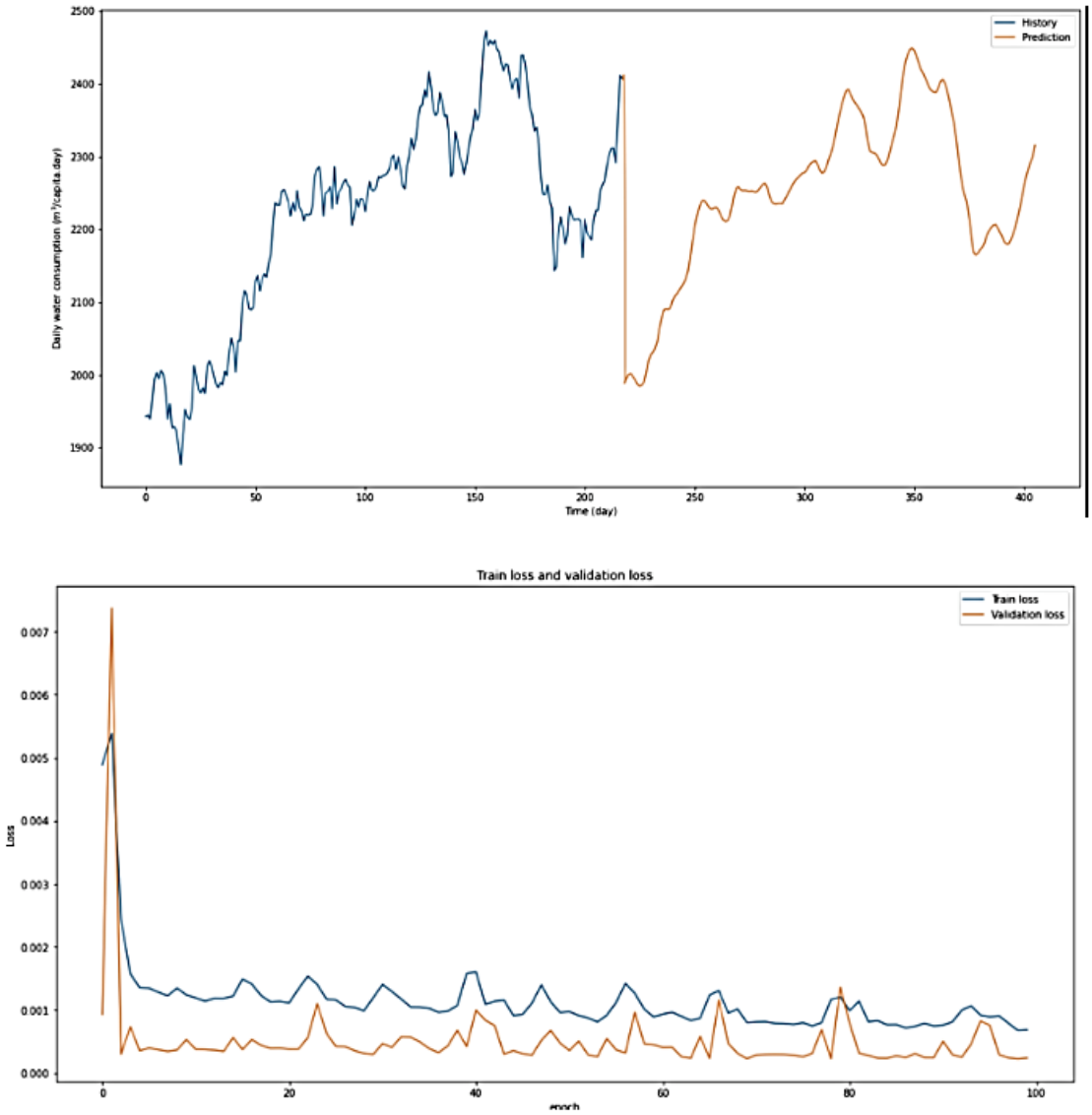

Figure 6. Prediction results for a period of 3 days and result of the accuracy.
Source: own work.

The similar experiments were performed for days 1, 3, 5, 7, 14, 30. The LSTM model achieved the best results for predicting prices three days in advance. During the research, it was noticed that the neural network for the period of which the timely show of the action, the direction of the share price (whether the price will fall and fall).

4. Conclusion

The paper contains an overview of the existing solutions of the mathematical and Isaac technical analysis of the exchange. One of the approaches to investing is so called technical analysis. It bases on analyzing candlestick charts or bar OHLC charts. Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models developed by experienced brokers, including the RSI indicator, the ROC change indicator, CCI and stochastic oscillators, or the MACD curve. These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues. Additionally, a model of a neural network for stock exchange prediction has been proposed. The LSTM model is good at dealing with data series, therefore it is an ideal choice for the problem of prediction of market prices. The model has a long and short-term memory, thanks to which it produces correlations between the data. The similar experiments were performed for days 1, 3, 5, 7, 14, 30. The LSTM model achieved the best results for predicting prices three days in advance. Future work on the project aims to develop the network to the state of predicting very low stock prices.

References

1. Alhilfi, M. (2019). Role of using the relative strength index in making speculation decision in stock applied research in the Iraq stock exchange. *International Journal of Academic Research in Accounting, Finance and Management Sciences 9, 1*.
2. Anghel, G.D.I. (2015). Stock market efficiency and the MACD. evidence from countries around the world. *Procedia Economics and Finance, vol. 32,* pp. 1414-1431.
3. Biznesradar.pl Formations. Retrieved from: https://www.biznesradar.pl/formacja-swiecowa/trzech-bialych-zolnierzy#:~:text=Formacja%20odwr%C3%B3cenia%20trendu%20spadkowego.,jest%20kurs%20powy%C5%BCej%20trzeciej%20%C5%9Bwiecy, 1.06.2022.
4. Bulkowski, T. (2011). *Analiza formacji na wykresach giełdowych*. Warszawa: Linia.
5. Cfainstitute. *Measuring and managing market risk*. Retrieved from: https://www.cfainstitute.org/en/membership/professional-development/refresher-readings/measuring-managing-market-risk#:~:text=Market% 20risk%20is%20the%20risk, exchange%20rates%2C%20and%20commodity%20prices, 1.06.2022.

6. Edukacja giełdowa. *The Basic information on candle formation*. Retrieved from: https://www.edukacjagieldowa.pl/gieldowe-abc/analiza-techniczna/narzedzia-analizy-technicznej/formacje-swiecowe-odwrocenia-trendu/, 1.06.2022.
7. Graham, B. (2006). *Inteligentny Inwestor*.
8. Han, Y., Liu, Y., Zhou, G., Zhu, Y. (2021). Technical analysis in the stock market: A review. *SSRN Electronic Journal.* Elsevier BV.
9. Lempart, J., Zalewski, G. (2013). *Leksykon formacji świecowych*. Warszawa: Linia.
10. *LSTM architecture*. Retrieved from: https://towardsdatascience.com/growing-your-own-rnn-cell-simplified-b68ba2c0f082, 1.06.2022.
11. Moghara, A., Hamiche, M. (2020). Stock Market Prediction Using LSTM Recurrent Neural Network. *Procedia Computer Science, Vol. 170*, pp. 1168-1173.
12. Murphy, J. (2006). *Analiza Rynków Finansowych*.
13. Nti, I.K., Adekoya, A.F., Weyori, B.A. (2019). A systematic review of fundamental and technical analysis of stock market predictions. *Artificial Intelligence, vol. 53, no. 4,* pp. 3007-3057.
14. Statisa.com (2021). The analysis of stock market investments in the us (1999-2021). Retrieved from: https://www.statista.com/statistics/270290/number-of-ipos-in-the-us-since-1999/, 1.06.2022.
15. Wu, M., Diao, X. (2015). *Technical analysis of three stock oscillators testing MACD, RSI and KDJ rules in SH &amp SZ stock markets*. International Conference on Computer Science and Network Technology (ICCSNT), IEEE.