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Full Length Research Paper

The relative strength index revisited

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The relative strength index (RSI) is one of the best known and most widely used technical analysis indicators. In this paper, the study aim to empirically test the functioning of the RSI in its classic form, on a set of data and to reconfigure the indicator by also taking account of the trading volume in its calculation formula. After adjusting the RSI with the trading volume, the study will test its new form on the same set of data. Finally, it will compare the obtained results by applying the classic form of the indicator with those obtained by using the adjusted form. In future research, the study intend to analyse whether higher yields can be obtained by using the RSI compared to those which result from applying the buy and hold strategy.

Key words: Technical analysis, fundamental analysis, technical indicators, stock market, financial forecasting, S&P 500 (Standard & Poor's 500).

INTRODUCTION

In order to provide a sharpened focus on the research problem and the need of the study, the introduction is divided as follows (Alam, 2011).

Research problem

Technical analysis of the stock market is a way to forecast the future evolution of stock prices, taking into account their past and including a multitude of highly varied techniques. This kind of analysis implicitly assumes that there is a dependency between the future price and its past values. In other words, changes in stock prices from the past are important in order to forecast their future evolution.

In the past, technical analysis has been highly used on capital markets around the world and continues to be similarly used at present. That does not mean that the use of various technical analysis methods has not or has not had its fervent opponents.

Through the ideas expressed in this paper we take the side of the technical analysis advocates both due to the obtained results and to an argument of a more general nature, namely that the market uses the various tools of technical analysis since many decades. If some of these would not have yielded any result within such a long period of time, they would have been certainly long forgotten. Thus, the study also support the idea that certain instruments used in technical analysis to study the future evolution of prices - namely the forms of the RSI – are more sensitive to market reactions for the study of which they were created compared to the general statistical tools and, therefore, more accurate when used for the capital market analysis.

Research aim and objectives

In this paper, the study aim to empirically test the functioning of the RSI in its classic form, on a set of data and to reconfigure the index by also taking account of the trading volume in its calculation formula. After adjusting the indicator with the trading volume, the study will test its new form on the same set of data. Finally, it will compare the obtained results by applying the classic form of the indicator with those obtained by using the adjusted form. In future research, the study intend to analyse whether higher yields can be obtained by using the RSI compared to those which result from applying the buy and hold strategy.

Research questions

In order to achieve the aim and objectives of this study we will answer the following questions: The first question is whether the enounced research problem was studied before, and if it was, which were the most important researches in the field and what were the conclusions of these researches. The second question is which are the

materials and methods needed to be use in order to test the functioning of the RSI and which is the most appropriate form of the index: the classic form or the new one. To get an answer to this second question it must be established what set of data should be used to test both RSI forms and to determine which of them is the most efficient. Afterwards both RSI forms should be tested on the chosen data set. The third question that arises is what the original results of the study are, how they contribute to the development of the knowledge in the business field and how they could be used.

LITERATURE REVIEW

In the economic literature, the moments when the opponents and critics of technical analysis seemed to gain ground have alternated since the middle of last century (Alam, 2009). Fama (1965a) asserts that there are two approach categories of those who try to predict the future evolution of the shares' trend: the chartist approach, which involves the use of technical analysis and the fundamental analysis theory. Both assume that the prices of shares can be reliably estimated for a certain future period, but the techniques used in these theories are different. If chartists study the behaviour of prices in the past in order to determine how they will evolve in the future, the advocates of fundamental analysis attempt to determine the intrinsic value of the shares according to their capacity to generate returns and if the current price is below or above their intrinsic value (Alam et al., 2009, 2010). The hypothesis from which fundamental analysis departs is that in time, the price of stocks has a tendency towards their intrinsic value.

In antithesis to both technical analysis and the fundamental analysis is the theory of random walks. According to traditional approaches, on the efficient capital markets, characterized by the existence of a large number of rational competitors pursuing the maximization of profit and having real-time access to market information at almost no cost, the current price of a stock at any given time reflects both the information generated by past events as well as information related to events known to occur in the future. For this reason, the advocates of the random walks theory argue that the future development of the rate cannot be forecasted. A large number of studies conducted in the middle of last century using classical statistical tools support the theory of random walks through the obtained results, or, even if they admit the existence of a certain dependency between past and future stock prices, consider that it is much to small in order to be used for the obtaining of profits that are higher than trading costs. In this respect we mention the papers of Kendall (1953), Cootner (1962), Godfrey et al. (1964), Fama (1965b), Jensen and Benington (1967).

But there are also studies like those written in the same period by Alexander (1961) and Levy (1967) whose authors provide, through the obtained results, arguments for the use of various categories of instruments specific to technical analysis.

If the first academic papers in the field of technical analysis were mostly subordinate to the idea of its uselessness, even considering it an "anathema for the academic world" (Malkiel, 1981). In the last period of time, the efficient markets hypothesis has been reviewed (Timmermann and Granger, 2004) and the ratio of forces has changed. Many papers show the existence of a link between past developments and future evolutions. Studies such as those published by Sweeney (1988), Jegadeesh (1990), Brock et al. (1992), Chopra et al. (1992), Gencay (1997), Dempster and Jones (2001), Austin et al. (2004), Grant et al. (2005) are relevant in this respect. Recently, the opponents of the technical analysis concept have become opponents of the various techniques of analysis in use. For example, Marshall et al. (2006), remark the inefficiency of the candlestick trading strategies on Dow Jones Industrial Average stocks during the period between 1992 and 2002. Nevertheless, this result does not confirm the inefficient putting into practice of this strategy or of other trading strategies on different stocks, markets or periods.

MATERIALS AND METHODS

The classic form of the RSI

The RSI is a commonly used oscillator in technical analysis because of its ease of use and interpretation. In its classic form, it was developed by Welles Wilder Jr. (1978) and presented by him in the book "New Concepts in Technical Trading Systems" and in "Commodities Magazine" published in June of the same year. The RSI involves comparing the increase of the closing prices with their falls within a certain period of time.

The term is often used to highlight the relative strength of a security in relation to the market on which it is traded or with a different security. This is the reason why, in order to avoid confusion between the Relative Strength Index, an index reflecting the relative strength of the price of a security in relation to itself and the term relative strength explained before, many authors use only the abbreviation RSI for the Relative Strength Index.

To determine the RSI, the increase of the closing price (upward change) (U) or the decrease of the closing price (downward change) (D) are calculated for each day, according to Formulas (1) and (2).

$$U_{close} = close_{today} - close_{yesterday} \quad (1)$$

$$D_{close} = close_{yesterday} - close_{today} \quad (2)$$

If U is positive for a certain day, then D is replaced with 0 for that day and vice versa, if D is positive for a certain day, then U is replaced with 0 for the respective day.

In order to calculate the RSI, an exponential moving average (EMA) is determined for U and for D using a "multiplier" (α) calculated based on a certain number of days (N). The moving average is used to limit the influence of random factors, unusual for the average. The number of days recommended by Wilder in his

book mentioned earlier is 14, but the EMA formula presented by him in the same book corresponds to N equal to 27. EMA is determined using the α "multiplier" in order to associate different degrees of importance to the data considered in the calculation, depending on their age. Thus, older data will weigh less in the EMA, and the latest data will weigh more.

The α "multiplier" is determined in relation to N number of days, according to Formula (3).

$$\alpha = \frac{2}{N+1} \quad (3)$$

For example, for a number of days equal to 27, α is 1/14. The determination of EMA requires the calculation of a simple arithmetic average (SMA) of the data for the first N days in the string under consideration, according to Formula (4).

$$SMA_N = \frac{X_1 + X_2 + ... + X_N}{N} \quad (4)$$

Where: SMA_N - the arithmetic average of a string of data corresponding to a number of N days; X_N - the value corresponding to the N day from the data string. When determining RSI X = U or X = D.

The exponential moving average of the N+1 day is determined as follows (previously used notations are maintained):

$$EMA_{N+1} = \alpha \times X_{N+1} + (1-\alpha) \times SMA_N \quad (5)$$

After determining the exponential moving averages of the U closing prices increase Formula (6) which represents the relative strength (RS).

$$RS = \frac{EMAofU}{EMAofD} \quad (6)$$

It is converted into an index which can range between 0 and 100 units, calculated according to Formula (7) and called the relative strength index (RSI).

$$RSI = 100 - 100 \times \frac{1}{1+RS} \quad (7)$$

Generally, when the RSI exceeds the value of 30 units from bottom to top, it is considered a buy signal and when it exceeds the value of 70 points from top to bottom, it is considered a sell signal. In other words, when the RSI has values below 30, the underlying asset based on which the price is calculated is oversold and when it has values over 70, the underlying asset is overbought. For highly volatile markets certain technical analysts recommend the use of the levels of 20 and 80 units instead of 30 and 70 units, as signal levels. Some traders recommend the use of the RSI only for the buy signals in an uptrend market (bull market), or only for the sell signals in a downtrend market (bear market).

The sell and buy signals can also be caused by divergences between the graphs that reflect the evolution of the RSI and that of the data based on which the indicator is calculated. For example, when the RSI graph reaches a local maximum (top) higher than the last and the chart of the share price based on which the RSI is determined reaches a local maximum below the previous one, the indicator provides a buy signal. In the reverse situation, the indicator provides a sell signal. The signal is even more powerful as the difference between the RSI chart and the data graph based on which the indicator is calculated appears after a period in which the index showed overselling or overbuying.

The RSI average level is of 50 units. Another interpretation of the indicator indicates that when it exceeds this value from bottom to top it indicates the emergence/ continuation of an upward trend (bullish trend), and when it exceeds this value from top to bottom it indicates the emergence/ continuation of a downward trend (bearish trend). This interpretation results from the RSI calculation formula. When it has values over 50, the average gain from the last period is higher than the average loss. In the reverse situation the indicator has values below 50.

The adjusted form of the RSI

The classic form of the RSI only takes into account the price of the underlying asset, without considering the volume of trading that led to that price. Therefore, with this paper we aim to adjust the calculation formula of the index so that the new calculation method takes into account the volume of trading. This is an extremely important indicator because it shows the power that drives the market in one direction or another.

In the formula in question we consider two relative forces: the price, compared to the prices related to a number of previous trading days and the volume of trading expressed in terms of value in relation to the volumes of trading associated with the same number of days. Therefore, in determining the adjusted form of the RSI, the study considers the following ratios:

$$RS_{P/V} = \frac{EMAofU_{P/V}}{EMAofD_{P/V}} \quad (8)$$

Where: $RS_{P/V}$ is the relative strength of the price/volume; EMA of $U_{P/V}$ - the exponential moving average of price/volume increase for N days of trading; EMA of $D_{P/V}$ - the exponential moving average of price/volume decrease for N days of trading.

Determining the RSI in our adjusted version (noted RSI_M) involves comparing the relative strength of the volume of trading with the one of the price, according to the following formula (previously used notations are maintained):

$$RSI_M = 100 \times \left(\frac{1}{1+RS_V} - \frac{1}{1+RS_P}\right) \quad (9)$$

If the study uses Formula (9), the RSI will have values between -100 and 100 units. In order that the indicator falls within the value limits of 0 and 100 units proposed by Wilder for the classic form of the RSI, the study will use the following adjusted form of Formula (9):

$$RSI_M = 50 \times \left(1 + \frac{1}{1+RS_V} - \frac{1}{1+RS_P}\right) \quad (10)$$

By applying Formula (10), the interpretation of the results suggested by Wilder does not change. The buy and sell signal levels recommended differ though from those proposed by Wilder. Thus, for the RSI_M, exceeding the level of 37.5 units from bottom to top signals an increase in the underlying asset's price for the next period, while the exceeding of 62.5 units from top to bottom indicates a price decrease in the near future.

The other interpretations mentioned in the presentation of the classic form of the RSI also remain the same for the proposed form.

The data

In the paper, the study will use the daily closing values of the S&P 500 (standard and poor's 500) index from the period March 01, 2004 to April 30, 2010 and the daily trading volume corresponding to the same period.

S&P 500 is a value weighted index of the share prices of the largest companies traded on the two largest U.S. equity markets, the New York Stock Exchange and NASDAQ, according to their market capitalization. S&P 500 has been published since 1957 and takes account of almost all share prices of the top 500 com-panies on the U.S. equity market after their market capitalization. Although, the most popular index on the U.S. equity market remains the Dow Jones Industrial Average (DJIA), in this paper we opted for the S&P 500 index, because in our opinion, it succeeds to reflect even better than the DJIA the evolution of the U.S. economy and the expectations related to it. The study believe this happens because the S&P 500 takes account of the share prices of 500 American companies, and the DJIA includes only 30 companies.

As regards the period taken into account, the study tried to capture the last bull market which ended in 2007 together with the emergence of the first news regarding the credit crisis and the transition into a bear market, of which at the time this paper was written (May to August 2010), the study had concrete, but not clear confirmation that it ended. The data included in the design of the study extend therefore, over six years.

The study was aware that the choice of data is extremely important for the credibility of the obtained results. From this point of view, it was known that a period of six years is not nearly extensive enough to generalize the obtained results and to assert that these results are undeniable. As a continuation of the research initiated by this paper, if the indicator constructed in the period under review confirms its ability to give signals to anticipate the future evolution of the market for a sufficient number of cases, the study will extend the analysis for the entire period in which the S&P 500 index was published.

The daily values of the index that was used were adjusted to the effects of dividends and splits. For this reason, the study could make a comparison of the obtained results using the proposed technique with those which an investor would have obtained for the same period by applying the buy and hold strategy, but this is not the objective. The study simply wants to examine whether the putting into practice of the technique is more profitable than using the traditional form of the RSI. In a future research, the study will examine if the use of both forms of the RSI is more profitable than using the buy and hold strategy.

RESULTS AND DISCUSSION

Through this study, it tried to verify, based on the presented empirical data, the accuracy of the RSI signals determined in the classic form and those of the RSI_M at extreme points. The study used as the extreme points (signal values) the levels of 30 and 70 for the classic version of the RSI, respectively the levels of 37.5 and 62.5 for the version of the indicator. For the determination of EMA, the study used the value of N equal to 14 days for both forms of the indicator. In what follows, the study present the two interpretation strategies applied.

The first strategy

The indicator shows a sell signal, regardless of the calculation version, if the RSI closes the day on a level above the maximum signal value. Selling a unit of the S&P 500 index will take place on the first day the RSI, in any form used, reaches levels below the maximum signal value, provided that these levels are not, on that day, below the average value of the 50 points. In the latter case, the sell signal will not be taken into account. Closing the open position will take place the first day the indicator reaches either the maximum signal value again or a level below 50 points (whichever of the two situations occurs first).

If the RSI closes the day at a level below the minimum signal value, regardless of the used version of calcu-lation, it gives a buy signal. Buying a unit of the S&P 500 index will take place on the first day that the RSI, in any form used, reaches levels above the minimum signal value, provided that these levels are not, on that day, above the average value of the 50 points. In the latter case, the buy signal will not be considered. Closing the open position will occur on the first day the indicator reaches either the minimum signal value again or a level above 50 points (whichever of the two situations occurs first).

By applying the above described strategy for the classic form of the RSI we obtained the results sum-marized in Table 1.

It was seen from Table 1 that the use of the classic form of the RSI and the putting into practice of the above described strategy has resulted for the analysis period in one hundred and twenty-two buy and sell signals which were not equally distributed, that is, fifty-five buy signals and sixty-seven sell signals, with an overall total loss of 283.89 points. From the buy signals twenty-eight were successful, generating a gain of 594.75 points and an average gain per signal of 21.24 points and the other twenty-seven were losing signals, resulting in a total loss of 867.36 points and an average loss per signal of 32.12 points. All fifty-five buy signals have led to a loss of 272.61 points. Regarding the sell signals thirty-three were successful leading to a total gain of 457.04 points and to an average gain of 13.85 points. The remaining thirty-four sell signals were losing ones, generating a total loss of 468.32 points and an average loss per signal of 13.77 points. All sixty-seven sell signals led to a loss of 11.28 points.

It follows that in the period under review, the number of buy signals that were successful was almost equal to the one of the unsuccessful ones, but the average gain per successful buy signal was much smaller than the average loss per losing buy signal. The recommendation is, when investors use the classic form of the RSI, to follow the buy signals generated by this indicator and to reverse the interpretation of the index by transforming them into sell signals. Using this strategy will change the loss of 272.61 points into a gain of the same value. However, in the study opinion, the sell signals must be ignored because they are neutral, the number and the average gain of the successful ones being almost equal with the number and the average loss of the unsuccessful signals. If both

Table 1. Results obtained by applying the classic form of the RSI.

The classic form of the RSI	Total number of signals	The number of successful signals	The number of losing signals	Gain from successful signals	Gain from losing signals	Total gain
Buy	55	28	27	594.75	-867.36	-272.61
Sell	67	33	34	457.04	-468.32	-11.28
Total	122	61	61	1051.79	-1335.68	-283.89

Source: Calculations by the author.

Table 2. Results obtained by applying the RSI_M.

RSI_M	Total number of signals	The number of successful signals	The number of losing signals	Gain from successful signals	Gain from losing signals	Total gain
Buy	68	31	37	455.38	-709.01	-253.63
Sell	71	29	42	387.31	-511.39	-124,08
Total	139	60	79	842.69	-1220.40	-377.71

Source: Calculations by the author.

the sell and buy signals of the period under review are followed, the total loss of 283.89 points is significant and it can completely transform into gain in the case of totally reversing the interpretation of the index, that is, transforming the buy signals in sell signals and vice versa.

By applying the above presented strategy of trading for the proposed form of the RSI, the study obtained the results summarized in Table 2.

It was seen from Table 2 that by applying the above described strategy and using the RSI_M, for the period under review there were a total of one hundred and thirty-nine buy and sell signals unevenly distributed, respectively sixty-eight buy signals and seventy-one sell signals, with an overall total loss of 377.71 points. From the buy signals, thirty-one were successful, generating a gain of 455.38 points and an average gain per signal of 14.69 points while the other thirty-seven were losing signals, resulting in a total loss of 709.01 points and an average loss per signal of 19.16 points. All sixty-eight buy signals led to a loss of 253.63 points. Regarding the sell signals, twenty-nine were successful leading to a total gain of 387.31 points and an average gain of 13.36 points. The remaining forty-two were losing sell signals generating a total loss of 511.39 points and an average loss per signal of 12.18 points. All seventy-one sell signals led to a loss of 124.08 points.

It follows that in the period under review, both from the buy and the sell signals, the majority were losing ones. The average gain per successful signal was under the average loss per losing signal for the buy signals and vice versa for the sell signals. The overall total loss was significant, with a value of 377.71 points. At first glance, the results obtained by applying the RSI_M led to believe the same thing believed for the classic form, namely that this indicator is unnecessary because, regardless of its use, it generated loss. The only thing that stopped from asserting this was, as in the situation the study used the classic form of the indicator, the high value of the loss, bigger that the one obtain by using the classic RSI. The study used the same strategy as before to turn the loss into gain: it reversed the interpretation.

Thus, the indicator shows a buy signal when the RSI closes the day on a level above the maximum signal value. Buying a unit of the S&P 500 will take place on the first day when the RSI_M reaches levels below the maximum signal value, provided that these levels are not below the average value of the indicator of 50 points. In the latter case, the buy signal will not be considered. Closing the open position will take place the first day that the indicator will reach either the maximum signal value again or a level below 50 points (whichever of the two situations occurs first).

In the event the RSI_M closes the day at a level

below the minimum signal value, it gives a signal to sell. The sale of a unit of the S&P 500 index will take place on the first day when the RSI, regardless of the used form, reaches levels above the minimum signal value, provided that on that day these levels are not above the average value of the indicator of 50 points. In the latter case, the sell signal will not be considered. Closing the open position will take place on the first day that the indicator will reach either the minimum signal value again or a level above 50 points (whichever of the two situations occurs first).

It is noted that by applying this trading strategy, both the sell and buy signals generate positive results and the total gain of 377.71 points is considerably higher in value than the one reached by applying the same interpretation to the RSI in its classic form.

The second strategy

The indicator shows a sell signal, regardless of the calculation version, if the RSI closes the day on a level above the maximum signal value. Selling a unit of the S&P 500 index will take place on the first day the RSI, in any form used, reaches levels below the maximum signal value. Closing the open position will take place the first day the indicator reaches the minimum signal value.

If the RSI closes the day at a level below the minimum signal value, regardless of the used version of calculation, it gives a buy signal. Buying a unit of the S&P 500 index will take place on the first day that the RSI, in any form used, reaches levels above the minimum signal value. Closing the open position will occur on the first day the indicator reaches the maximum signal value.

By applying the above described strategy for the classic form of the RSI, the study obtained the results summarized in Table 3.

As seen from Table 3 that the use of the classic form of the RSI and the putting into practice of the above described strategy has resulted for the analysis period in thirty-three buy and sell signals which were almost equally distributed, that is, seventeen buy signals and sixteen sell signals, with an overall total loss of 318.32 points. From the buy signals fourteen were successful, generating a gain of 359.78 points and an average gain per signal of 25.7 points and the other three were losing signals, resulting in a total loss of 556.27 points and an average loss per signal of 185.42 points. All seventeen buy signals have led to a loss of 196.49 points. Regarding the sell signals nine were successful leading to a total gain of 322.34 points and to an average gain of 35.82 points. The remaining seven sell signals were losing ones, generating a total loss of 444.17 points and an average loss per signal of 63.45 points. All sixteen sell signals led to a loss of 121.83 points.

It follows that in the period under review, the number of buy signals that were successful was bigger than the one of the unsuccessful ones, but the average gain per successful buy signal was very small compared to the average loss per losing buy signal. The number of successful and unsuccessful sell signals shows the same situation. The recommendation is, when investors use the classic form of the RSI, to follow the signals generated by this indicator and to reverse the interpretation of the index, that is, to transform the buy signals in sell signals and vice versa.

By applying the above presented strategy of trading for the proposed form of the RSI, the study obtained the results summarized in Table 4.

As seen from Table 4 that by applying the above described strategy and using the RSI_M, for the period under review there were a total of forty-eight buy and sell signals evenly distributed, respectively twenty-four buy signals and twenty-four sell signals, with an overall total loss of 358.67 points. From the buy signals, seventeen were successful, generating a gain of 511.55 points and an average gain per signal of 30.09 points while the other seven were losing signals, resulting in a total loss of 595.5 points and an average loss per signal of 85.07 points. All twenty-four buy signals led to a loss of 83.95 points. Regarding the sell signals, nine were successful leading to a total gain of 228.48 points and an average gain of 25.39 points. The remaining fifteen were losing sell signals generating a total loss of 503.2 points and an average loss per signal of 33.55 points. All twenty-four sell signals led to a loss of 274.72 points.

It follows that in the period under review, the majority from the sell signals were losing ones and the majority of the buy signals were winning ones. The average gain per successful signal was under the average loss per losing signal leading to a loss for both buy and sell signals. The overall total loss was significant, with a value of 358.67 points. The study used the same strategy as before to turn the loss into gain: it reversed the interpretation.

It is noted that by applying this trading strategy, both the sell and buy signals generate positive results and the total gain is higher in value than the one reached by applying the same interpretation to the RSI in its classic form.

Conclusion

In comparison with the classic form of the indicator and for the period taken into account, the RSI version proposed by us generated a higher gain when using a different and even opposite interpretation from the classic one and much greater losses in the reverse situation. Therefore, the study conclude that by analyzing the results of the research, the extreme values of the RSI and RSI_M do not indicate the return of a trend but the continuation of its direction, at least for the short term. So, the classic interpretation is useless while the reversed interpretation gives positive results for both forms of

Table 3. Results obtained by applying the classic form of the RSI.

The classic form of the RSI	Total number of signals	The number of successful signals	The number of losing signals	Gain from successful signals	Gain from losing signals	Total gain
Buy	17	14	3	359.78	-556.27	-196.49
Sell	16	9	7	322.34	-444.17	-121.83
Total	33	23	10	682.12	-1000.44	-318.32

Source: Calculations by the author.

Table 4. Results obtained by applying the RSI_M.

RSI_M	Total number of signals	The number of successful signals	The number of losing signals	Gain from successful signals	Gain from losing signals	Total gain
Buy	24	17	7	511.55	-595.50	-83.95
Sell	24	9	15	228.48	-503.20	-274,72
Total	48	26	22	740.03	-1098.70	-358.67

Source: Calculations by the author.

the indicator. The biggest gains are obtained by using the RSI version proposed by us, regardless of the interpretation strategy used.

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