Multi-trend trade system for financial markets

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Abstract

At present, more and more people are beginning to be interested in the field of investment. This is due to the growth in incomes of the population, on the one hand, and development of financial technologies, on the other hand. The problematic situation is analyzed in this article and the main known models, algorithms and indicators used to build trading strategies are considered. A conservative trading strategy based on trend indicators is proposed. The strategy can be an alternative to the popular conservative "buy and hold" strategy. Exponentially moving averages of various orders that reveal the presence of trends of variable duration in the price dynamics of a financial asset are used as system indicators. A distinctive feature of the proposed trading system is the combination in one approach of the trading method that generates trade signals and the rules for position size management. The article contains results of testing a proposed trading strategy based on historical data. A comparative analysis of the results obtained with the results of the "buy and hold" strategy and the strategy based on two exponential moving averages of different orders is carried out. The proposed system can be easily integrated into automated trading systems. The R language was used for data processing and visualization.

Introduction

Real estate, bank deposits, currency, as well as securities (mainly stocks and bonds) are traditionally among the most popular investment tools used by non-professional investors to save and accumulate their capital. However, real estate prices in Russia have risen significantly over the past few years. As a result, the "entry threshold" to this market has increased, on the one hand, and the profitability of investments in real estate has decreased, on the other hand. At the same time, bank deposit rates systematically declined. Despite the fact that there was a trend towards an increase in the average deposit rates in 2021, the average amounted to 6.1% per annum during 2021 [1], which was significantly lower than the average annual inflation rate of 8.38%, for the same time period [2].

As a result, there has been an outflow of Russian funds from bank deposits to the stock market over the past few years. Thus, according to experts of the Russian National Rating Agency, the net outflow of funds held by Russians in banks amounted to 1.5 trillion rubles for the period from January 01, 2021 to January 11, 2021 [3].

At the same time, according to the Moscow Exchange, as of July 6, 2021, the number of individuals with brokerage accounts was about 13 million people, and the total inflow of funds from individuals into various financial market instruments amounted to 1.1 trillion rubles over 12 months [4].

However, investments in financial markets are traditionally among the most complicated activities [5]. The main reason is the high volatility of prices for financial assets due to the simultaneous impact of a very large number of both objective and subjective factors on them. It is high volatility that has caused a sharp increase in the use of algorithmic trading in exchange assets trading [6–9] because a person often does not physically have time to respond to rapid changes in stock quotes. The share of transactions made by trading robots on the Moscow Exchange has long exceeded 50% of the total number of transactions [10].

Trading robots are computer programs that make transactions for the purchase / sale of securities according to embedded algorithms. In turn, any algorithm implements a trading system (trading method), which is a set of rules for opening and closing positions. Obviously, it is the trading system that determines the efficiency of the trading robot.

The range of approaches to creating trading systems is quite wide:

♦ undamental analysis [11];

♦ technical analysis [12];

♦ statistical analysis [13, 14];

♦ text mining [15];

♦ fractal analysis [16, 17];

♦ machine learning with neural networks [18, 19];

♦ computer analysis [6–9].

It should be noted that trading systems based on technical and computer analysis are most widely used in algorithmic trading. Among such trading systems, we can identify:

♦ trend systems – based on trend indicators (for example, moving averages) and designed to apply on strong stable trends;

♦ countertrend systems – based on the different oscillators (for example, RSI, %R, stochastics etc.) and designed to apply in periods of price consolidation (no trend (flat));

♦ breakdown systems — systems based on the idea of breaking through key support/resistance levels formed in conditions of price consolidation;

♦ combined systems — various combinations of the previous systems.

The development and use of automated trading systems are only possible for professional market participants and these are

rather complicated processes [20−23]. For this reason, companies have entered the financial market in recent years that develop and sell computer programs for algorithmic trading. Big investment and brokerage companies also do not stand aside. For example, the FINAM investment holding constantly presents the results of a dozen different investment strategies on its portal [24]. The company offers its clients to join to them to save their labor costs for developing investment decisions. However, all of these products are, in fact, "black boxes" because the developers do not disclose the trading strategies that underlie them.

Almost all trading systems that work on one or another indicator of technical or computer analysis have one common problem − the problem of stability, or robustness. The robustness of a trading system is usually understood as the ability of an algorithm to maintain profitability for a sufficiently long time, regardless of the type of changes in market prices [21]. The volatility of modern financial markets leads to the need for constant reconfiguration (optimization) of the parameters of the algorithms underlying trading systems. At the same time, the more parameters the used trading method contains, the faster the optimization will be required. At the same time, if we take as an axiom the random nature of pricing in financial markets, then we cannot create a stable trading system with optimized parameters on a random price sequence. That is why any "black box" sooner or later begins to bring losses to its owners.

The consumers of these software products, as a rule, are that part of inexperienced investors who naively believe that they will be able to increase their fortune quickly and easily with the help of these "black boxes."

Another segment of investors uses in their practice more conservative strategies such as "buy and hold." The "buy and hold" trading system is a simple system without any parameters, and it is matched to the market perfectly. The profitability of the strategy will always exactly match the profitability of the financial asset: there will be large volatility of profitability, with strong price fluctuations; the volatility of profitability will be low with low price fluctuations.

High volatility is a distinctive feature of modern financial markets. Therefore, such strategies can lead to significant losses or to the "freezing" of investments for long periods of time. Typical examples of such situations are the price dynamics for the GAZPROM shares and for VTB Bank shares shown in *Figs. 1, 2.*

The graphs presented show that investors who bought GAZPROM shares in 2007−2008 were able to return their investments only after fourteen years, and investors who bought VTB Bank shares at the same time were unable to sell their shares with a profit during the review time.

The purpose of this work is to develop and test a conservative trading strategy based on popular trend indicators which can be used by non-professional investors when working on the stock exchange.

1. A brief overview of trend strategies

Any trend strategy is based on trend indicators [23, 25, 26]. The main purpose of this group of indicators is to determine the presence of an up-trend or a downtrend in the price dynamics for a financial asset. The disadvantages of trend indicators include the delay of the buy/sell signals relative to price changes generated by them. In addition, trend indicators work well on strong, well-defined trends, but these have been quite rare in recent years. Nevertheless, it was shown in [27] that the time for prices to stay in a particular trend is from

Fig. 1. Price dynamics for GAZPROM shares for the period from 2007 to 2021.

Fig. 2. Price dynamics for VTB shares for the period from 2007 to 2021.

25% to 30% even in the modern highly volatile Russian stock market. Therefore, the popularity of trend strategies is still quite high.

At the present time, a quite large number of trend strategies have been developed. Most trend strategies are based on the use of moving averages (MA). There are several types of this trend indicator, but the most popular are the simple moving average (SMA) and the exponential moving average (EMA).

The main parameter of the moving average is the averaging period *n*. Moving averages with a small value of *n* are usually called short-term MA. Moving averages with a large value of *n* are usually called long-term MA. When choosing an EMA order, you need to understand that the smaller this order, the more sensitive the EMA to price changes and the faster it reveals new trends. But, on the other hand, a short EMA changes its direction more often and, accordingly, it gives false signals more often. A slow EMA gives false signals less often, but it also reacts more slowly to a trend change.

Another way of choosing the order of the EMA is to link it to the cyclical nature of the market. When we identify the duration of the cycle, the order of the EMA should be equal to half of the dominant market cycle. For example, if a 26-day cycle is identified, then a 13-day EMA should be used to analyze such a market. However, the problem with this approach is that the cycles very often change their periodicity and even disappear altogether sometimes.

Therefore, investors often use a simple rule for choosing an EMA order: the longer the trend they are trying to find, the larger the EMA order should be. Most often *n* values are used in the range from 10 to 20 in real trading. Fibonacci numbers are used as the EMA order quite often.

The first trading systems using moving averages used the following rules:

♦ buy when the MA rises and the price closes above MA;

♦ sell when the price closes below MA.

Another version of the simplest trend trading system is as follows:

♦ buy when the short-term moving average crosses above the long-term moving average;

♦ sell when the short-term moving average crosses the long-term moving average downwards.

In [28] the trading method based on the intersection of two moving averages is proposed. Such an approach is used as a reference technique of this kind quite often. The technique uses a 9-day moving average as the short-term moving average, and an 18-day moving average is used as the long-term moving average. Many traders use other values for the averaging order to improve trading results with this strategy [19].

However, such approaches give relatively good results in markets with a pronounced trend component only. A lag of the moving averages leads to false signals and losses when the prices enter in a range.

One way to increase this kind of trending systems efficiency in markets with an implicit trend component is to use different kinds of filters. Filters are some rules that reject some trading system signals. Examples of the simplest filters: the price must close on the other side of the EMA several times (usually twice), or the price must break through the MA by a certain percentage. However, any filters are a "double-edged sword": by reducing losses, they also reduce profits. In addition, filters detract from the main advantage of the moving average – its ability to catch the trend at an early stage.

An intersection of three moving averages with different orders (for example, 4-, 9- and 18-day MA) is often used as a filter [23]. Trading signals come at those moments when all three MAs turn in the same direction. It is clear that this approach will miss a significant part of the trend, so it only makes sense to use it in markets with very strong trends.

In [29] the author's Triple Choice trading system is described, which is a combination of trend indicators and oscillators. In the system, EMA is used to identify trends, and oscillators are used to generate trading signals.

In [19] the TEMA (Triple Exponentially Moving Average) indicator is considered as a possible indicator for building trend trading

systems instead of classical moving averages. This indicator is an advanced version of exponential smoothing.

Moving Average Convergence Divergence (MACD) is another way to improve a trend indicator that consists of three MAs [23, 25]. The MACD indicator consists of two lines: solid (MACD line) and dotted (signal line). MACD line is the difference between two MAs of different orders. It reacts to price changes faster. The signal line is the moving average of the MACD line. It reacts to price changes more slowly.

By crossing the MACD line and the signal line we can decide on a change in the trend. Such a system generates many fewer false signals than a system using a single moving average.

The rules for opening/closing positions using this indicator are as follows

♦ buy when the fast MACD line rises above the signal line;

♦ sell when the fast MACD line falls below the signal line.

The MACD indicator is included in most programs for technical analysis and trading terminals. The algorithm for its calculation is as follows:

1. Calculation of the 12-day EMA.

2. Calculation of the 26-day EMA.

3. Calculation of the difference between the 12-day and 26-day EMA and plotting it on the chart as a solid line (fast MACD line).

4. Calculation of the 9-day EMA fast line and plotting it on the chart as a dotted line (slow or signal line).

Some users of the MACD indicator try to optimize it by using other values (not 12, 26 and 9) for the order of the moving averages used to calculate the indicator. In particular, the combination (5, 34 and 7) is popular.

Some investors try to align the MACD indicator to market cycles. However, many analysts question the idea that financial markets are cyclical. If we still consider cycles, then it is believed that the order of the first EMA should be one quarter of the dominant cycle, and the order of the second EMA should be half of it. The third EMA is a smoothing tool, so it is not necessary to correlate it with a cycle.

Some investors adjust the MACD indicator until it produces the desired (but not necessarily correct) result for them.

Quite often, in real trading, not the standard MACD indicator is used, but the MACD histogram. This indicator has historically been considered as one of the best indicators in the arsenal of investors. It represents the difference between the MACD line and the signal line.

A graphical representation of both variants of the MACD indicator is shown in the *Fig. 3.*

The MACD histogram generates two types of trading signals. The first is the direction of the slope of the histogram. The second is the divergence between the MACD histogram and the price chart. The second signal does not appear on the charts very often, but it is considered as a very strong signal [25].

The rules for opening/closing positions using MACD histogram are as follows:

♦ buy when the MACD histogram goes from negative to positive;

♦ sell when the MACD histogram goes from positive to negative;

♦ sell when price makes a new high and there is a lower high on the MACD histogram (bearish divergence);

♦ buy when price makes a new low and there is a higher low on the MACD histogram (bullish divergence).

The indicator of directional movement ADX is often used to identify the presence of a trend [23]. This indicator is also included in most

Fig. 3. Graphical representation of the MACD indicator and the MACD histogram.

technical analysis software. The calculation of the indicator is rather complicated. It is based on a methodology for assessing not only the direction of the trend, but also its strength.

2. Multi-trend trade method

A strategy that generates trade signals based on the presence of various duration trends in price dynamics is proposed in this article.

There are three models to describe the price dynamics of a financial asset: an uptrend (the price is growing), a downtrend (the price is falling) and a neutral trend (flat — there is no directional movement in the price). Depending on the time interval, short-, medium- and long-term trends are distinguished.

Under the proposed approach, the position size can vary from 0% (no investment, free cash ratio is 100%, all trends are down) to 100% (all free cash is invested, all trends are up).

In general, the formula for calculation of the position size γ is as follows:

$$\gamma = \alpha_1 \beta_1 + \alpha_2 \beta_2 + \alpha_3 \beta_3, \tag{1}$$

where α_i — coefficients for the presence of long-, medium- and short-term trends, respectively;

β_i — weight coefficients of the influence of long-, medium- and short-term trends, respectively.

The following condition is satisfied for the weight coefficients:

$$\sum_{i=1}^{3} \beta_i = 1.$$

The α_i coefficients take the following values: in the case of an up-trend $\alpha_i = 1$, in the case of a downtrend $\alpha_i = 0$ and in the case of no trend (flat) $\alpha_i = 0.5$.

Position size calculation example. Suppose that at the current moment of time the following situation has developed for the traded

financial asset: no long-term trend ($\alpha_1 = 0.5$), no medium-term trend ($\alpha_2 = 0.5$), the short-term trend is downtrend ($\alpha_3 = 0$), and the following values are used for weight coefficients of the influence of trends:

♦ long-term trend, $\beta_1 = 0.5$;

♦ medium-term trend, $\beta_2 = 0.3$;

♦ short-term trend, $\beta_3 = 0.2$.

Then the position size is:

$$\gamma = 0.5 \cdot 0.5 + 0.3 \cdot 0.5 + 0.2 \cdot 0.0 = 0.4.$$

i.e., the size of the current position should be equal to 40% and free cash should be equal to 60%. If, for example, the position size is 70%, then it is necessary to sell 30% of the position at the current market price in order to adjust the position size to the required value (40%).

The presence of trends was determined by the slope of the corresponding exponential moving average. The advantage of exponential averaging over simple or weighted averaging is that in exponential averaging each of the prices of the analyzed time interval is given its own "weight." Moreover, the greatest weight is assigned to the last price (as the most significant), and the least weight is assigned to the first one.

To calculate the exponential moving average of the n-th order at the i-th time moment, the following iterative formula was used [25]:

$$EMA\,(i,\,n) = kP_i + (1 - k)\,EMA\,(i - 1,\,n), \quad (2)$$

where $k = 2 / (n + 1)$ — smoothing factor;

P_i — the price of a financial asset at the i-th time moment.

As an initial approximation for the iterative formula (2), we can take a simple moving average over a similar averaging period n.

An example of EMAs of various orders, calculated using formula (2), is shown in *Fig. 4.* From the chart it can be seen that EMAs smooth out price fluctuations. At the same time, the greater the order of EMA (the value of n), the more smoothly its graph changes.

To identify the presence of the trend, the method of determining the slope of the exponential moving average of the corresponding order was used. For example, to determine the presence of a trend in an interval of 21 days,

Fig. 4. An example of EMAs of various orders.

a 21-day exponential moving average is calculated. If the slope of the calculated moving average is positive, then it is concluded that there is an up-trend on the interval of 21 days and, therefore, the corresponding coefficient $\alpha_i = 1$. If the slope of the exponential moving average is negative, then we have a downtrend (the corresponding coefficient $\alpha_i = 0$). If the exponential average is a horizontal line (slope = 0), then this means that there is no trend in the price dynamics in the time interval of 21 days (the corresponding coefficient $\alpha_i = 0.5$).

The presence of a slope was determined by four consecutive EMA values at different points in time:

♦ if $EMA_i > EMA_{i-1} > EMA_{i-2} > EMA_{i-3}$ — slope is positive ($\alpha_i = 1$);

♦ if $EMA_i < EMA_{i-1} < EMA_{i-2} < EMA_{i-3}$ — slope is negative ($\alpha_i = 0$);

♦ for any other ratio of EMA values, it was considered that there is no slope ($\alpha_i = 0.5$).

The following values for the order of averaging n and weight coefficients of the influence of trends (β_i coefficients in formula (1)) were used in this work:

♦ short-term trend: $n = 8$, $\beta = 0.2$;

♦ medium-term trend: $n = 21$, $\beta = 0.3$;

♦ long-term trend: $n = 55$, $\beta = 0.5$.

Thus, the maximum weight (0.5) was given to the long-term trend.

As a result, the position is managed in the following way. At each new time moment (new week, new day, new hour, etc.), new values of three EMAs of the corresponding orders are calculated using formula (2). After that, the parameters of short-, medium- and long-term trends (α_i coefficients in formula (1)) are determined and a new position size α is calculated using formula (1). If the value of α has increased, then the required amount of the traded asset is bought. If the value of α has decreased, then the required amount of the traded asset is sold.

3. Data source

The portal of the financial holding "FINAM" was used as a source of data on prices for financial assets [24]. This resource allows you to get a history of quotes of all financial assets traded on the Moscow Exchange for an arbitrary period. The data can be saved both in a text file (file with the .txt extension) and in a csv file (a file with the .csv extension).

4. Technologies

The functional programming language R [30, 31] used to implement all the necessary calculations and to visualize the results. In recent years, this language has become one of the most popular tools for data processing and visualization in the field of Big Data and Data Science.

The basic tools of the R language as well as the capabilities of the dplyr, lubridate, and ggplot2 libraries were used for data processing and data visualization.

5. Results

Below are the results of testing the proposed trading system for the shares of four Russian companies from various sectors of the economy traded on the Moscow Exchange: Sberbank (SBER ticket), Novolipetsk Iron and Steel Company (NLMK ticker), Akron (AKRN ticker) and Yandex (YNDF ticker). The testing period was one year from December 15, 2020 to December 15, 2021. One day was used as the time frame.

In *Figs. 5–8*, the left charts show the price dynamics of the corresponding asset, and the right charts show the change in the return on investment in this asset (profit or loss) if you were to use the strategy considered above.

The figures presented clearly show the effect of the proposed trading system. It lies in the
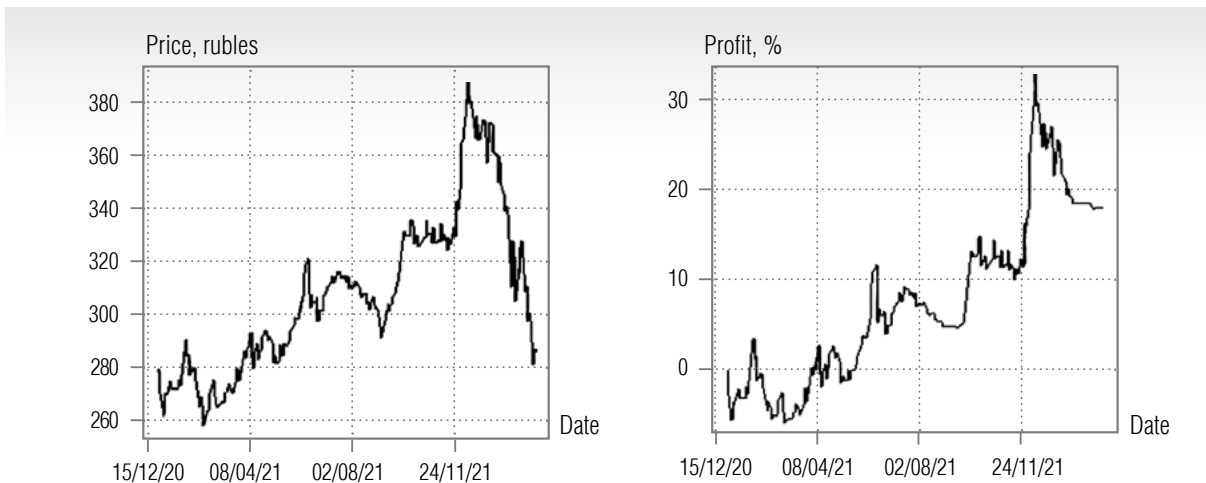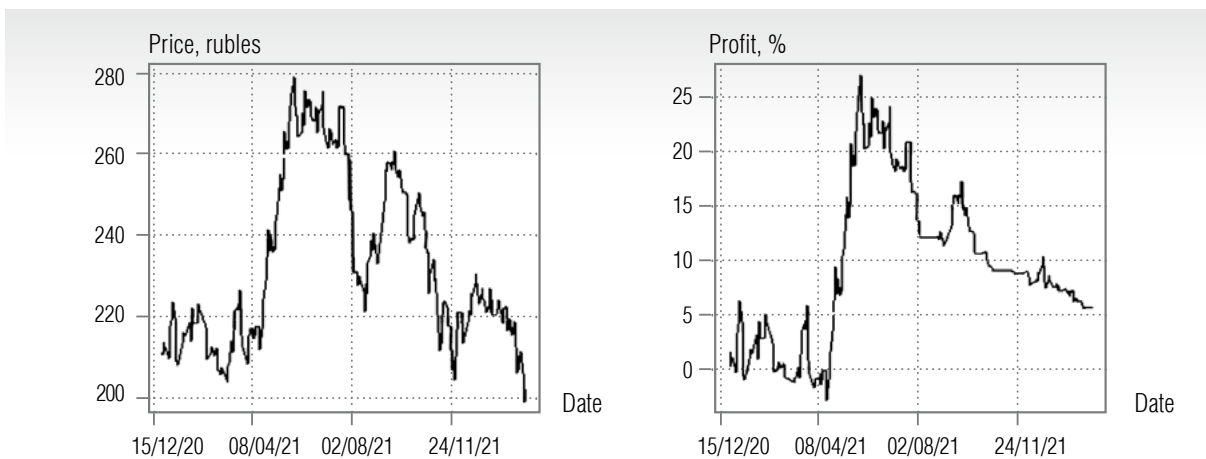
Fig. 5. The test resultsfor Sberbank share.

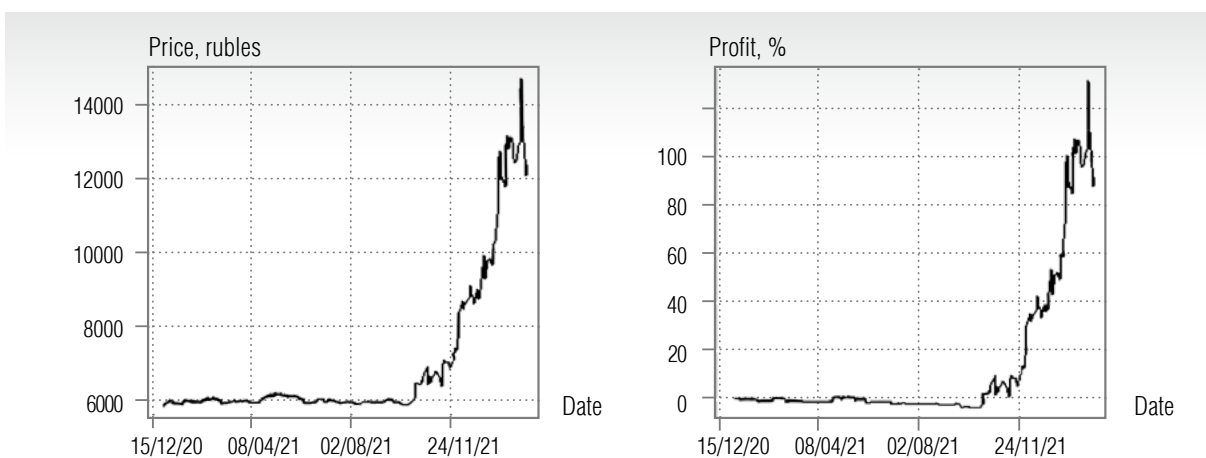*Fig. 6.* The test results for Novolipetsk Iron and Steel Company share.

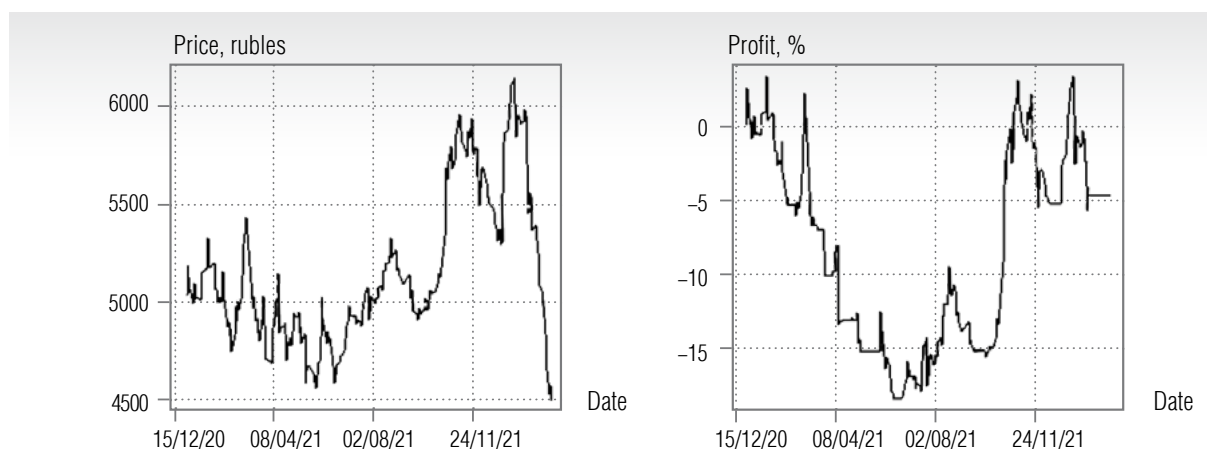*Fig. 7.* The test results for Akron share.

Fig. 8. The test results for Yandex share

fact that the profit chart is not an exact copy of the price chart (as opposed to the use case of "buy and hold" strategy). The difference between the charts is due to the fact both the opening and closing of a position is not carried out immediately in full, but in parts as each of the three trends forms.

One consequence of this approach is to obtain lower losses in the case of generating false signals. For example, if the system reacted to a false signal with 20% of the funds, then when the position is closed with a loss, this loss will be five times less than in a case when all 100% of the funds were involved in this unsuccessful transaction.

But, on the other hand, the same reason (formation of a position in parts) can also lead to a shortfall in profit at the initial stage of opening a position.

However, the main advantage of the proposed approach compared to the "buy and hold" strategy lies in the complete closing of the position with a big price drop, which leads to limiting losses. This effect is especially pronounced for the shares of Sberbank and Yandex (*Figs. 5, 8*). The charts clearly show that at the end of 2021, all positions were closed (horizontal lines on the right profit charts). As a result, it was possible to avoid significant losses in the event of a subsequent strong decline in prices for these assets.

To quantify the quality of the proposed system, *Table 1* presents summary results on the return on investment in selected assets, which could be obtained by using this strategy in real exchange trading.

Table 1.

The summary test results

Share ticket	Strategy profit, %	Strategy "Buy and hold" profit, %
SBER	17.61	2.85
NLMK	5.53	−4.04
AKRN	91.24	108.30
YNDF	−4.67	−10.66

For comparison, *Table 1* shows the return on investment in the same assets that would have been obtained using the "buy and hold" strategy. Based on the data in the table, we can conclude that in most cases (with the exception Akron stock) the use of the proposed strategy allows you to get significantly better results in terms of profitability compared to the conservative strategy.

It can be seen the strategy gives good results in areas with pronounced trends. Such a result is quite expected because the strategy is based on trend indicators. The higher the volatility of an asset is, the worse the results obtained are.

It should be noted that the purpose of this work was to develop a relatively simple trading strategy that can be considered as an alternative to the conservative "buy and hold" strategy and not to oppose the proposed strategy to other existing strategies. As noted at the beginning of the article, currently there are a very large number of different strategies. However, firstly, not all developers disclose the details of their strategies, and secondly, it is necessary to test different strategies on the same data sets to make a correct comparative analysis.

Such an analysis is beyond the scope of this work. Nevertheless, as an example, the results of the proposed strategy were compared with the results obtained in [19] using one of the most popular strategies described in paragraph 1. This strategy is based on the intersection of two moving averages of different orders. In particulary, 9-day and 20-day EMAs were used in [19]. The stock quotes of the American company AJG for the period from November 12, 2012 to November 10, 2021 were used as the data set. The profitability of the conservative "buy and hold" strategy was 125%. The profitability of the strategy for two EMAs was 82.99%. The profitability of the proposed strategy amounted to 134.63%.

Conclusion

An original trading strategy for working on financial markets is proposed. The strategy is based on trend indicators. A distinctive feature of the strategy is the combination of the trading method (rules for opening/closing a position) and the position size control system in one approach.

The results of testing the strategy on historical data showed that such strategies can bring investors returns that exceed those of conservative strategies even in today's highly volatile markets. Such strategies can also be considered as an alternative to both high-frequency robots and bank deposits for long time trading.

The strategy can be easily integrated into an automated trading system for short time trading. ∎

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