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The Use of Technical Analysis in the US, European and Asian Stock Markets

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Abstract. Technical analysis is a widely used tool in making investment decisions. Nowadays it becomes very popular in the context of big data analysis and artificial intelligence framework. Although the analysis of the results of indicators in certain markets often becomes the axis of technical analysis research, it is difficult to find articles aimed at applying and comparing this analysis in different markets. This paper attempts to answer the question of whether technical analysis indicators work in the same or different ways in the US, European, and Asian stock markets. For this purpose, 8 indicators are calculated, and their results are compared in three selected markets. The correlation between the indicators themselves in individual markets is also determined. It has been observed that the performance of technical analysis is similar in different markets so this type of analysis can be used in artificial intelligence framework.

Keywords. Artificial intelligence, stock market, technical analysis.

1. Introduction

Technical analysis becomes especially relevant topic in big data and artificial intelligence field because this type of analysis is integrated in decision making framework. The importance of big data and artificial intelligence increases day by day and financial institutions and investors seek to be involved in this technological process. Increasing interest in big data and artificial intelligence force market players to take decisions how to apply technologies in order to improve their daily activities.

The term artificial intelligence first appeared at Dartmouth College in 1956. So it is not a new concept but nowadays because of high technological development artificial intelligence can help to improve daily processes much more than could do many years ago. In United Kingdom Prudential Regulation Authority (PRA) and Financial Conduct Authority (FCA) focus a lot on algorithmic trading and the main concern is that poorly designed and managed algorithms can increase financial stability risks. The regulators try to strengthen requirements even for companies and products which are not covered by MiFID II. But what about a situation when a central bank is a user of algorithmic trading. What institution should be responsible for monitoring risks? Is it enough if only local Risk management department is monitoring and managing risks?

According to FCA the firms using algorithmic trading should have a detailed definition of algorithmic trading and consider potentially relevant activities across the firm's business. FCA also indicates that the company should have a formal process to identify material changes to algorithmic trading activity – either in terms of a shift in strategy or the introduction of new algorithms. Also the company should have very detailed algorithmic inventory which should include:



- a breakdown of various components/algorithms contained within the strategy or system;
- technical details of the coding protocols;
- a comprehensive list of all the risk controls.

There are various types of algorithmic trading strategies. The most popular are signal processing, market sentiment, news reader and pattern recognition. Signal processing strategies can be described as mathematical extension of technical analysis eliminating noise and discerning trading patterns. Market sentiment strategies are based on market activity. The model should be fed by market data flows and only after that the algorithm becomes aware of market agitation and participant activity. The main point is to provide the appropriate information in order to analyze and to learn market psychology of supply and demand. Some algorithms can be taught to read news headlines and can react to major political events. Pattern recognition strategies enable algorithms to learn, adapt and react when patterns arise creating revenue opportunities.

Technical analysis is one of the tools for asset management and investment decisions based on the historical data of the investment instrument. Investment management consists of two main stages. Firstly, the investment is monitored, analysed, and forecasted for future scenarios, which the investor must trust, and secondly, the information is used to develop or change the portfolio management strategy (Alsulaiman [2013]). Technical analysis does not predict the prices of the investment instruments themselves, it predicts their movements in one direction or another, i.e. if the price of your investment is volatile and the price upturns change downturns and continues, the technical analysis states that with each price variation, previous the highest (or the lowest) price will not necessarily be reached. Thus, technical analysis allows the investor to decide when is the right time to enter or leave the market.

Although technical analysis is used as a tool for investment decisions for a while and lot of scientists research this method, there are still many questions about the feasibility of this method and the probability of making right decisions. Critics say the technical analysis method is not effective because the results are quite different. They are the result of differing interpretations of investment prices and the use of different methods of technical analysis. Likewise, not all investors interpret information in the same way, because not all receive it at the same time and not all perceive it the same way. Authors of scientific articles often study how this analysis works in a particular market, but it is difficult to find work that inquires the application of technical analysis in different markets by comparing them with each other. Therefore, the main goal of this paper is to analyse whether the relative performance of the technical analysis or whether this method performs better in some markets is the same based on technical analysis or whether this method performs better in some markets than in others. The research is focused on technical analysis in the context of artificial intelligence framework for different markets.

2. Review of related literature: technical analysis in the field of machine learning

Machine Learning: it's the science of getting computers to act by feeding them data so that they can learn a few tricks on their own, without being explicitly programmed to do so. According to Abadie A. and Kasy M. [2017], the interest in adoption of machine learning methods is growing rapidly. The mentioned authors studied two common features of machine learning algorithms: regularization and data-driven choice of regularization parameters. Machine



learning: set of algorithms to solve problems and whose performance improves with experience and data without ex post human intervention. Deep learning is a subcategory of machine learning. Machine learning is used in particular for marketing, fraud detection, portfolio management and risk assessment purposes (e.g. scoring of risk).

Bajari P., Nekipelov D. and others [2015] analyzed different machine learning techniques and compared econometric models with machine learning ones using a typical demand estimation scenario. The researchers found that machine learning models in general give better results in out of sample fits comparing to linear models without loss of in-sample goodness to fit. The main finding of the mentioned research was that machine learning models fill the gap between parametric models with user selected covariates and completely non-parametric approaches. Also the authors demonstrate that machine learning methods can produce superior predictive accuracy as compared to a standard linear regression or logit model. Central banks use lots of forecasting procedures so machine learning could help to achieve better results.

The authors Fliche Olivier and Yang Su [2018] described three different types of risk factors which could influence financial stability. The first risk factor was technology directional trading. This factor is called "sheep-like behavior". The main reason of this risk factor is the fact that algorithms are coded with similar variables so such a process creates the convergence to the same investment strategies. Because lots of institutional investors begin to use artificial intelligence in their daily activity taking investment decisions there is a big risk to increase the pro-cyclicality and market volatility by simultaneously making deals of purchases and sales in large quantities. This risk can be increased even more because even central banks begin to use artificial intelligence processes in foreign reserves management.

The second risk factor was market vulnerability to attacks. Cyber- criminal can easier to influence agents which act in the same way comparing with the autonomous agents. And the third risk factor is training on historical data. Usually algorithms are trained not in times of crisis so machine learning can increase the possibility of financial market crisis. But those risks factors are not the only ones.

Aikman D., Galesic M. and others [2014] made a research discussing on the topics of risk and uncertainty trying to identify main differences. The central premise of their paper is that the distinction between risk and uncertainty is crucial and it is strange that this topic has received too little attention from the researches. So according to the mentioned authors analyzing financial systems it is better to use the term "uncertainty" because there are lots of unpredictable factors.

Lui and Hu [2012] searched for a stock price patterns using one of the oldest methods of technical analysis - candlesticks. For detecting such pattern, they formed stock price vector with shape clustering (normalizing low, high, open and close prices) and scale clustering including K-means algorithm. Finally, to discover patterns of a stock, they used adjusted residue analysis. Of the 42 stock price data analysed, only 2 had associative relationships. But no reverse relationship was found. Thus, the authors concluded that generic candlestick patterns do not exist.

Feng, Wang and Zychowicz [2017] have been investigating the effectiveness of technical analysis inflection in the market with a certain sentiment. Considering that the use of technical analysis in an efficient market (where prices do not deviate from average values) is limited, it is hypothesized that, due to the rational behavior of investors, it will be more appropriate in high-sentiment periods. The study uses 22 indicators, based on a list provided by Bloomberg, that are tailored to the following stock market indices: the S&P 500 Index, the S&P MidCap 400 Index, the S&P SmallCap 600 Index, the Dow Jones U.S. LargeCap Index, the Dow Jones



U.S. MidCap Index, and the Dow Jones U.S. SmallCap Index. The positive coefficients of the sentiment level confirmed that technical analysis indicators are more effective in high-sentiment periods. In 2013, Alsulaiman drafted an article which focuses on a problem of too many indicators of technical analysis. Since these indicators are often contradictory, K-medoids clustering is used to group technical analysis indicators by their similarities or differences. The experiment used data of 30 stocks for which various indicators were applied. Correlation and distance matrices were developed, which showed possible classification of related technical analysis indicators. In the result of the research, the indicators were divided into three groups: 1) SMA, TMA, RSI TSMA, TEMA, MACD; 2) EMA, DM, AROON, BB, CCI, DEMA, MFI, ROC, TRIX; 3) WMA, TTMA, TWMA.

There are many articles in the literature on the application of technical analysis to a specific market. For example, Corelli [2019] is estimating the application of technical analysis for the equity prices in the Italian market using neural networks. The study is conducted in several stages, eliminating insignificant indicators. As a result, the performance of selected stock prices was matched by two indicators, the EDF and the DMA, and the use of neural networks confirmed that this method is appropriate for technical analysis and for the purpose of evaluating the correlation between the results obtained. Meanwhile Čaljkušić [2011] investigates the possibility of fundamental and technical analysis to provide the investor with knowledge about the appropriate moment of purchase and sale of shares in the Croatian market. Both graphical (candlestick, line, column chart) and mathematical (the average mean deviation and the relative strength index) technical analysis methods are used for the analysis. Correlation and regression are also used. The results showed that all study models were statistically significant. And in the findings of the study, the author argues that the investor should rely on technical analysis to find out the most appropriate moment of purchase or sale. But at the same time, it is encouraged to consider changes in the market, irrational actions of investors, the economic situation (macroeconomic indicators). Escobar, Moreno, and M'unera [2013] combines article intelligence methodology known as fuzzy logic and technical analysis to assess the Colombian stock market. The survey aims to answer the investor's question: buy or sell? after assessing his level of risk tolerance. The work uses well known indicators like moving averages, RSI and MACD.

In 2016 Širůček and Šíma investigated the issue of optimization of technical analysis indices to determine whether this method is appropriate for predicting future return on investment. The expected results of investors and indicators in the case of market volatility are compared, but assuming that the volatility does not change too much. After a detailed analysis of the literature, the author chose to study the 4 most commonly used indicators of technical analysis: Simple Moving Average (SMA), Moving Average Convergence / Divergence (MACD), Relative Strength Index (RSI), Bollinger Bands (BB). Comparing the results, the MACD and BB indices were found to provide the best conclusions.

3. Technical analysis for stock markets

Stocks are one of the riskiest investment instruments with high price fluctuations. These fluctuations are caused by the slightest movements in the market and prices change instantly. Therefore, forecasting stock prices is exceedingly difficult. The relevance of technical analysis to valuation of stock prices is based on three axioms: 1) price includes everything; 2) prices move purposefully; 3) "the story repeats itself". Damodaran A. [2012] also says that stock prices tend to fluctuate in a pattern that continues for a considerable period. In general,



researchers typically explore the suitability of applying technical analysis to the stock or currency market.

Although graphical analysis is widespread and commonly used in technical analysis, it may not always be enough to make important investment decisions. Therefore, the calculation of indicators is used. In order for a mathematical method to be truly reliable, several indicators need to be counted, but too many may lead to erroneous conclusions.

An analysis of the literature (see Table 1) reveals that three indicators are most commonly used in studies: Relative Strength Index (RSI), Simple Moving Averages (SMA), and Moving Average Convergence/Divergence (MACD). No matter what market is being researched or how many different methods are used, RSI is almost always used. As a rule, the authors base this choice on the simplicity of these indicators and the fact that they are widely used.

| Table 1. A Survey of Technical Analysis | | | | | | | | |
|--|-------|--|---|--|--|--|--|--|
| Authors | Years | Article | Used technical analysis indicators | | | | | |
| Angelo Corelli | 2019 | Equity Price Prediction with Neural Networks: Technical Analysis of the Italian Market | ACC, MCO, RSI, DMA, MCD, AUP, BBP, BBW, VIX, EPF | | | | | |
| Mohamed Masry | 2017 | The Impact of Technical Analysis on Stock Returns in an Emerging Capital Markets (ECM's) Country: Theoretical and Empirical Study | SMA | | | | | |
| Shu Feng, Na Wang, Edward J. Zychowicz | 2017 | Sentiment and the Performance of Technical Indicators | Boll, CMCI, DMI, MACD, RSI, TAS, Wm, PTPs, SMA, EMA, WMA, VMA, TMA, ADO, GOC, Kband, MAE, MAO, FG, REX, ROC, TE | | | | | |
| Martin Širůček, Karel Šíma | 2016 | Optimized Indicators of Technical Analysis on the New York Stock Exchange | SMA, BB, RSI, MACD | | | | | |
| J. Zuzik, R. Weiss, M. Antošova | 2014 | Use of Technical Analysis Indicators at Trading Shares of Steel Companies | RSI | | | | | |
| Eng Talal Alsulaiman | 2013 | Classifying Technical Indicators Using K-Medoid Clustering | SMA, EMA, WMA, TMA, DM, RSI, Aroon, BB, MFI, CCI, DEMA, ROC, MACD, TSMA, TRIX, TEMA, TWMA, TTMA | | | | | |
| Alejandro Escobar, Julián Moreno, Sebastián Múnera | 2013 | A Technical Analysis Indicator Based on Fuzzy Logic | DWMA, MACD, RSI | | | | | |
| Veronika Čaljkuši | 2011 | Fundamental and Technical Analysis on Croatian Stock Market | SMA, RSI | | | | | |

Indices of technical analysis are usually categorized according to their functions. Different classifications of indicators can be found in different literature, but they are usually classified into trend, momentum, volume, volatility and other. Table 2 demonstrates several indicators of each of the four main groups. Sometimes researchers choose to classify indicators according to



their compatibility or other criteria as the axis of their research (a similar study was conducted by Alsulaiman [2013]).



4. Pros and cons of technical analysis

As any other method, technical analysis has advantages and disadvantages. It is characterized by the fact that all market participants have access to all the necessary data to perform it. One of the advantages of this analysis is its flexibility, as this method is applied to stock, currency and commodity markets. Proper understanding and interpretation of technical analysis can yield satisfactory results in managing investment portfolios made up of different investments. This analysis also ignores the irrational decisions of investors - avoids the psychological factor, which allows investors to see a clearer view of the market and the trends prevailing in it. Trends are particularly clearly represented graphically. While there are plenty of investors who feel the need to invest based on intuition, supporters of technical analysis would argue that an investment management strategy is a safer way to manage their assets, and the performance of the strategy itself can be verified using technical analysis – adapting it to historical data. Wang, Liu, Du and Hsu [2019] says that Certain trading strategies based on technical indicators reflect the behavior of investors, therefore, a useful technical indicator can identify the behavior of investors and can be applied in a trading strategy to make more profit or reduce risks.

Although technical analysis is recognized as an appropriate method for valuing investments, it also has negative features. One deficiency is the wide variety of indicators. Different indicators may show different results; while some can indicate the moment of purchase, others - signal the sale. In most cases, the interpretation of the results obtained depends on the investor himself, so the analysis itself can be described as subjective. Nor is there yet one best way to combine indicators, how much of them and which ones to use when analysing a particular investment instrument. Another disadvantage of this method is the prediction of future scenarios based only



on past indicators. Technical analysis may not predict a sudden and unexpected event that could lead to significant changes in the market. The technical analysis would hardly have predicted such important market developments as the beginning of the financial crisis in 2007 or a "Flash crash" in 2010. Such and similar unforeseen events result in significant losses. It should also be noted that this analysis is more suitable for predicting short-term fluctuations in investment prices.

In general, the method of technical analysis is more suitable for use as a risk management tool than as a profit forecasting tool.

5. Selected data and indicators

As mentioned before, there is no consensus on how many and which indicators should be combined to make the results representative. Therefore, it was chosen to use several indicators for each group, which reflect certain macroeconomic areas:

- 1) Moving Average Convergence/Divergence;
- 2) Simple Moving Average;
- 3) Relative strength index;
- 4) Parabolic SAR;
- 5) Average Direction Index;
- 6) Volume Price Trend;
- 7) Accumulation/Distribution;
- 8) Money Flow Index.

To study the performance of technical analysis indicators in different markets, it was chosen to examine their signals in the respective stock market indices. The US market will be represented by the Dow Jones index, Europe - Euro Stoxx 50 and Asia - Nikkei 225. Configuration options selected for the indicators calculation and interpretation are given in Table 3.

In order to assess market trends, indicators will be calculated over the last two years, from May 1, 2018 to May 1, 2020.

| MACD | Simple Moving Average |
|---------------------------|-----------------------|
| Fast MA period - 12 | Period - 21 |
| Slow MA period - 26 | Field - close |
| Signal period - 9 | |
| | |
| RSI | Parabolic SAR |
| Period - 14 | Minimum AF - 0,02 |
| Field - close | Maximum AF - 0,2 |
| Over bought - 80 | |
| Over sold - 20 | |
| | |
| Average Direction Index | Volume Price Trend |
| Period - 14 | Field - close |
| | |
| Accumulation/Distribution | Money Flow Index |
| - | Period - 14 |
| | Over bought - 80 |
| | Over sold - 20 |

 Table 3. Configuration Options of Technical analysis indicators

 MACD



6. Methodology

Further in this work, the calculations of the selected technical analysis indicators, their formulas and interpretations of possible results are discussed. To be able to rely on non-individual results of different indicators on US, European and Asian stock market signals, the correlation between indicators and their interactions in different continental markets will be calculated and evaluated.

Simple Moving Average

SMA is the simplest indicator of technical analysis. It determines the market trend by calculating the arithmetic average of the closing prices for the selected period (in this case, period is 21):

$$SMA = \frac{P_1 + P_2 + \dots + P_{21}}{21}$$

SMA indicator allows to eliminate short-term or insignificant price movements. Svetunkov and Petropoulos [2018] states that SMA is a flexible model that performs very well in terms of accuracy and bias.

Moving Average Convergence/Divergence

MACD is one of the most widely used indicators. It shows market trend and acceleration and is therefore used to search for buy or sell signals, in other words, it identifies opportunities to trade available assets in the market. This indicator consists of two exponential moving averages, a signal line and a histogram, calculated as follows:

MACD = EMA 12 (fast) – EMA 26 (slow) signal = EMA 9 (period) of MACD

histogram = MACD - signal

The MACD histogram and signal line are compared to the MACD zero line, and their fluctuations represent the best moments of entry into or exit from the market. When the histogram and signal line are below the zero line, the market is bear, and when above, the market is bull. In other words, the buy signal is given when shorter EMA crosses the longer moving average from below and if shorter moving average crosses the longer moving average from above, the sell signal gets triggered (Subramanian and Balakrishnan [2014]).

Relative strength index

RSI shows the relationship between upward and downward movements, which allows to evaluate whether the asset is overbought or oversold. To calculate this indicator, it is first necessary to calculate the gain (U) and loss (D) between closed price in the current and previous period:

Gain:

 $U = close_{now} - close_{previous} ; D = 0$

Loss:

U = 0; D = close_{previous} - close_{now}

Then is calculated relative strength, i.e. the ratio between U and D:

 $RS = \frac{EMA (U)}{EMA (D)}$

Interaction between RSI and EMA helps finding shares in upward trends being in the local, short-term bottoms (Flotyński [2016]).

Finally, RSI value ranging from 0 (total loss) to 100 (total gain) is calculated:



$$RSI = 100 - (\frac{100}{1 + RS})$$

If the RSI is more than 80, the market is considered overbought, if less than 20 – oversold. *Parabolic Stop and Reverse*

Parabolic SAR identifies trends and shows when it is possible to close or reverse transactions, in other words, bullish or bearish market can be recognized. The indicator is calculated as follows:

 $SAR_{tomorrow} = SAR_{today} + AF(EP - SAR_{today})$

AF is the acceleration factor. This is a variable value that increases each time a new high point is reached (long position) or decreases each time a new low point is reached (short position). AF value ranges between 0.02 and 0.20. EP is an extreme point, i.e. the highest point of rise or the lowest in a downward trend.

Average Direction Index

Average Direction Index identifies a trend, measures its strength and acts as a filter for different trading strategies. It consists of two directional indicators, positive (+DI) and negative (-DI).

When +DI is not equal to zero, -DI = 0, when -DI is not equal to zero, +DI = 0.

+DI > -DI - positive directional movement (+DM)

+DI < -DI - negative directional movement (-DM)

After selecting the period, + DI and -DI are calculated:

$$+DI = \frac{100 * EMA of + DM}{ATR}$$
$$-DI = \frac{100 * EMA of - DM}{ATR}$$

Then:

$$ADX = \frac{100 * EMA of + DM - -DM}{+DI + -DI}$$

The values of the ADX indicator range between 0 and 100. When this value is less than 20, the trend is considered weak or absent, and the higher the value, the stronger the trend. *Volume Price Trend*

Volume Price Trend relates price and volume in the stock market to detect divergences between them. The percentage change in the share price indicates the supply or demand for those shares, and the volume indicates the buy or sell signals. The VPT formula is:

$$VPT = VPT_{previos} + volume \times \frac{close_{today} - close_{previous}}{close_{previous}}$$

When VPT and price increase, the price trend increases. When VPT and price fall, the price trend decreases.

Accumulation/Distribution

Accumulation/Distribution index informs whether price changes are accompanied by increased accommodation or distribution movements, the indicator assumes that the higher the accompanying increases in turnover, the more convincing the price changes are. The indicator is calculated as follows:

 $CLV = \frac{(close - low) - (high - close)}{(high - low)}$



 $A/D = A/D_{\text{previous}} + \text{volume} \times \text{CLV}$

When the A/D ratio increases and the stock price decreases, a change in the stock price trend is signalled.

Money Flow Index

Money Flow Index measures the strength of cash inflows into and out of a share. This indicator is similar to the RSI, the difference being that MFIs additionally include turnover. the calculation of money flow is based on the fluctuation of transaction prices and the strength of buyers and sellers (Ye, Qiu, Lu and Hou [2018]).

To calculate MFIs, the typical price (TP) and money flow (MF) for the period are first calculated:

 $TP = \frac{high + low + close}{3}$ $MF = TP \times volume$

The money ratio (MR) is then calculated: **DME**, where:

$$MR = \frac{PMF}{NMF} ,$$

Positive money flow (PMF) - the amount of positive money flows during a specified period;

Negative money flow (NMF) - the amount of negative money flows during a specified period. Finally, the money ratio is used to calculate MFIs:

$$MFI = 100 - (\frac{100}{1 + MR})$$

As in the case of RSI, if the MFI value is higher than 80, the market is considered to be buy, if less than 20 it is considered to be sold.

Correlation

Correlation can usually be described as the interdependence of two or more quantities, phenomena, or processes. Analysing the change in the values of quantitative variables, it is observed whether these variables are dependent and, if so, what its trend is. For example, as one variable increases, another upward or downward trend is observed. The trend itself can be monotonic (when one value increases, the other also changes in the same or opposite direction) or non-monotonic. It is also important to investigate the strength of the relationship between the quantities studied. The correlation coefficient ranges from -1 to +1. The closer the magnitude is to -1, the more negative the correlation is and vice versa.

The following is the correlation calculation formula:

$$r(X,Y) = \frac{\text{cov}(X,Y)}{\sqrt{s^2(X)s^2(Y)}} = \frac{E(X,Y) - E(X)E(Y)}{\sqrt{s^2(X)s^2(Y)}}$$

As Levy and Razin [2015] argue, intuitively, correlation neglect magnifies the effect of information on individuals behavior. By calculating the correlation between each pair of two indicators, it will be possible to assess whether the signals of the strongly correlated indicators are the same (buy or sell). This will allow discrepancies in the results obtained or will amplify the signals emitted.



7. Research data and results

The study assessed the performance of certain technical analysis indicators on selected stock indices corresponding to the US, European and Asian markets over the past two years and the investment strategies offered to stockholders.

Although the indicators were calculated for the period from May 2018 to May 2020, table 4 shows only the results of the indicators for the last month. This is because due to the threat of a pandemic in the world, there was a sharp drop in stock prices in March, which distorts the general trend and, in an attempt to graph the trend line, it has a negative slope in all cases. And looking at last month's data, the stock price trend is on the rise.

| | Date | MACD | SMA | RSI | PSAR | ADX | VPT | A/D | MFI |
|---|------------|----------|----------|-------|----------|-------|---------------|---------|-------|
| 01/04 02/04 03/04 06/04 07/04 | 01/04/2020 | -1319.69 | 22433.15 | 49.20 | 19330.99 | 47.22 | -169778149.46 | 3328.68 | 58.47 |
| | 02/04/2020 | -1237.15 | 22340.45 | 43.88 | 19526.83 | 43.40 | -157896350.79 | 3329.50 | 56.90 |
| | 03/04/2020 | -1187.17 | 22223.37 | 53.64 | 19710.92 | 39.48 | -165480988.45 | 3329.15 | 58.74 |
| | 06/04/2020 | -1004.66 | 22264.88 | 55.80 | 19883.97 | 36.85 | -118266327.07 | 3329.96 | 58.14 |
| | 07/04/2020 | -852.31 | 22300.24 | 62.39 | 20115.93 | 35.92 | -118951467.43 | 3329.00 | 66.32 |
| | 08/04/2020 | -661.03 | 22403.27 | 64.29 | 20466.06 | 35.30 | -102680484.95 | 3329.81 | 65.50 |
| | 09/04/2020 | -480.83 | 22522.92 | 70.51 | 20781.18 | 33.34 | -95772597.94 | 3329.66 | 74.10 |
| es | 13/04/2020 | -360.39 | 22601.81 | 72.16 | 21168.52 | 31.33 | -101235365.41 | 3329.64 | 76.36 |
| on | 14/04/2020 | -217.32 | 22724.35 | 67.49 | 21509.37 | 30.85 | -89623137.57 | 3330.13 | 75.73 |
| ٧J | 15/04/2020 | -138.29 | 22795.26 | 62.49 | 21863.74 | 30.14 | -97762043.72 | 3330.43 | 68.63 |
| 00 | 16/04/2020 | -72.13 | 22862.75 | 56.23 | 22168.50 | 29.61 | -97094076.56 | 3331.12 | 60.96 |
| Д | 17/04/2020 | 36.74 | 22988.18 | 66.93 | 22430.59 | 30.50 | -81345068.52 | 3332.02 | 68.82 |
| | 20/04/2020 | 74.40 | 23048.39 | 58.71 | 22723.97 | 31.07 | -91685599.49 | 3331.12 | 62.16 |
| $\overline{\Omega}$ | 21/04/2020 | 52.67 | 23045.71 | 57.05 | 24264.21 | 30.92 | -104640721.82 | 3330.48 | 54.79 |
| — | 22/04/2020 | 71.50 | 23084.81 | 67.34 | 24237.76 | 33.35 | -97635828.95 | 3330.48 | 60.91 |
| | 23/04/2020 | 88.58 | 23123.94 | 65.29 | 24211.85 | 35.70 | -96981820.50 | 3329.64 | 60.39 |
| | 24/04/2020 | 121.70 | 23183.15 | 70.11 | 24186.45 | 37.98 | -92824142.78 | 3330.39 | 66.40 |
| | 27/04/2020 | 174.86 | 23269.57 | 63.21 | 22941.88 | 38.12 | -86952490.40 | 3330.99 | 65.44 |
| | 28/04/2020 | 211.94 | 23345.21 | 63.14 | 22967.20 | 35.99 | -87486988.68 | 3330.28 | 64.50 |
| | 29/04/2020 | 281.04 | 23462.36 | 61.41 | 23029.00 | 34.17 | -77431420.81 | 3330.44 | 64.56 |
| | 30/04/2020 | 308.99 | 23542.66 | 55.95 | 23133.14 | 31.07 | -83137614.37 | 3330.24 | 55.95 |
| | 01/04/2020 | -1.94 | 30.21 | 51.18 | 25.91 | 49.90 | -3136920.93 | 41.30 | 57.19 |
| | 02/04/2020 | -1.84 | 30.05 | 47.23 | 26.20 | 45.20 | -3073674.66 | 41.69 | 58.27 |
| | 03/04/2020 | -1.79 | 29.86 | 57.56 | 26.46 | 41.29 | -3111324.69 | 41.81 | 60.59 |
| | 06/04/2020 | -1.58 | 29.84 | 58.68 | 26.71 | 38.35 | -2921063.65 | 42.32 | 60.78 |
| | 07/04/2020 | -1.40 | 29.84 | 69.89 | 26.94 | 37.21 | -2898378.09 | 41.32 | 67.26 |
| 20 | 08/04/2020 | -1.21 | 29.86 | 69.81 | 27.25 | 36.14 | -2860833.19 | 41.79 | 60.92 |
| × | 09/04/2020 | -0.98 | 29.96 | 71.51 | 27.53 | 35.12 | -2735143.04 | 42.14 | 62.69 |
| XC | 13/04/2020 | -0.82 | 30.01 | 68.92 | 27.88 | 33.29 | -2761025.00 | 42.14 | 64.16 |
| Ste | 14/04/2020 | -0.64 | 30.11 | 63.55 | 28.21 | 32.31 | -2704489.98 | 41.68 | 63.49 |
| 0 | 15/04/2020 | -0.60 | 30.08 | 52.06 | 28.60 | 30.02 | -2835249.42 | 41.47 | 56.64 |
| ĵur | 16/04/2020 | -0.58 | 30.04 | 45.36 | 28.95 | 27.61 | -2847983.49 | 41.40 | 47.81 |
| щ | 17/04/2020 | -0.46 | 30.10 | 57.08 | 29.26 | 27.15 | -2774455.60 | 41.96 | 53.97 |
| ں ف | 20/04/2020 | -0.40 | 30.12 | 52.55 | 29.53 | 26.56 | -2805429.05 | 41.36 | 47.80 |
| do | 21/04/2020 | -0.41 | 30.06 | 50.10 | 31.51 | 25.61 | -2882332.28 | 40.87 | 48.86 |
| ŭn | 22/04/2020 | -0.38 | 30.05 | 60.40 | 31.47 | 27.03 | -2856220.60 | 41.17 | 55.96 |
| É | 23/04/2020 | -0.39 | 30.00 | 56.36 | 31.43 | 28.50 | -2917610.02 | 40.42 | 44.72 |
| | 24/04/2020 | -0.36 | 29.99 | 61.16 | 31.38 | 29.12 | -2887840.76 | 41.17 | 44.16 |
| | 27/04/2020 | -0.28 | 30.03 | 55.44 | 31.34 | 28.17 | -2854923.73 | 41.88 | 42.37 |
| | 28/04/2020 | -0.21 | 30.08 | 55.50 | 31.30 | 25.09 | -2841283.54 | 40.92 | 40.01 |
| | 29/04/2020 | -0.06 | 30.23 | 59.37 | 29.37 | 22.87 | -2760906.11 | 41.36 | 46.82 |
| | 30/04/2020 | 0.00 | 30.31 | 51.05 | 29.42 | 19.54 | -2845471.98 | 41.36 | 34.85 |

Table 4. Data of technical analysis indicators in April 2020



| | 01/04/2020 | -840.36 | 19120.27 | 42.33 | 16978.55 | 63.07 | -27967.02 | 1483.59 | 34.01 |
|-----|------------|---------|----------|-------|----------|-------|-----------|---------|-------|
| | 02/04/2020 | -829.80 | 19001.95 | 45.48 | 17081.98 | 57.59 | -29432.24 | 1483.11 | 35.03 |
| | 03/04/2020 | -831.75 | 18894.52 | 52.75 | 17181.28 | 51.77 | -29424.33 | 1482.96 | 37.31 |
| | 06/04/2020 | -823.68 | 18865.59 | 60.64 | 17276.60 | 46.68 | -24939.47 | 1483.74 | 43.62 |
| | 07/04/2020 | -747.65 | 18873.28 | 62.49 | 17368.12 | 42.85 | -22761.77 | 1484.04 | 51.33 |
| | 08/04/2020 | -649.74 | 18916.91 | 66.67 | 17455.97 | 39.25 | -20509.33 | 1484.76 | 58.97 |
| S | 09/04/2020 | -533.48 | 18955.90 | 68.10 | 17540.30 | 36.29 | -20541.10 | 1485.27 | 67.29 |
| 52 | 10/04/2020 | -436.90 | 19005.23 | 67.33 | 17621.27 | 33.40 | -19850.31 | 1486.25 | 66.03 |
| . 5 | 13/04/2020 | -344.07 | 19008.70 | 57.01 | 17698.99 | 31.02 | -21381.43 | 1485.43 | 60.07 |
| ξ, | 14/04/2020 | -303.73 | 19065.98 | 50.78 | 17773.61 | 29.39 | -18820.74 | 1486.21 | 58.27 |
| Ţ. | 15/04/2020 | -221.16 | 19109.99 | 58.63 | 17889.55 | 27.57 | -19245.85 | 1486.07 | 66.31 |
| ~ | 16/04/2020 | -161.03 | 19126.37 | 48.94 | 17998.54 | 25.41 | -20327.95 | 1486.38 | 58.53 |
| a | 17/04/2020 | -132.81 | 19196.45 | 58.18 | 18100.98 | 25.18 | -17564.89 | 1487.24 | 66.71 |
| .sı | 20/04/2020 | -60.77 | 19239.42 | 57.48 | 18246.67 | 25.39 | -18310.18 | 1486.91 | 59.96 |
| • | 21/04/2020 | -21.83 | 19243.18 | 63.31 | 18380.70 | 26.09 | -19877.82 | 1486.43 | 60.96 |
| | 22/04/2020 | -22.05 | 19233.62 | 64.79 | 18504.01 | 27.06 | -20443.79 | 1487.43 | 62.17 |
| | 23/04/2020 | -33.36 | 19251.42 | 66.94 | 18617.46 | 28.76 | -19338.02 | 1488.43 | 69.12 |
| | 24/04/2020 | -18.60 | 19252.38 | 58.24 | 18721.83 | 28.84 | -20067.95 | 1488.41 | 61.51 |
| | 27/04/2020 | -20.17 | 19300.64 | 59.67 | 18817.84 | 27.61 | -17968.13 | 1489.23 | 60.61 |
| | 28/04/2020 | 20.40 | 19343.42 | 55.33 | 18906.18 | 25.68 | -18009.85 | 1489.54 | 59.37 |
| | 30/04/2020 | 51.00 | 19420.71 | 59.78 | 18987.45 | 24.03 | -15800.24 | 1489.31 | 60.29 |

After performing the calculations of the selected technical analysis indicators, their results and signals can be divided into three positions - buying, selling and neutral. Such data are presented in Table 5.

 Table 5. Data of technical analysis indicators in April 2020

| | Tuble 5. Data of teeninear analysis indicators in riprit 2020 | | | | | | | | | |
|----------------------------|---|-----|---------|------|-----|-----|-----|---------|--|--|
| | MACD | SMA | RSI | PSAR | ADX | VPT | A/D | MFI | | |
| US Dow Jones | BUY | BUY | NEUTRAL | BUY | BUY | BUY | BUY | NEUTRAL | | |
| Europe Euro Stoxx 50 | BUY | BUY | NEUTRAL | BUY | BUY | BUY | BUY | NEUTRAL | | |
| Asia Nikkei 225 | BUY | BUY | NEUTRAL | BUY | BUY | BUY | BUY | NEUTRAL | | |

In 2018-2020, the SMA indicator was fairly stable for almost the entire period, with no sudden changes in the trend line in any of the three markets studied. In all markets, a sharper decline in the share price is observed from March to early April 2020. Such changes were driven by the prevailing COVID-19 virus in the world. However, the second half of April shows a rising trend in stock prices, which is expected to increase in the near future, so based on this indicator, the market signal is to buy.

From the MACD indicator, its signal line, and the histogram presented in Exhibit 6 (the top left shows data for the US market, the right for Europe, and the bottom for Asia; the blue line indicates the MACD values, the yellow line the signal line, and the yellow line is histogram.), it is observed that recent trends and price fluctuations in all real markets are the same. Following the recent sharp fall in prices, an equally rapid upward trend can be seen. The indicator histogram and signal line in the US and Asian markets are already above the zero line, and in Europe it is close to it. All three markets can be considered bullish, as the SMA indicator analyzed above not only shows an upward trend in the US and Asian markets, but also prevails in Europe.





Table 6. MACD, signal line and histogram in US, European and Asian stock markets

It has already been mentioned that for both RSI and MFI calculations, when the values of these indicators are more than 80, the market is considered bullish, when less than 20 - bearish. Exhibit 4 shows that in the US market, both of these indicators are below 80, but not far from that. It can be said that the market itself is more bullish, but it cannot be said that the signal is buy, so it is considered neutral. The situation is similar in the European and Asian stock markets, only the values of RSI and MFI indicators are closer to the average possible value of indicators, but still the signal is also neutral.

Parabolic SAR indicator values are increasing in all three markets, the markets themselves are considered bullish, so their signal is to buy. The accumulation / distribution index also shows the purchasing strategy, as there is no signal that the current upward trend in prices will change in the near future.

In terms of the Average Direction Index, the market trend is stronger in the US than in the Asian and European markets. It is noted that in all markets the slope of the ADX indicator is negative, which means that the trend is weakening but not changing. Since the trend was to buy before, it remains that way.

During the period under review, the values of both stock closing prices and the VPT indicator are uneven in all studied markets. As in the MACD charts, these charts show a sharp decline in April, followed by a rise in stock prices and the VPN (see Table 7, where the US market is depicted at the top, European in the middle and Asian at the bottom; the left side shows stock prices, the right side shows the values of the VPN indicator.). As the indicator increases, buying pressure is increases too. Therefore, the VPN signal in the US, European and Asian markets is to buy.





Table 7. US, European and Asian stock closing price and VPT trend charts

Thus, the 8 indicators of the technical analysis studied showed the same investment signals in all three stock markets. It is therefore interesting to see whether the correlation between indicators is also the same in these markets.

Exhibit 8 presents the correlations between the research indicators in the US, European and Asian markets. Strong such correlations can be found in all markets. Also, all relationships are positive. There are three correlations in the US market, four in Europe and five in Asia. In all three markets, the strongest correlation prevails between SMA and Parabolic SAR indicators - 0.93 in the USA and Asia, and 0.94 in Europe. Both of these indicators show a trend in price movements, it is logical that when stock prices move in one direction in the market, all indicators of this type must also show the same trend. Also, in all these markets, a strong correlation exists between RSI and MFIs. These indicators are generally presented as complementary. These data also suggest such a conclusion.

In the US and Asian markets, there is a correlation between the MACD and VPN indicators, with a correlation strength of 0.83 and 0.79, respectively. The other two pairs of strong



correlations are observed in the European and Asian markets. First, between the SMA and VPT indicators (0.71 and 0.77), and also between Parabolic SAR and VPT (0.73 and 0.77). These data reveal that of these 8 indicators, the Volume Price Trend indicator is the most flexible and most compatible with other indicators of technical analysis.

| US | MACD | SMA | RSI | PSAR | ADX | VPT | A/D | MFI |
|--------|-------|-------|-------|-------|-------|-------|------|-----|
| MACD | 1 | | | | | | | |
| MA | 0.39 | 1 | | | | | | |
| RSI | 0.54 | 0.08 | 1 | | | | | |
| PSAR | 0.55 | 0.93 | 0.06 | 1 | | | | |
| ADX | -0.35 | -0.15 | -0.02 | -0.24 | 1 | | | |
| VPT | 0.83 | 0.48 | 0.27 | 0.57 | -0.36 | 1 | | |
| A/D | -0.18 | 0.47 | 0.05 | 0.31 | 0.17 | -0.42 | 1 | |
| MFI | 0.48 | 0.47 | 0.82 | 0.02 | -0.16 | 0.21 | 0.07 | 1 |
| | | | | | | | | |
| Europe | MACD | SMA | RSI | PSAR | ADX | VPT | A/D | MFI |
| MACD | 1 | | | | | | | |
| MA | 0.43 | 1 | | | | | | |
| RSI | 0.57 | -0.04 | 1 | | | | | |
| PSAR | 0.56 | 0.94 | -0.05 | 1 | | | | |
| ADX | -0.50 | -0.33 | -0.10 | -0.42 | 1 | | | |
| VPT | 0.56 | 0.71 | 0.08 | 0.73 | -0.40 | 1 | | |
| A/D | -0.05 | 0.00 | 0.12 | -0.12 | 0.01 | -0.63 | 1 | |
| MFI | 0.44 | 0.00 | 0.86 | -0.06 | 0.02 | 0.03 | 0.14 | 1 |
| | | | | | | | | |
| Asia | MACD | SMA | RSI | PSAR | ADX | VPT | A/D | MFI |
| MACD | 1 | | | | | | | |
| MA | 0.50 | 1 | | | | | | |
| RSI | 0.60 | 0.05 | 1 | | | | | |
| PSAR | 0.59 | 0.93 | 0.01 | 1 | | | | |
| ADX | -0.38 | -0.20 | -0.21 | -0.25 | 1 | | | |
| VPT | 0.79 | 0.77 | 0.36 | 0.77 | -0.40 | 1 | | |
| A/D | -0.01 | -0.02 | 0.08 | -0.10 | 0.21 | -0.23 | 1 | |
| MFI | 0.62 | -0.02 | 0.88 | 0.06 | -0.24 | 0.36 | 0.12 | 1 |

Table 8. Correlation between technical analysis indicators in US, European and Asian stock markets

8. Conclusion

The main question raised in this work was to examine whether the image of technical analysis is the same in different markets or whether it works differently. This topic is very relevant in the context in big data analytics and artificial intelligence framework so it is very important to check the capabilities of technical analysis methods.

The different markets study showed that with equally directed stock price movements in the US, European and Asian markets, the conclusions of the technical analysis were also the same, as the same market movements lead to the same results of the same method. The correlation



between the indicators studied was also remarkably similar in these markets. This further reinforces the correctness of this conclusion. These results also confirmed the practical rule of trading that there are a strong correlation between different stock markets if we analyse the broad tendencies. Of course there can be some differences in analysing different sectors or companies. So for further research it will be interesting to check if there are the same tendencies of technical analysis signals in different sectors. Also it is interesting to expand the main idea of artificial intelligence and the role of algorithmic trading in that framework.

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