

## Application of MACD and RVI indicators as functions of investment strategy optimization on the financial market\*

Dejan Eric<sup>1</sup>, Goran Andjelic<sup>2</sup>, Srdjan Redzepagic<sup>3</sup>

### Abstract

*The determination of trends and prediction of stock prices is one of the main tasks of the MACD (Moving Average Convergence Divergence) and the RVI (Relative Volatility Index) indicators of the technical analysis. The research covers the sample representing stocks which are continually traded on the financial market of the Republic of Serbia. Subject of this research is to determine the possibility of MACD and RVI indicators application in investment decision making processes on the financial market of the Republic of Serbia. The main goal of the research is to identify the most profitable parameters of the MACD and RVI indicators as functions of investment strategy optimization on the financial market. The main hypothesis of the research is that the application of the MACD and RVI indicators of technical analysis significantly contributes to investment strategy optimization on the financial market. The applied methodology during the research includes analyses, synthesis and statistical/mathematical methods with special focus on the method of moving averages. Research results indicate significant possibilities in application of MACD and RVI indicators of technical analysis as functions of making optimum decisions on investment. According to the obtained results it is concluded that the application of the optimized MACD and RVI indicators of technical analysis in decision making process on investing on the financial market significantly contributes maximization of profitability on investments.*

**Key words:** technical analysis, MACD indicator, RVI indicator, investment strategy, financial market.

**JEL classification:** G10, G11

---

\* Received: 10-02-2009; accepted: 19-06-2009

<sup>1</sup> Full Professor; Institute of Economic Sciences, Zmaj Jovina 12, 11000 Belgrade, Serbia. Scientific affiliation: economy and management. Phone: + 381 11 26 22 357. Mob: + 381 64 23 11 233. Fax: + 381 11 26 23 055. E-mail: dejan.eric@ien.bg.ac.rs.

<sup>2</sup> Teaching Professor; University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovica 7, 21000 Novi Sad, Serbia. Scientific affiliation: investment management. Phone: + 381 21 485 2190. Mob: + 381 63 555 619. Fax: + 381 21 6350 300. E-mail: gandjelic@iis.ns.ac.yu

<sup>3</sup> Assistant Professor; Researcher; Institute of Economic Sciences, Zmaj Jovina 12, 11000 Belgrade, Serbia. Scientific affiliation: international economics. Phone: + 381 11 26 23 578. Fax: + 381 11 2181 471. E-mail: srdjan.redzepagic@ien.bg.ac.rs

## 1. Introduction

The extensive investment activities in the past seven years on the financial market of the Republic of Serbia initiated the application of modern tools and techniques as functions of investment process optimization. Particularly, foreign direct investments between 2000 and 2007 caused the absolute amount of investment activities on the financial market of the Republic of Serbia to increase for \$ 13.5 billion. Also the increase of investment activities has been largely improved due to the introduction of the new system of trading in March 2004 on the Belgrade Stock Exchange as well as the introduction of continuous regime of trading in the same year, for stocks which were significantly traded on the financial market of the Republic Serbia. Continuous trading is a particularly important factor and the prerequisite of increase in the scale of trading on the financial market. With increase in the scale of trading, the preconditions for technical analysis of stocks are created. Namely, intensification of investment activities largely affects the increase of the use both the fundamental and the technical analysis, aiming the optimization of investment strategy. The subject of fundamental analysis is the analysis of previous enterprise business, its development potential and the analysis of its surroundings. The fundamental analysis is the starting point of any decision regarding investments. A large body of evidence demonstrates the ratios of measures of fundamental value to market value systematically predict future stock returns (Dechow, 2001:2). After the fundamental analysis indicates the reasonability of investing into certain stocks, it is necessary to apply the technical analysis in order of timely implementation of the investment strategy. The subject of technical analysis is the analysis of the record of market price movements and trading volume for the stock under investigation, which together with the results of fundamental analysis provides the base of prediction of its future market price fluctuation. The general goal of technical analysis is to identify regularities in the time series of prices by extracting nonlinear patterns from noisy data (Andrew W. Lo, 2001:1708). Technical indicators are one of the most important segments of technical analysis. There are two main types of indicators: leading and lagging. Lagging indicators identify the direction of the movement and the strength of the trend, while leading indicators identify the level of underestimation and overestimation of stock prices. The MACD (*Moving Average Convergence Divergence*) is a classical lagging indicator, and the RVI (*Relative Volatility Index*) is a modification of the RSI (*Relative Strength Index*) indicator, which is one of the most important leading indicators.

On the basis of the main characteristics of the MACD and RVI indicators of technical analysis and other research in relevant field we propose the first hypothesis:

*Hypothesis 1:* The application of the MACD and RVI indicators significantly contributes to investment strategy optimization on the financial market.

A considerable amount of work has provided support for the view that simple technical trading rules are capable of producing valuable economic signals (Brock et al., 1992, Bessembinder and Chan, 1998). However, the majority of these studies have ignored the issue of investment parameter optimization, leaving them open to the criticism of datasnooping and the possibility of a survivorship bias (Lo and MacKinley, 1990). Also, we propose the following hypothesis:

*Hypothesis 2:* The MACD and RVI indicators are adequate for monitoring and assessment of the stock market prices on financial markets in transitional countries.

There is an ongoing belief in investment community that technical analyses, which involve the study of past price and volume data, can be used to infer the direction of future prices. (Kaufman, Perry J., 2003). The application of the MACD and RVI indicators on financial markets in transitional countries requires special attention, especially regarding insufficient liquidity of financial markets in these countries, small scale of trading and historically speaking, asymmetrical and low number of trading days with certain stocks.

The research goal is to determine the place, role and significance of two specific indicators of the technical analysis, i.e. possibility of application MACD and RVI indicators in investment decision making processes on the financial market of the Republic of Serbia. The motivation of this paper is to show how the MACD and RVI indicators can be used in investment activities and their importance in investment strategy optimization on financial markets in transitional countries. Results of this research will be especially interesting and beneficial for both domestic and foreign investors in terms of adequate investment strategy optimization on the financial market.

The paper is organized as follows. Section 2 presents theoretical background of the research, while Section 3 describes the methodology used to calculate optimized MACD and RVI indicators, i.e. investment strategy optimization. Section 4 describes the data and Section 5 presents empirical results and discussion on the application of the MACD and RVI indicators as functions of investment strategy optimization on the financial market. Finally, Section 6 summarizes and concludes the paper.

## **2. Theoretical background**

Technical analysis is a study which primarily uses charts to predict future trends in the stock market price movements on the stock exchange (Murphy, 1999). Information about the market price of a particular stock and the trading volume are the bases of technical analysis. The basic assumptions of technical analysis are the following:

- a) The market discounts all relevant information;
- b) Price moves in trends;
- c) History tends to repeat itself.

*a) The market discounts all relevant information* – assumption of technical analysis that the market discounts all relevant information is one of the main reasons of existence of technical analysis. Technical analysts assume that all information of fundamental, political, psychological or any other nature that may affect the market movements are already reflected in the stock market price. According to this assumption, it could be concluded that it is sufficient for the investor to analyze the previous movement in stock market price, and according to this information he may decide upon investing, i.e. without using fundamental analysis of a particular stock. Due to the assumption that the market discounts all relevant information, technical analysts are able to recognize this phenomenon in timely manner by analyzing the chart of stock price movements and trading volume. If markets are efficient in the sense that the current price impounds all information, then such activity is clearly pointless. But if the process of adjusting prices to the latest information is not immediate, market statistics may impound information that is not yet incorporated into the current market price. In particular, volume may be informative about the process of security returns (Blume et al., 1994:153).

*b) Price moves in trends* – at the technical approach of stock analysis, the importance of the concept of trend is absolutely essential. The purpose of technical analysis is to identify the direction of movement and the strength of the trend in its earliest stage possible. According to the law of physics, the moving body tends to remain in the state of motion unless an external force is applied to it that changes its direction or stops the motion. Analogue to this, the trend of stock market price movement remains the same until it is reverted. The technical analyst is not an investor that initiates the trend with his actions. He will try to identify the trend in its earliest stage and thus, he decides upon investment.

*c) History tends to repeat itself* – a large area of technical analysis deals with study of human psychology, i.e. the behavior of investors which is repetitive in nature. For example, since they are the result of human behavior whose character is permanent in time, some of the technical formations that were identified more than a hundred years ago are still valid.

One of the most important characteristics of technical analysis is its adaptability to virtually any financial instrument, which includes stocks, bonds, stock indexes, currencies, gold, oil, i.e. any subject of trading on the organized securities market. Technical analysis is also applicable to any time dimension and is flexible with regard to the time aspect. Despite its jargon and methods, technical analysis may well be an effective means for extracting useful information from market prices

(Andrew W. Lo., 2000:1705). Concerning fundamental analysis, the investor that brings his decision exclusively based on technical analysis significantly shortens the time necessary for the analysis, which enables him simultaneously to monitor several markets. Because of the time limit in market analysis, fundamental analysts are forced to specialize in analyzing a smaller number of markets (Leigh, 2002). Due to the cyclical nature of some markets, fundamental analysts are not able to make profit on these markets unless these belong to their group of analyzed markets. By the application of new software solutions, technical analysts are able to monitor virtually all world markets simultaneously. There are several programs on the software market whose purpose is to generate buying and selling signals based on condition set by the user. Appropriately setting the afore mentioned conditions, the technical analyst is able to generate profit based on the cyclical nature of all industries on a certain market. For example, the fundamental analyst is specialized to the market with lateral tendency of movement in certain period of time. In the same period, the technical analyst may focus his assets to markets with growing tendencies, while the fundamental analyst has no such flexibility. Much of technical analysis involves pattern recognition using specific frequency (intra-day, daily, weekly) charts that display opening, high, low, and closing prices, as well as trading volume in some form (Kavajecz and Odders-White, 2004: 9).

Due to their mathematical nature, technical indicators are often misinterpreted. Technical analysis is valuable because current market statistics may be sufficient to reveal some information, but not all (Blume et al., 1994:177). Since the mathematical definition of indicators is clear and accurate, a certain number of investors tend to mechanically use the indicators of technical analysis. It is also important to note that the indicators are best used together with the other tools of technical analysis. However, since technical trading strategies require frequent transactions, return predictability may not imply increased returns once transaction costs are considered (Bassembinder and Chan, 1998:2). Closing prices are the most frequently used at all indicators, however indicators may also use the opening prices, maximum and minimum prices during the trading day. Indicators of technical analysis are used to help to identify:

- direction of the trend,
- strength of the trend,
- the level of resistance and support,
- the divergence between the movement of indicators and prices as signals of possible reverse trends,
- the confirmation of reverse trends.

The MACD (*Moving Average Convergence Divergence*) indicator is introduced in 1970s by Gerard Appel. Since then, it became one of the most popular indicators of technical analysis. The advantage of application of this indicator is that it is

equally useful for both the short-term and long-term oriented investors. The MACD indicator is constructed by subtraction of the 26-days' exponential moving average from the 12-days' exponential moving average. From the MACD indicator that has been obtained in this way, the 9-days' exponential moving average is calculated as a signal line. The shorter 12-days' exponential moving average is closer to the movement of the stock price and is more sensitive to changes of trends than the longer, 26-days' moving average (Appel, 2005).

The Relative Volatile Index (RVI) is developed in 1993 by Donald Dorsey. The RVI indicator of technical analysis is used to identify the direction of stock price volatility. This indicator is calculated identically as the Relative Strength Index, with the single difference that the RVI measures the standard closing price deviation for the monitored number of days instead of absolute changes of price, as is the case with the RSI indicator (Dorsey, 1993). Developing this indicator, Dorsey was looking for an appropriate indicator for traditional indicator confirmation that follows the trend, as the moving averages or the MACD. His researches proved that the use of oscillators as functions of confirmation of the other "repacked" oscillator is usually inefficient, and that technical analysts frequently use one type of indicators to confirm the other one. Also, it is possible to use the MACD to confirm the signal generated by the stochastic oscillator. Logically, this type of diversification would improve the results, but the confirming indicator frequently is merely a "repacked" original indicator which uses the similar theory for measuring the markets' behavior. Any investor should be familiar with the nature of indicators in use to avoid information duplication.

Mieko Tanaka-Yamawaki and Seiji Tokuoka (2007) examined the adaptive use of technical indicators by applying them on the tick data of various stock prices for the prediction of intra-day stock prices on the New York Stock Exchange. In this paper we examine the application of the MACD and RVI indicators of the technical analyses over a longer time period, especially regarding investment strategy optimization and the afore mentioned trading conditions on the Belgrade Stock Exchange. These indicators are used in analyzes of the stock exchange trading processes on the world's major stock exchanges. Gencay (1998) examined the profitability of simple technical trading rules based on nonparametric models which maximize the total returns of an investment strategy. Namely, the profitability of an investment strategy was evaluated against a simple *buy&hold* strategy on the security and its distance from the ideal net profit. Also, Chong and Ng (2008) examined the profitability of the MACD and Relative Strength Index (RSI). They used 60-year data of the London Stock Exchange FT30 Index and found that the RSI as well as the MACD rules can generate returns higher than the *buy&hold* strategy in most cases. Our research differs from these because we used the MACD and RVI indicators and examined their application to the stocks which are continually traded on the Belgrade Stock Exchange. Optimization of these indicators of the



technical analyses is done for each stock separately. Obtained results of the research are compared with a simple *buy&hold* strategy. Our intention is to determine by testing and monitoring stock market prices whether application of these indicators contribute to investment strategy optimization and if they are adequate and applicable on the Belgrade Stock Exchange, i.e. in transitional countries.

### 3. Methodology remarks

This section of the paper presents the research methodology which is particularly focused on the possibility of applying the method of technical analysis, i.e. MACD and RVI indicators, on financial market investment procedures in transitional countries. The methodology used in research includes analyses, synthesis and statistical/mathematical methods with special attention on the method of moving averages. Mathematical part of the research has been realized through Microsoft Excel as well as MetaStock software.

Since it is used with the indicators, the exponential moving average will be discussed in more details. *The exponential moving average* (EMA) allows for the most recently pricing activities to generate a faster change of average. There are two ways to calculate the exponential moving average: percentile and with regard to the interval. Exponential moving average (EMA) is a weighted average of today's close and the preceding EMA value. The weight for today's close is a smoothing factor alpha,

$$EMA[\text{today}] = \alpha * \text{close} + (1-\alpha) * EMA[\text{yesterday}], \quad (1)$$

where  $\alpha=2/(n+1)$ .

Thus, the MACD calculation is:

$$\sum_{i=1}^n EMA_k(i) - \sum_{i=1}^n EMA_d(i)$$

$$\text{where } EMA_n(i) = \alpha \cdot p(i) + (1-\alpha) \cdot EMA_n(i-1) \quad (2)$$

$$\alpha = \frac{2}{1+n} \quad \text{where } n - \text{number of days}$$

$$p(i) - \text{asset price on } i^{\text{th}} \text{ day}$$

As previously mentioned, the Relative Volatility Index (RVI) by Donald Dorsey is similar to the Relative Strength Index (RSI) but where the RSI adds up price change amounts based on price direction, the RVI instead adds standard deviations based on price direction. Thus, the RVI calculation is:

$$\begin{aligned}
 S &= \text{Stddev}[10 \text{ days}] \\
 U &= \begin{cases} S & \text{if } p(i) > p(i-1) \\ 0 & \text{otherwise} \end{cases} \\
 RVI &= 100 * \frac{EMA_{14}(U)}{EMA_{14}(S)}
 \end{aligned} \tag{3}$$

Also, if there is more values during the trading day, then average for that specific day can be calculated, but in our research we have only one value. Standard deviation is calculated for 10 days and EMA for 14 days.

$$RVI = \frac{RVI_{\text{orig of highs}} + RVI_{\text{orig of lows}}}{2} \tag{4}$$

The scope of the paper is on the financial market of the Republic of Serbia in terms of analyzing and surveying the possibilities of applying indicators of technical analysis, MACD and RVI indicators, to the stocks which are continually traded on the above mentioned market, with the goal to optimize the investment strategy. Hence, two investment strategies are tested in this research, i.e. one that comprise the optimization of technical analysis indicators with aim of achieving maximization of investment processes and other that is based on simple *buy&hold* approach. Having in mind the characteristics of the MACD and RVI indicators of technical analysis, the research of its application includes stocks which are continually traded in the period between June 2004 and May 2008 on the financial market of the Republic of Serbia, i.e. on Belgrade Stock Exchange Inc. Belgrade. Stocks traded by the method of prevailing price are inappropriate for technical analysis due to the way they are traded, which means that during a trading day there is only one coupling of biddings precisely at 12:00 and that virtually all transactions are completed at the same price. Frequently, in these conditions, there are no biddings to couple on the part of demand and supply, which practically mean that on that day there is no transaction at all. Since the volume of trading with stocks by this method is small and often there is no transaction carried out for weeks or even months, these stocks are inappropriate for technical analysis and they are not included in the research. Stocks traded according to this method could be traded at any moment of the trading day, i.e. every working day from 10:00 to 13:00. This implies more accomplished transactions during the trading, at different prices depending on supply and demand of the trading subject. Having all the above mentioned in mind, this research analyzes the possibility of application of the MACD and RVI indicator to stocks which are traded by the continuous trading method on the financial market of the Republic of Serbia.



The research described in this paper includes the identification of the most profitable parameters of the MACD and RVI indicator of technical analysis. Namely, the empirical analysis in this work is based on the optimization of moving averages at the MACD indicator, as well as on adjustment of the RVI indicator's confirmation parameters, all these as function of optimization of the investment strategy on the financial market, i.e. maximization of profitability of the given process. It is important to emphasize that the intervals of moving average at the MACD indicator represent parameters which are optimized in the research, while at the RVI indicator only the parameter of confirmation limit is optimized. Optimization procedure required determination of the most optimal number of days for the MACD calculation, while monitoring the volatility of the stock market price. We optimized MACD parameters that are maximizing the investment process. Namely, we considered different time periods for the MACD calculation, starting from shortest to longest and we determined which combination is the most optimal for each stock. Thus, we calculated the most optimal combination of days for each stock separately as functions of yield maximization. Afterward, the RVI indicator is used as a confirming indicator for the calculated value of the MACD indicator. The results are compared with the basic 12-26-9 MACD indicator and *buy&hold* approach. The out of the sample backtesting procedure implied using already determined combinations of parameters for the MACD and RVI indicator.

Previously, it is said that the author of the MACD indicator (G. Appel) proposed the 12-26-9 combination of moving averages and that development of software solutions enabled cheaper and faster way of continuous research of the most profitable combination of moving averages in the period under observation. This virtually implies that it is useful to investigate the historically most profitable combination of the MACD indicators' moving averages with regard to different characteristic periods dependent on the trend movement direction. Such principle of application of the MACD indicators could be applied also to some characteristic stock groups or to the entire financial market. The purpose of the RVI indicator is primarily to neutralize downward trend signal of the MACD indicator. This paper investigates the combination of the above mentioned parameters that yields in the best possible result depending on the nature of change of the stock's market price.

The calculation of profitability of a MACD parameters combination is accomplished by calculating the faster and slower exponential moving averages for the given interval according to the formula (1). The MACD line is obtained by subtraction of the slower moving average from the faster one, and its signal line is obtained using the same formula with the difference of taking the value of the already calculated MACD instead of the price. When the MACDs' value becomes higher than its signals' exponential moving average, the buying signal occurs, and when its value becomes lower than its signals' value, the selling signal occurs. All possible combinations of parameters have to be considered, starting from the shortest of 2,

3, 2 (2 – shorter moving average, 3 – longer moving average, 2 – signal moving average) through the longest of 29, 30, 20. Longer moving averages were not considered due to the general unprofitability with all stocks. Charges are added to the buying price at which a transaction is accomplished, and from the selling price they are subtracted. From the so obtained values the difference is calculated of which the 10% capital return tax is subtracted if the difference is positive, i.e. if the investor realized profit. In the case if the selling price is lower than the buying, the capital loss of 10% is added to the negative difference. The capital loss is set-off with capital return which is generated in the later trading. To simplify the process, it is calculated as profit, i.e. decreasing of loss. One trading cycle is made of the buying and the next selling signal. The increase or decrease percentage is calculated from the values obtained after the subtraction of all taxes and charges. The increase or decrease percentage is of all subsequent trading cycles to the last one, after which the total profitability of the MACD signal for the given intervals of moving average, is calculated by using the principle of conform interest-bearing. After that, the total profitability of each combination of moving averages is calculated and the combination of the highest profitability is identified. Then, all buying signals of the most profitable combination are compared with the values of the RVI indicator for the same day, and if this value is lower than the defined limiting value, the actual buying signal is neutralized, i.e. the investor avoids buying based on this signal. After that, the total profitability of the MACD signal is calculated with the condition of RVI confirmation for every given limiting value from 40% to 65%. The optimum confirmation limit is the one with the highest total profitability. As with the MACD indicators, where it is necessary to adjust the parameters of moving averages, also at the RVI indicators it is necessary to adjust its parameters that represent the confirmation limit. The movement of any stock price has its own particularities which the RVI must take into account during the definition of the limiting value for confirmation of other indicators' signal. In this research only the parameter of confirmation limit is adjusted, while for the interval for which the RVI is taken, the standard 14-days value will be used. With adjustment of the interval under consideration the RVI may have different levels of responsiveness to price changes. A shorter interval would affect the RVI in the way that it would increase or decrease rapidly according to the short-term price changes, while at longer intervals, RVI would move around the average value, mainly between 40-60%. By excluding virtually all the unnecessary extremely short and long intervals, the change of intervals with appropriate change of the confirmation limit would virtually yield the same results. Therefore, regardless to the interval that was taken, by moving the confirmation limit, the most profitable parameters of the RVI indicator from the previous period may be obtained. The basic interval of 14 days is the mean value which is applicable to almost all levels of price volatility. Profitability of the *buy&hold* investment strategy is calculated by taking the price of the first buying signal of the most profitable MACD combination of moving averages as the buying price, and taking the price of the last selling signal as the selling price.

## 4. Data

Having in mind that the organizer of the securities and other financial instruments on the financial market of the Republic of Serbia is the Belgrade Stock Exchange, the data used in the analyses of the MACD and RVI indicators are the daily stock market prices. Due to data availability and possibility of its dynamic processing monitoring, i.e. application of the MACD and RVI indicators of the technical analysis, specimen in the research comprises stocks which were continuously traded between June 2004 and May 2008 on the financial market of the Republic of Serbia. In that time frame, the possibility of application of the MACD and RVI indicators of the technical analysis in the investment decision making processes on the financial market can be determined, both in upward, lateral and downward trend. To secure the out of the sample backtesting period for all of the tested stocks, the out the sample procedure was run in the period from May 2008 to May 2009 with aim to validate obtained results in new time interval. The out of the sample backtesting period includes the latest financial market crisis in the global and regional financial markets. The out of the sample backtesting procedure implies calculation of afore optimized MACD and RVI indicator parameters application for each stock for the period of 255 trading days.

The data in the paper are presented in Tables (Appendices). Namely, Table 1 shows the names of corporations with their stock symbols, while Table 2 shows the trading results based on signals generated by the optimized MACD and RVI indicators. The first column of Table 1 shows the symbol of stocks on the Belgrade Stock Exchange. Table 3 presents trading results based on the optimized MACD and RVI indicators in upward trend, while Table 4 and 5 presents trading results based on the optimized MACD and RVI indicators in lateral and downward trend, respectively. The first column of Tables 2-7 presents symbol of stocks on the Belgrade Stock Exchange, while the second, third and fourth column are the shorter moving average, longer moving average and the signal moving average, respectively. The fifth column shows the trading results of the optimized MACD indicator with the most profitable combination of moving averages shown in the previous three columns, while the sixth column shows the number of trading cycles occurring with the above mentioned combination of moving averages. The seventh column shows the trading results of the MACD indicator with standard intervals of moving averages of 12, 26 and 9 days. The ninth column shows the trading results with the RVI confirmation with optimum limiting values shown in the eight column. Analogue to the sixth column, the tenth column shows the number of trading cycles with the RVI confirmation, whose results are shown in the ninth column. The eleventh column shows the results of the *buy&hold* approach. The twelfth column shows the number of days on which the actual stock was traded on the Belgrade Stock Exchange.

## 5. Results and discussion

This section of the paper presents and analyzes the trading results based on signals generated by the MACD (*Moving Average Convergence Divergence*) and RVI (*Relative Volatility Index*) indicators of technical analysis. Namely, application possibilities of these indicators are investigated and their most profitable parameters as functions of optimization of the investment strategy have been identified.

Based on this paper's research and in accordance with the described methodology in Section 3, the stated hypotheses are confirmed.

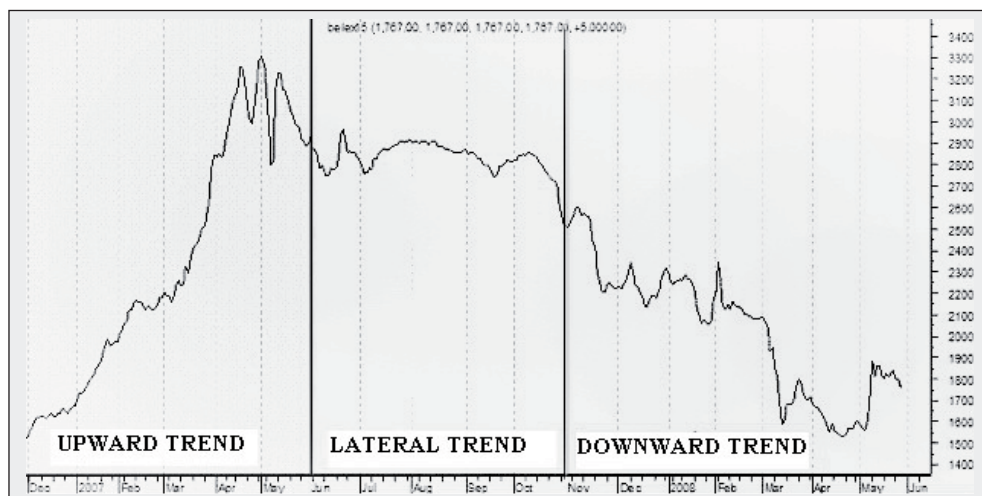
Hypothesis 1 stated that the application of the MACD and RVI indicators significantly contributes to investment strategy optimization on the financial market. Findings in the Appendices confirm this hypothesis. Based on the Table 2 (Appendices) it could be concluded that the average of the most profitable combinations of intervals of moving averages is 12-20-8, which is close to the optimum value defined by the author of the MACD indicator. However, the average total profitability of the basic MACD indicator with intervals of 12-26-9 is 53.62%, which is significantly lower than the average total profitability of the *buy&hold* approach, which is 188.39%. This fact indicates the validity of identification of the MACD indicators' optimum parameters, though in the average, the most profitable intervals are close to the values of basic intervals. The average total profitability of application of the MACD indicator with optimized parameters is 289.63% which is significantly higher than in the case of application of the *buy&hold* approach. The average number of trading cycles at optimum parameters of the MACD indicator is 40. By using the principle of confirmation by the RVI indicator, the average number of trading cycles of achievement of the most profitable combination of the MACD parameters is significantly decreased from 40 to 19. This means that the investor was in position to hold his capital in monetary value for longer time or to invest it into less risky stocks which imply lower return. This is certainly better than to invest it into the actual stock in the wrong time. The total average profitability of the MACD indicator with RVI confirmation is 325.85%, which implies higher profit with less capital involved. The average optimum limiting value of the RVI indicator is 49%. This is only for 1% less than the basic value defined by the author of this indicator. However, the setting an average limiting value for the parameter of the RVI indicator at every stock would result in lower total profitability, so its optimization is necessary for each stock separately in order to achieve maximum total profitability of the investment strategy on the financial market. The out of the sample backtesting procedure confirms the above findings and hypothesis. Hence, the average total loss of application of the MACD indicator with optimized parameters is -2.81% which is significantly lower than loss in the case of application of the *buy&hold* approach (-65.87%). The average total loss of the basic MACD indicator with intervals of 12-26-9 is -4.55% which is higher value than the obtained

optimized MACD parameters value (Table 6). The out of the sample results are all with negative values and the downward trend for the entire time period (total loss for all observed stocks in the period 15.05.2008-18.05.2009 is 63.57%).

Thus, in that situation any combination of days for the MACD calculation would result in negative values. Small scale of trading in this period influenced on the MACD calculation because some values were transferring on several consecutive days which affected on moving averages.

Hypothesis 2 stated that the MACD and RVI indicators are adequate for monitoring and assessment of the stock market prices on financial markets in transitional countries. Findings in the Appendices confirm this hypothesis. Hence, the trends of the stock market prices movement on the Belgrade Stock Exchange are important for determining the level of profitability of the MACD and RVI indicators and monitoring and assessment of the stock market price (Figure 1). The upward trend occurred in the period between December 2006 and May 2007, the lateral trend between June 2007 and October 2007, and the downward trend between November 2007 and May 2008. The optimum parameters of the MACD and RVI indicators of technical analysis have been identified in these different characteristic trends within the observed period of time.

Figure 1: The trends of the stock market prices movement on the Belgrade Stock Exchange



Source: Author's calculations

Table 3 (Appendices) shows the trading results based on the optimized MACD and RVI indicators in upward trend. Stock prices in the period of upward trend from December 2006 and May 2007 were taken under consideration. The average total



profitability of applied optimized MACD indicator is somewhat lower than the profitability of the *buy&hold* approach in upward trend and is 117.34%, while the application of the principles of the RVI confirmation would yield poorer results. The most profitable parameters imply somewhat shorter intervals of moving averages of 7, 13 and 4 days. Table 4 (Appendices) shows the trading results according to the optimized MACD and RVI indicators in lateral trend. Only the stock market prices from the period between June 2007 and October 2007 were considered. The average total profitability of MACD signals is higher in comparison with the profitability of the *buy&hold* approach in lateral trend, and is 5.66%, which is still a significant increase since the average loss of the *buy&hold* approach is -8.32%. Using the principle of the RVI confirmation, the results would minimally improve and then the average total profitability would amount 6.49%. The intervals of moving averages are at standard levels, with average values of 15, 23 and 10 days. The lateral trend is characterized by a very small number of trading cycles, which is 2 on the average, and with the RVI confirmation there is only one trading cycle on the average. Table 5 (Appendices) shows the trading results based on the optimized MACD and RVI indicators in downward trend. Only the stock market prices in the period of downward trend between November 2007 and May of 2008 were considered. The average total profitability of MACD signals is 4.61%, which is an outstanding result considering the fact that the average loss of the *buy&hold* approach is - 21.86%. With the RVI confirmation the result is slightly improved to 6.42%. The average optimum intervals of moving averages are 12, 18 and 10 days, which is somewhat shorter than the optimum intervals of the lateral trend. The average number of trading cycles is 6, and with the RVI confirmation it is 2, which is somewhat higher than for the lateral trend.

According to the afore results, it can be concluded that application of the MACD indicator in upward trends provides better results with faster combination of moving averages. Thus, the confirmation limit of the RVI indicator increases along with the rise of stock's market price, and as a result, most of the MACD signals are confirmed allowing profit generation. Trading based on signals of the MACD indicators at *downward trend* yields with smaller losses in the case of use of longer moving averages of the MACD. At the *lateral trend* of stocks market price movement, trading based on the MACD indicators' signal largely depends on volatility in the period under observation. In the case of small price volatility, the MACD signals are not much useful, while in the reverse case significant profits may be achieved even if the price remains at the same level as at the beginning of the period under observation. At the lateral price movement with small volatility, the path of the curve representing the values of the RVI indicator in the charts is mainly similar as that of the price and slightly varies around 50%. Therefore, it is necessary to set the values of the confirmation limit higher in order to neutralize any unprofitable signals. The use of slower moving averages and the optimization of the limit confirmation of RVI indicators at lateral and downward trend caused the



decrease of the number of trading cycles, and thereby the avoidance of unprofitable buying signals. This absolutely confirms the appropriateness of the process of identifying the optimum moving averages of the MACD indicator and filtering their signals by RVI indicator. At the upward trend, on the average, the profitability of the *buy&hold* approach is not higher than that of the MACD indicator. However, after the upward trend, the investor who applied the *buy&hold* approach would realize certain loss in the downward trend, while in the case of the MACD indicator he would realize certain lower profit. This leads to the conclusion that generally, the application of the MACD indicator is more profitable than the use of the *buy&hold* approach.

The out of the sample backtesting procedure was performed only for downward trend, because upward and lateral trend are not present in the observed time period. The out of the sample backtesting procedure confirms the above findings and hypothesis. The out of the sample results imply that the *buy&hold* approach has higher total average loss compared with application of the optimized MACD and RVI indicators (Table 7). Namely, the average total loss of MACD signals is -2.05%, which is an outstanding result considering the fact that the loss of the *buy&hold* approach is - 64.79%. The average number of trading cycles is 16, and with the RVI confirmation it is 8.

## 6. Conclusion

The research confirmed the main hypothesis that the application of the MACD and RVI indicators of technical analysis significantly contributes to investment strategy optimization on the financial market. The results imply that the MACD and RVI indicators are effective upon formulating and optimizing investment strategy on financial market in transitional country. It can be concluded that investment strategy that comprise the optimization of technical analysis indicators is more profitable than the one that is based on simple *buy&hold* approach. Namely, it is important to determine optimal parameters of the MACD and RVI indicators for each stock separately. That is especially determined while calculating the profitability of the basic 12-16-9 and optimized MACD indicator. Accordingly, trends of stock market price movement are volatile in time and once determined values of the optimized MACD and RVI parameters are not the most profitable one in the future. Thus, it is important to optimize these parameters in time and recalculate their values for each stock, especially when there are significant changes in stock exchange trading (stock market price movement, scale of trading, number of trading days, etc.). Based upon research results and data presented in appendices, it is determined that the highest profitability of the investment strategy that comprises the optimization of technical analysis indicators is obtained exactly on the optimized MACD and RVI parameters. The advantage of application of these indicators of technical analysis

in comparison with the investment strategy that is based on simple *buy&hold* approach is especially obvious in markedly volatile conditions on the financial market, in lateral and downward, as well as upward trend. Hence, these results offer domestic and foreign investors important information based on the empirical and scientifically verified results about the investment strategy optimization, i.e. the basis for the adequate investment decision making process.

The out of the sample backtesting results imply that all optimized MACD parameter values result in total average loss of the investment process, although significantly less than the *buy&hold* approach. Also, application of the RVI indicator caused higher total profitability of the afore mentioned investment strategy. Regarding transitional countries, while monitoring and assessment of the stock market prices, more frequent investment strategy optimization is needed because of developing financial market that characterize small scale and frequency of trading.

This research also has its share of limitations. Thus, insufficient liquidity of the financial market of the Republic of Serbia, small scale of trading and historically speaking, asymmetrical and low number of trading days with certain stocks, limited historical trading data and intense market volatility are limiting factors in this research. Most of the instruments of technical analysis show its full potential, especially, in circumstances when a significant number of transactions continuously occur during the trading day. Stocks continuously traded on the Belgrade Stock Exchange are especially characterized by the fact that their turnover is low, with small number of transactions during the trading day, and frequently, there are no transactions at all, for several consecutive days. That fact presents a significant limitation which directly effects the calculation and application of the technical analyses indicators.

Finally, in this paper, we have used only data from the Belgrade Stock Exchange. Therefore, future research should include analyses, comparison and the backtesting of investment strategy optimization on other financial markets in transitional countries. According to the obtained data results in this research, the application of the MACD and RVI indicators indicates that the focus of future research in this area should be on dynamic optimization of these indicators in time, especially if having in mind that once determined values of the optimized MACD and RVI parameters are not necessarily the most profitable ones in the future.

## References

- Andrew, W. Lo, Mamaysky, Harry and Wang, Jiang (2000) "Foundations Of Technical Analysis: Computational Algorithms, Statistical Inference, And Empirical Implementation", *Journal of Finance*, Vol. 55, No. 4, pp. 1705-1765.

- Appel, Gerald (2005) *Technical Analysis: Power Tools For Active Investors*, Financial Times/ Prentice Hall
- Bessembinder, Hendrik and Chan Kalok (1998) "Market Efficiency and the Returns to Technical Analysis", *Department of Finance, College of Business, Arizona State University*, pp. 1-22
- Blume, Lawrence et. al. (1994) "Market Statistics and Technical Analysis: The Role of Volume", *Journal of Finance*, Vol. 49, Issue 1, pp. 153-181
- Brock, W., Lakonishok, J., and LeBaron, B. (1992) "Simple Technical Trading Rules and the Stochastic Properties of Stock Returns", *Journal of Finance*, Vol. 47, Issue 5, pp. 1731-1764
- Chong, T.T.L. and Ng, W.K. (2008) "Technical analysis and the London stock exchange: testing the MACD and RSI rules using the FT30", *Applied Economics Letter*, Vol. 15, Issue 14, pp. 1111-1114
- Dechow, Patricia M., Hutton, Amy P., Meulbroek, Lisa and Sloan, Richard G. (2001) "Short-sellers, fundamental analysis and stock returns", *Journal of Financial Economics*, Vol. 61, Issue 1, pp. 77-106
- Dorsey, Donald (1993) *Technical Analysis of Stocks and Commodities*, New York
- Gencay, R. (1998) "Optimization of technical trading strategies and the profitability in security markets", *Economics Letters*, Vol. 59, pp. 249-254
- Kaufman, Perry J. (2003) *A Short Course in Technical Trading*, John Wiley & Sons, Inc.
- Kavajecz, Kenneth A. and Odders-White, Elizabeth R. (2004) "Technical Analysis and Liquidity Provision", *The Review of Financial Studies, The Society for Financial Studies*, Vol. 17, No. 4, pp. 1043-1071
- Leigh, Stevens (2002) *Essential Technical Analysis: Tools and Techniques to Spot Market Trends*, John Wiley & Sons, Inc.
- Lo, A. and MacKinley, A. (1990) "Data snooping biases in tests of financial assets pricing models", *Journal of International Money and Finance*, Vol. 12, pp. 451-474
- Murphy, John. J. (1999) *Technical Analysis of the Financial Markets: A Comprehensive Guide to Trading Methods and Applications*, New York: New York Institute of Finance
- Tanaka-Yamawaki, M. and Tokuoka, S. (2007) "Adaptive use of technical indicators for the prediction of intra-day stock prices", *Physica A: Statistical Mechanics and its Applications*, Elsevier, Vol. 383, Issue 1, pp. 125-133

## Primjena MACD i RVI pokazatelja u funkciji optimizacije strategije investiranja na financijskom tržištu

Dejan Erić<sup>1</sup>, Goran Anđelić<sup>2</sup>, Srđan Redžepagić<sup>3</sup>

### Sažetak

Determiniranje trendova i predviđanje cijena dionica jedna je od ključnih zadaća MACD (Moving Average Convergence Divergence) i RVI (Relative Volatility Index) pokazatelja tehničke analize. Istraživanje u radu obuhvaća uzorak koji predstavljaju dionice s kojima se kontinuirano trguje na financijskom tržištu u Republici Srbiji. Predmet istraživanja je sagledavanje mogućnosti primjene MACD i RVI pokazatelja tehničke analize u procesima donošenja odluka o investiranju na financijskom tržištu Republike Srbije. Glavni cilj istraživanja je pronalaženje najprofitabilnijih parametara MACD i RVI pokazatelja u funkciji optimiziranja strategije investiranja na financijskom tržištu. Temeljna pretpostavka rada je da se primjenom MACD i RVI pokazatelja tehničke analize u procesima generiranja odluka o investiranju na financijskom tržištu u znatnoj mjeri doprinosi optimiziranju strategije investiranja. Primijenjena metodologija u radu obuhvaća metode analize, sinteze i statističko-matematičke metode s naročitim akcentom na metodu pokretnih prosjeka. Rezultati provedenog istraživanja ukazuju na značajnu mogućnost primjene MACD i RVI pokazatelja tehničke analize u funkciji donošenja optimalnih odluka o investiranju. Analizirajući rezultate do kojih se došlo istraživanjem provedenim u okviru rada zaključuje se da se primjenom optimiziranih MACD i RVI pokazatelja tehničke analize u procesima generiranja odluka o investiranju na financijskom tržištu značajno doprinosi maksimizaciji profitabilnosti od aktivnosti investiranja.

**Ključne riječi:** tehnička analiza, MACD pokazatelj, RVI pokazatelj, strategija investiranja, financijsko tržište.

**JEL klasifikacija:** G10, G11

<sup>1</sup> Redoviti profesor, Institut ekonomskih znanosti, Zmaj Jovina 12, 11000 Beograd, Srbija. Znanstveni interes: ekonomija i menadžment. Tel.: + 381 11 26 22 357. Mob: + 381 64 23 11 233. Fax: + 381 11 26 23 055. E-mail: dejan.eric@ien.bg.ac.rs

<sup>2</sup> Docent, Sveučilište u Novom Sadu, Fakultet tehničkih znanosti, Trg Dositeja Obradovića 7, 21000 Novi Sad, Srbija. Znanstveni interes: investicijski menadžment. Tel.: + 381 21 485 2190. Mob: + 381 63 555 619. Fax: + 381 21 6350 300. E-mail: gandjelic@iis.ns.ac.yu

<sup>3</sup> Docent, Istraživač, Institut ekonomskih znanosti, Zmaj Jovina 12, 11000 Beograd, Srbija. Znanstveni interes: međunarodna ekonomija. Tel.: + 381 11 2623 578. Fax: + 381 11 2181 471. E-mail: srdjan.redzepagic@ien.bg.ac.rs

## Appendices

Table 1: Symbols of stocks being traded by continuous method on the Belgrade Stock Exchange

Stock symbol on the s.e.	Corporation	Stock symbol on the s.e.	Corporation
AGBC	Agrobacka Inc., Backa Topola	MTLC	Metalac Inc., Gornji Milanovac
AGBN	Agrobanka Inc., Belgrade	NAVP	Navip Inc., Zemun
AGRC	Agrocoop Inc., Novi Sad	NPRD	Napred GP Inc., Belgrade
AIKB	AIK banka Inc., Nis	PLNM	Planum GP Inc., Belgrade
ALFA	Alfa plam Inc., Vranje	PLTK	Politika Inc., Belgrade
BMBI	Bambi Banat Inc., Belgrade	PRBN	Privredna banka Inc., Belgrade
BNNI	Banini Inc., Kikinda	PRGS	Progres Inc., Belgrade
CCNB	Cacanska banka Inc., Cacak	PTLK	Pupin Telecom Inc., Zemun
CYBN	Credy banka Inc., Kragujevac	PUUE	Putevi Inc., Uzice
DJMN	Dijamant Inc., Zrenjanin	RDJZ	Radijator Inc., Zrenjanin
DNOS	Dunav osiguranje Inc., Belgrade	RMBG	Ratko Mitrovic Inc., Belgrade
EGMN	Energomontaza Inc., Belgrade	SJPT	Sojaprotein Inc., Becej
ENHL	Energoprojekt holding Inc., Belgrade	SMPO	Simpo Inc., Vranje
FIDL	Fidelinka Inc., Subotica	TGAS	Messer Tehnogas Inc., Belgrade
FITO	Galenika Fitofarmacija Inc., Zemun	TIGR	Tigar Inc., Pirot
GLOS	Globos osiguranje Inc., Belgrade	TLFN	Telefonija Inc., Belgrade
IKRB	Ikarbus Inc., Zemun	UNBN	Univerzal banka Inc., Belgrade
IMLK	Imlek Inc., Belgrade	UNVR	Univerzal - holding Inc., Belgrade
INFM	Informatika Inc., Belgrade	VDAY	Voda Vrnjci Inc., Vrnjacka Banja
IRTL	Iritel Inc., Belgrade	VINZ	Vino Zupa Inc., Aleksandrovac
JMBN	Jubmes banka Inc., Belgrade	VITL	Vital Inc., Vrbas
KMBN	Komercijalna banka Inc., Belgrade	VLFR	Veľefarm Inc., Belgrade
LSTA	Lasta Inc., Belgrade	VZAS	Veterinarski zavod Inc., Subotica
MTBN	Metals banka Inc., Novi Sad	ZOPH	Zorka Pharma Inc., Sabac

Source: Belgrade Stock Exchange Inc. Belgrade (<http://www.belex.rs>)

Table 2: Trading results based on the optimized MACD and RVI indicators

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cye.	12,26,9 %	Lim. conf.	RVI result %	Tr. cye.	Buy& hold %	No.of tr.days
AGBC	2	4	2	94.16	41	-45.95	46	71.51	15	-0.96	303
AGBN	3	4	4	82.03	63	-24.28	40	167.45	33	1.34	605
AGRC	2	3	2	240.97	48	-59.57	56	318.70	13	7.03	308
AIKB	23	30	13	81.84	11	57.46	49	106.64	8	191.66	642
ALFA	29	30	4	28.57	20	4.99	52	102.27	6	-11.17	889
BMBI	24	30	16	99.20	10	-31.16	41	99.20	10	131.48	853
BNNI	18	26	14	61.01	10	13.23	46	53.11	7	37.33	754
CCNB	25	26	2	228.62	34	194.93	53	81.37	17	142.76	867
CYBN	3	15	3	8.67	31	-48.2	57	62.27	7	-22.14	385
DJMN	29	30	8	220.16	13	107.51	47	249.83	8	337.85	689
DNOS	5	25	12	272.95	24	85.46	49	300.12	15	220.13	840
EGMN	7	8	2	8.78	17	-21.21	55	41.08	5	13.72	193
ENHL	26	28	14	484.10	16	207.26	53	564.61	8	862.35	964
FIDL	2	4	3	186.92	101	6.33	48	278.50	36	102.88	805
FITO	23	26	17	356.90	14	192.58	41	431.89	11	239.51	966
GLOS	23	26	5	414.23	17	245.16	43	555.06	10	286.97	853
IKRB	23	30	11	18.39	3	3.17	49	35.49	2	-1.76	266
IMLK	20	27	2	426.97	45	161.16	40	432.98	36	271.09	971
INFM	2	7	18	58.56	13	39.83	46	42.96	5	39.5	259
IRTL	13	14	20	-15.63	4	-24.36	60	-8.68	1	-33.63	259
JMBN	3	29	2	710.35	69	188.15	41	1188.51	52	366.13	880
KMBN	21	22	2	34.46	18	4.07	59	85.99	6	17.03	437
LSTA	2	5	2	48.65	21	-22.13	47	56.14	12	-13.52	176
MTBN	2	22	12	-31.33	16	-44.07	50	-2.70	1	-43.64	348
MTLC	12	13	18	298.36	20	250.25	54	402.66	6	114.04	968
NAVP	2	10	2	131.11	47	5.59	54	122.39	9	-30.72	435
NPRD	2	29	2	500.72	85	36.12	42	315.57	66	484.84	967
PLNM	2	15	2	757.08	91	113.28	40	497.90	74	255.8	852
PLTK	25	26	20	-43.75	3	-70.22	42	-21.77	1	-46.9	281
PRBN	3	22	2	-5.63	46	-28.79	52	40.60	8	-24.41	472
PRGS	27	30	13	35.20	9	-20.73	40	35.20	9	14.11	677
PTLK	19	21	9	107.99	31	-21.46	62	303.95	3	192.6	918
PUUE	29	30	20	830.64	14	154.05	41	737.02	12	1700.52	958
RDJZ	28	30	17	-1.42	10	-62.74	55	70.75	3	-46.18	707
RMBG	2	8	2	92.95	118	-62.18	44	145.59	61	-51.75	849
SJPT	29	30	19	749.54	14	347.33	50	1253.34	14	709.98	965
SMPO	2	15	2	336.07	75	-15.3	46	51.94	30	-42.25	618
TGAS	21	26	2	551.94	35	356.66	40	918.75	26	679.44	952
TIGR	16	29	19	-22.39	21	-43.17	54	34.95	7	-9.5	738
TLFN	2	11	2	574.02	81	129.02	52	308.53	23	76.36	747
UNBN	6	20	12	92.98	18	86.87	47	118.86	9	65.69	582
UNVR	2	5	2	2564.71	106	203.33	55	3053.09	27	392.87	965
VDAV	2	3	18	274.54	56	13.85	46	396.17	37	156.19	834
VINZ	2	7	2	376.83	19	-0.18	40	389.13	8	539.31	151
VITL	2	6	2	696.43	59	-60.02	57	117.21	18	77.03	516
VLFR	2	20	2	355.10	89	-28.23	48	298.78	46	254.44	964
VZAS	3	30	2	244.07	66	30.42	51	285.22	30	230.59	807
ZOPH	2	30	2	285.83	125	69.45	50	450.62	59	208.72	968
Average	12	20	8	289.63	40	53.62	49	325.85	19	188.39	675

Source: Author's calculations



Table 3: Trading results based on the optimized MACD and RVI indicators in upward trend

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cyc.	12,26,9 %	Lim. conf.	RVI result %	Tr. cyc.	Buy& hold %	No.of tr.days
AGBC	2	3	2	16.06	4	0	0	0	0	-4.84	303
AGBN	2	4	2	14.61	13	-14.07	50	14.24	4	-4.30	605
AGRC	2	3	2	106.17	6	0.00	57	126.51	4	50.19	308
AIKB	2	7	2	106.80	11	0.33	44	106.80	11	84.33	642
ALFA	21	23	2	5.01	4	-7.34	56	12.04	1	-1.77	889
BMBI	28	29	14	37.88	1	9.16	48	37.88	1	80.52	853
BNNI	3	5	11	41.47	6	27.41	50	45.75	4	89.66	754
CCNB	10	24	3	41.59	2	19.63	46	41.59	2	39.78	867
CYBN	4	7	2	60.89	9	11.40	42	60.89	9	78.81	385
DJMN	23	30	3	133.87	2	74.06	48	133.87	2	127.44	689
DNOS	3	9	2	121.82	9	23.48	41	80.32	7	115.10	840
ENHL	2	3	2	175.60	17	45.32	41	175.60	17	157.16	964
FIDL	2	3	2	284.19	19	44.65	42	194.40	18	332.93	805
FITO	2	6	2	95.56	15	37.58	40	118.44	9	123.66	966
GLOS	2	26	2	80.25	12	26.79	47	92.29	10	91.36	853
IMLK	2	7	2	144.92	12	58.75	42	62.55	9	77.10	971
JMBN	2	18	2	88.41	12	-4.10	42	96.36	11	80.82	880
KMBN	24	26	4	70.35	2	36.50	51	70.35	2	75.79	437
MTBN	2	21	2	16.38	6	-5.89	40	20.47	3	-1.13	348
MTLC	3	9	5	60.20	6	18.09	43	60.20	6	43.39	968
NAVP	2	29	2	182.50	7	27.77	43	182.50	7	118.32	435
NPRD	2	4	2	158.14	14	37.33	42	140.50	13	198.81	967
PLNM	24	25	9	54.32	2	20.14	46	54.32	2	67.04	852
PRBN	3	5	3	48.08	11	-8.91	43	53.92	10	56.36	472
PRGS	2	13	5	61.13	8	4.40	47	53.52	3	56.59	677
PTLK	15	16	15	9.46	2	-10.05	41	9.46	2	-3.44	918
PUUE	2	26	3	70.43	7	-1.64	52	81.52	5	101.98	958
RDJZ	24	26	2	84.76	3	66.74	42	84.76	3	70.87	707
RMBG	2	4	2	73.80	22	-0.37	40	67.03	19	34.45	849
SJPT	4	6	3	76.80	11	17.09	47	76.80	11	163.86	965
SMPO	2	17	2	120.13	9	51.01	44	82.10	8	199.97	618
TGAS	2	9	2	109.01	14	41.85	48	109.01	14	134.40	952
TIGR	3	17	12	76.09	2	36.24	44	76.09	2	36.45	738
TLFN	2	3	2	339.20	20	0.00	53	264.72	8	153.53	747
UNBN	11	14	3	58.32	4	-12.42	40	58.32	4	54.37	582
UNVR	2	5	2	420.09	13	132.80	53	444.35	9	527.79	965
VDAV	4	10	2	107.64	8	36.34	48	104.85	6	108.38	834
VITL	2	7	2	723.17	11	220.14	46	126.59	5	686.70	516
VLFR	4	5	2	31.69	13	3.97	54	59.63	5	91.68	964
VZAS	3	21	2	274.07	8	195.12	46	274.07	8	519.08	807
ZOPH	26	27	3	29.87	1	18.88	45	29.87	1	24.45	968
Average	7	13	4	117.34	9	31.95	46	99.61	7	122.87	752

Source: Author's calculations

Table 4: Trading results based on the optimized MACD and RVI indicators in lateral trend

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cyc.	12,26,9 %	Lim. conf.	RVI result %	Tr. cyc.	Buy& hold %	No.of tr.days
AGBC	2	28	2	3.31	8	-9.22	0	0.00	0	-3.68	303
AGBN	6	16	7	2.37	1	-4.98	0	0.00	0	-29.73	605
AGRC	2	30	19	0.00	0	-6.24	0	0.00	0	-21.22	308
AIKB	2	9	20	1.99	1	-5.76	42	1.99	1	-9.27	642
BMBI	24	30	10	9.66	1	3.70	42	9.66	1	-4.23	853
BNNI	18	21	5	-7.78	3	-2.24	0	0.00	0	-9.48	754
CCNB	24	25	7	6.64	2	-13.88	55	10.35	1	0.65	867
CYBN	29	30	20	-6.32	1	-22.22	0	0.00	0	-7.57	385
DJMN	21	29	14	1.88	1	-7.63	52	1.88	1	-5.32	689
DNOS	25	29	2	-2.68	1	-3.42	0	0.00	0	-20.91	840
EGMN	7	21	2	18.69	1	0.00	52	18.69	1	18.65	193
ENHL	22	23	4	0.98	3	-7.50	45	0.98	3	-8.16	964
FIDL	6	23	3	21.24	3	-8.96	56	1.80	1	0.87	805
FITO	17	18	15	11.08	1	-4.24	0	0.00	0	-13.75	966
GLOS	7	10	7	28.20	3	5.71	41	17.65	2	21.85	853
IKRB	17	27	2	7.85	3	3.62	43	7.85	3	-1.21	266
IMLK	21	22	3	10.77	2	1.70	45	6.99	1	-1.47	971
INFM	2	21	6	88.92	4	63.92	52	42.89	1	63.89	259
IRTL	19	21	7	3.57	1	-3.64	0	0.00	0	-18.98	259
JMBN	11	13	15	8.48	2	1.27	40	8.48	2	-8.55	880
KMBN	3	7	17	6.22	2	-0.62	40	1.54	1	-9.35	437
MTBN	24	29	17	-5.60	1	-9.96	0	0.00	0	-21.00	348
MTLC	26	29	19	-6.59	2	-13.89	0	0.00	0	-13.78	968
NAVP	18	30	13	-17.83	4	-15.56	0	0.00	0	-27.32	435
NPRD	6	13	6	5.01	3	-7.47	47	5.23	2	16.79	967
PLNM	11	12	13	34.28	3	26.97	40	34.28	3	40.17	852
PLTK	8	29	7	-14.93	3	-15.90	0	0.00	0	-40.27	281
PRBN	2	22	3	1.55	2	0.00	40	0.31	1	-20.20	472
PRGS	29	30	20	-3.59	1	-19.72	0	0.00	0	-29.58	677
PTLK	22	25	19	2.92	1	-17.43	45	2.92	1	-11.74	918
PUUE	22	25	11	41.98	1	26.18	48	41.98	1	57.80	958
RDJZ	19	23	4	-24.32	5	-29.06	0	0.00	0	-29.03	707
RMBG	2	7	2	20.42	11	-17.16	40	22.60	10	-27.50	849
SJPT	8	10	15	0.53	2	-4.73	42	0.53	2	-33.34	965
SMPO	18	23	5	8.75	1	0.00	47	8.75	1	-29.02	618
TGAS	2	30	14	7.49	1	4.35	46	7.49	1	10.68	952
TIGR	20	21	12	-4.01	1	-8.41	0	0.00	0	-23.99	738
TLFN	29	30	20	-3.42	1	-11.43	0	0.00	0	-15.51	747
UNBN	23	27	5	-2.99	1	-5.86	0	0.00	0	-7.83	582
UNVR	26	27	15	-7.73	1	-14.16	0	0.00	0	-28.85	965
VDAV	17	18	17	18.06	1	-9.55	46	18.06	1	-2.09	834
VITL	21	24	10	-9.74	2	-20.00	0	0.00	0	-20.54	516
VLFR	7	28	12	-13.48	4	-10.93	0	0.00	0	-22.56	964
VZAS	2	30	5	5.70	1	-1.98	43	5.70	1	-20.37	807
ZOPH	22	26	8	6.97	1	-8.23	43	6.97	1	-8.50	968
Average	15	23	10	5.66	2	-4.55	45	6.49	1	-8.32	693

Source: Author's calculations

Table 5: Trading results based on the optimized MACD and RVI indicators in downward trend

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cyc.	12,26,9 %	Lim. conf.	RVI result %	Tr. cyc.	Buy& hold %	No.of tr.days
AGBC	2	4	2	13.42	14	-15.84	44	8.02	10	-8.97	303
AGBN	2	6	7	24.70	5	-8.81	0	0.00	0	-30.12	605
AGRC	2	24	2	32.82	8	-14.78	40	18.12	3	-47.71	308
AIKB	2	4	2	4.62	16	0.00	0	0.00	0	-15.92	642
ALFA	18	21	19	0.00	0	-12.30	0	0.00	0	-44.58	889
BMBI	21	23	16	0.64	1	-17.38	42	0.64	1	-23.50	853
BNNI	15	16	16	3.18	2	-2.82	0	0.00	0	-23.06	754
CCNB	26	29	19	0.00	1	-14.18	0	0.00	0	-40.41	867
CYBN	2	6	20	-14.96	4	-34.43	0	0.00	0	-48.18	385
DJMN	2	21	8	1.84	4	-23.05	0	0.00	0	-22.03	689
DNOS	13	29	14	-4.67	1	-4.14	0	0.00	0	-39.98	840
EGMN	13	14	18	-12.45	3	-16.73	0	0.00	0	-24.69	193
ENHL	2	3	7	18.67	10	-29.54	0	0.00	0	-24.52	964
FIDL	25	30	20	-10.00	1	-35.03	0	0.00	0	-41.39	805
FITO	19	30	13	-11.57	2	-35.43	0	0.00	0	-29.99	966
GLOS	29	30	20	0.00	0	-34.20	0	0.00	0	-47.96	853
IKRB	2	22	2	18.14	13	-17.97	40	19.82	7	-3.63	266
IMLK	28	29	15	-6.61	1	-14.85	0	0.00	0	-15.50	971
INFM	21	24	3	1.12	2	-8.31	44	1.12	2	-11.66	259
IRTL	2	3	2	6.48	15	-10.41	45	4.99	7	-30.77	259
JMBN	22	27	2	1.38	3	-11.87	43	4.82	1	-35.83	880
KMBN	2	12	2	11.72	11	-30.72	0	0.00	0	-32.88	437
LSTA	2	5	2	11.27	16	-6.33	48	16.88	7	-16.63	176
MTBN	21	22	20	0.00	0	-20.15	0	0.00	0	-23.24	348
MTLC	17	27	12	-22.89	4	-23.60	0	0.00	0	-32.87	968
NAV	19	20	6	11.10	3	-12.80	0	0.00	0	-19.34	435
NPRD	2	16	2	20.76	6	-31.47	55	15.03	1	-34.48	967
PLNM	3	9	2	62.03	9	-9.91	40	54.79	8	6.54	852
PLTK	23	26	20	-16.29	2	-33.38	0	0.00	0	-41.50	281
PRBN	3	30	2	-24.34	8	-4.87	0	0.00	0	-41.45	472
PRGS	2	3	5	44.40	15	-1.43	44	38.14	10	3.94	677
PTLK	22	30	15	-5.17	1	-16.84	0	0.00	0	-5.74	918
PUUE	20	21	20	-6.08	1	-20.13	0	0.00	0	-33.60	958
RDJZ	28	29	18	0.00	0	-31.32	0	0.00	0	-58.81	707
RMBG	2	5	2	10.84	14	-11.14	61	4.33	1	-26.36	849
SJPT	2	9	4	16.77	8	-24.13	40	12.81	4	-22.06	965
SMPO	2	15	2	24.33	16	-36.70	46	21.67	2	-35.95	618
TGAS	15	30	10	-24.46	4	-27.03	0	0.00	0	-29.06	952
TIGR	3	4	5	-9.79	13	-25.70	0	0.00	0	-21.17	738
TLFN	24	29	11	-10.24	1	-21.25	0	0.00	0	-32.45	747
UNBN	9	22	10	-0.61	2	-4.50	0	0.00	0	-27.96	582
UNVR	2	5	2	-1.90	16	-32.25	48	6.00	6	-44.19	965
VDAV	17	20	12	9.70	1	-0.78	43	9.70	1	-6.89	834
VINZ	2	4	2	62.99	19	-17.73	52	69.73	11	215.90	151
VITL	28	30	12	0.35	1	-12.66	44	0.35	1	-18.93	516
VLFR	25	27	7	-0.22	3	-13.36	0	0.00	0	-3.63	964
VZAS	5	7	15	1.32	2	-14.37	41	1.27	1	-29.25	807
ZOPH	25	28	16	-11.19	2	-27.43	0	0.00	0	-26.63	968
Average	12	18	10	4.61	6	-18.21	45	6.42	2	-21.86	675

Source: Author's calculations

Table 6: Trading results based on the optimized MACD and RVI indicators (out of sample)

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cyc.	12,26,9 %	Lim. conf.	RVI result %	Tr. cyc.	Buy& hold %	No.of tr.days
AGBC	2	4	2	-0.31	10	-2.01	46	58.24	4	-45.00	21
AGBN	2	30	2	-12.18	27	-6.43	40	64.02	4	-70.809	242
AGRC	2	3	2	-0.36	29	-5.21	56	48.07	6	-82.91	49
AIKB	23	30	13	-3.14	3	-5.92	49	68.02	6	-74.498	248
ALFA	29	30	4	-0.22	7	-2.84	52	62.12	12	-97.244	205
BMBI	24	30	16	-1.07	3	-2.24	41	54.75	8	-35.55	152
BNNI	18	30	16	-0.90	4	-1.01	46	34.33	6	-17.85	15
CCNB	25	26	2	-0.43	12	-5.90	53	55.51	6	-80.61	80
CYBN	3	15	3	-6.89	23	-9.16	57	53.03	8	-85.52	71
DJMN	29	30	8	-0.63	2	-5.90	47	54.37	6	-75.494	45
DNOS	5	25	12	-6.67	15	-4.83	49	64.27	10	-73.83	176
EGMN	7	8	2	-0.57	22	-9.18	55	53.03	4	-83.27	71
ENHL	26	28	14	-0.79	4	-5.24	53	67.17	7	-75.66	245
FIDL	2	4	3	-0.87	29	-6.73	48	56.34	8	-86.00	91
FITO	23	26	17	-0.77	8	-3.50	41	57.50	8	-58.57	187
GLOS	23	26	5	-1.75	7	-7.76	43	61.05	7	-78.22	180
IKRB	23	30	11	-1.15	2	-2.47	49	59.42	8	-27.30	86
IMLK	20	27	2	-1.18	7	-2.39	40	58.11	5	-47.721	191
INFM	2	7	18	-1.44	24	-4.09	46	55.09	5	-67.86	100
IRTL	13	14	20	-0.20	6	-2.82	60	58.89	9	-57.57	22
JMBN	3	29	2	-11.34	36	-6.27	41	59.34	11	-81.62	177
KMBN	21	22	2	-0.35	9	-4.68	59	64.31	7	-74.24	186
LSTA	2	5	2	-6.88	23	-4.21	47	58.66	7	-73.83	91
MTBN	2	22	12	-13.99	15	-11.50	50	69.60	7	-86.58	226
MTLC	12	13	18	-0.22	10	-2.97	54	65.58	10	-58.72	208
NAV	2	10	2	-0.26	19	-0.34	54	60.73	6	-24.35	57
NPRD	2	29	2	-3.92	12	-1.25	42	49.04	5	-27.41	43
PLNM	2	15	2	-2.64	21	-2.65	40	55.07	6	-60.47	54
PLTK	25	26	20	-0.25	4	-3.46	42	54.93	7	-49.37	85
PRBN	2	22	2	-7.84	45	-6.01	52	59.30	10	-78.341	212
PRGS	27	30	13	-1.25	5	-5.57	40	56.18	11	-80.86	153
PTLK	19	21	9	-0.72	5	-3.46	62	44.80	6	-73.23	44
PUUE	29	30	20	-0.58	3	-7.28	41	60.97	8	-82.14	78
RDJZ	28	30	17	-0.16	2	-1.23	55	59.81	5	-39.759	40
RMBG	2	8	2	-0.53	19	-1.03	44	46.59	9	-35.62	36
SJPT	29	30	19	-1.40	7	2.80	50	75.62	7	-73.46	249
SMPO	2	15	2	-3.54	32	-3.84	46	57.36	13	-66.500	121
TGAS	21	26	2	-2.19	13	-5.96	40	59.41	11	-83.64	138
TIGR	16	29	19	-3.90	3	-4.04	54	59.28	10	-52.25	191
TLFN	2	11	2	-3.09	35	-6.33	52	59.99	5	-75.93	176
UNBN	6	20	12	-4.65	13	-4.77	47	60.81	9	-76.06	164
UNVR	2	5	2	-0.95	19	-5.31	55	61.90	6	-76.00	37
VDV	2	3	18	-0.35	19	-5.60	46	46.55	9	-98.73	44
VINZ	2	7	2	-1.45	34	-7.08	40	52.65	7	-68.254	119
VITL	2	6	2	-1.85	41	-7.98	57	58.21	10	-67.15	125
VLFR	2	20	2	-8.41	38	-7.08	48	58.12	12	-88.83	144
VZAS	3	30	2	-10.95	25	-5.78	51	67.53	7	-84.28	214
ZOPH	2	30	2	0.11	28	0.07	50	60.93	9	-2.46	146
Average	12	20	8	-2.81	16	-4.55	49	58.05	7	-65.87	126

Source: Author's calculations

Table 7: Trading results based on the optimized MACD and RVI indicators in downward trend (out of sample)

Stock symbol on the s.e.	Sh. m.a.	L. m.a.	Sig. m.a.	MACD result %	Tr. cyc.	12,26,9 %	Lim. conf.	RVI result %	Tr. cyc.	Buy& hold %	No.of tr.days
AGBC	2	4	2	-0.31	8	-2.01	44	54.23	4	-46.34	255
AGBN	2	6	7	-1.39	26	-6.43	0	63.85	4	-83.50	255
AGRC	2	24	2	-8.07	21	-5.21	40	48.39	6	-82.10	255
AIKB	2	4	2	-8.64	39	-5.92	0	68.49	6	-71.39	255
ALFA	18	21	19	-0.61	1	-2.84	0	62.66	12	-39.47	255
BMBI	21	23	16	-0.36	4	-2.24	42	54.82	8	-35.56	255
BNNI	15	16	16	-0.07	6	-1.01	0	33.72	6	-17.85	255
CCNB	26	29	19	-1.27	3	-5.90	0	55.75	6	-71.47	255
CYBN	2	6	20	-2.08	20	-9.16	0	53.68	8	-85.79	255
DJMN	2	21	8	-3.80	18	-5.90	0	55.70	6	-86.00	255
DNOS	13	29	14	-5.62	7	-4.83	0	65.30	10	-76.27	255
EGMN	13	14	18	-0.62	8	-9.18	0	52.74	4	-89.78	255
ENHL	2	3	7	-0.36	35	-5.24	0	67.41	7	-68.95	255
FIDL	25	30	20	-2.38	1	-6.73	0	56.38	8	-66.67	255
FITO	19	30	13	-2.80	7	-3.50	0	57.80	8	-59.15	255
GLOS	29	30	20	-0.60	2	-7.76	0	61.57	7	-49.89	255
IKRB	2	22	2	-3.66	19	-2.39	40	60.50	8	-52.78	255
IMLK	28	29	15	-0.16	4	-2.39	0	58.17	5	-42.87	255
INFM	21	24	3	-0.89	11	-4.09	44	55.11	5	-68.99	255
IRTL	2	3	2	-0.22	10	-2.82	45	55.18	9	-62.57	255
JMBN	22	27	2	-2.27	19	-6.27	43	59.89	11	-83.87	255
KMBN	2	12	2	-2.82	37	-4.68	0	64.33	7	-65.72	255
LSTA	2	5	2	-6.88	23	-4.21	48	58.66	7	-73.83	255
MTBN	21	22	20	-0.86	3	-11.50	0	70.26	7	-90.72	255
MTLC	17	27	12	-2.10	10	-2.97	0	66.20	10	-59.02	255
NAVP	19	20	6	-0.03	6	-0.34	0	61.22	6	-26.45	255
NPRD	2	16	2	-2.33	12	-1.25	55	48.72	5	-50.01	255
PLNM	3	9	2	-1.23	32	-2.65	40	55.06	6	-51.72	255
PLTK	23	26	20	-0.70	4	-3.46	0	55.45	8	-49.37	255
PRBN	3	30	2	-11.23	54	-6.01	0	59.56	10	-75.69	255
PRGS	2	3	5	-0.39	36	-5.57	44	55.42	11	-79.36	255
PTLK	22	30	15	-1.89	3	-3.46	0	55.50	6	-70.24	255
PUUE	20	21	20	-0.53	5	-7.28	0	60.99	8	-83.48	255
RDJZ	28	29	18	-0.07	4	-1.23	0	64.85	5	-45.40	255
RMBG	2	5	2	-0.28	36	-1.03	61	47.31	9	-35.62	255
SJPT	2	9	4	1.74	28	2.80	40	71.46	7	-72.97	255
SMPO	2	15	2	-3.54	32	-3.84	46	57.40	13	-66.50	255
TGAS	15	30	10	-6.56	9	-5.96	0	60.63	11	-80.65	255
TIGR	3	4	5	-0.22	29	-4.04	0	58.84	10	-68.00	255
TLFN	24	29	11	-2.54	2	-6.33	0	60.11	5	-79.83	255
UNBN	9	22	10	-4.36	12	-4.77	0	61.26	9	-76.06	255
UNVR	2	5	2	-0.95	19	-5.31	48	58.85	6	-79.15	255
VDAV	17	20	12	-1.06	8	-5.60	43	46.82	9	-76.31	255
VINZ	2	4	2	-0.60	38	-7.08	52	52.43	7	-69.56	255
VITL	28	30	12	-1.27	4	-7.98	44	59.22	10	-70.20	255
VLFR	25	27	7	-1.04	12	-7.08	0	58.57	12	-85.79	255
VZAS	5	7	15	-0.75	16	-5.78	41	67.04	7	-83.77	255
ZOPH	25	28	16	0.03	3	0.07	0	61.16	9	-3.33	255
Average	12	18	10	-2.05	16	-4.55	45	58.30	8	-64.79	255

Source: Author's calculations

