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DOI: 10.15290/oes.2019.04.98.13

ASSESSMENT OF THE EFFECTIVENESS OF POLISH SOCIAL RESPONSIBLE COMPANY PORTFOLIOS BASED ON MOVING AVERAGES[1]

Summary

Purpose – Assessment of the effectiveness of portfolios composed of shares of Polish socially responsible companies based on moving averages and determination of their optimal lengths.

Research method – The moving average method was used as a part of the technical analysis of companies included in the RESPECT index. Data from the Thompson Reuters database was used using the Metastock XVI program. The research was conducted on daily data from 30/12/2009 to 30/09/2019 (2418 sessions). The strategies used to build the portfolios were optimized to maximize the rate of return.

Results – Definitely higher rates of return were obtained by using two moving averages rather than one. Multi-component portfolios based on two averages generated better results than the buy and hold strategy and compared stock indexes: RESPECT, WIG20, WIG30, WIG. There is a different optimal average length for each portfolio tested that should be used to maximize returns.

Originality / value / implications / recommendations – According to the authors' knowledge this paper is one of the first studies in Poland that uses moving averages to optimize the investment portfolio using shares of socially responsible companies. Owing to the results obtained, the work indicates that there are simple investment strategies that enable achieving above-average returns in the long run, which undermines the hypothesis of information-efficient markets in a weak form.

Key words: social responsibility company, securities portfolios, socially responsible investments, moving average, technical analysis

JEL Classification: A13, G11, G14, M14

[1] Article received on 5 September 2019, accepted on 9 December 2019.

1. Introduction

The use of appropriate strategies on the stock market is inherently associated with the concept of market efficiency itself. In economic sciences, efficiency is used in a variety of contexts and meanings. The most commonly used concept is economic efficiency, which as a praxeological category, is synonymous with the rationality of human activities in the management process.

In the face of the inability to find methods to forecast the prices of financial assets effectively, the concept of an information-effective market was created. It has become an object of interest and much research, both from practitioners and financial market theorists. The market is efficient in terms of information if there is no way to obtain unusually high income by using this information. In practice, of course, it may turn out that the market is not fully effective. Therefore, if there are investment strategies to achieve above-average returns or if the market does not react immediately, but with a certain delay or too abruptly in relation to the information received, it means that the market is most likely inefficient.

The use of technical analysis tools can be used to assess the effectiveness of the capital market. If it turned out that technical strategies allow to achieve extra-ordinary profits in the long run permanently, this would give rise to undermining efficiency in a weak form. In the last decade, research results focusing on the use of averages and oscillators on various markets and financial instruments in the context of analyzing their effectiveness and efficiency have been increasingly published. By entering this trend, the purpose of this work is to assess the effectiveness of portfolios composed of shares of socially responsible companies based on moving averages and to determine optimal, in terms of maximizing rates of return, average lengths.

2. Efficient market hypothesis vs. effectiveness of strategies based on technical analysis

A number of empirical studies conducted on capital markets have revealed the existence of many deviations from efficiency, which are called anomalies, i.e. the fact that there were above average return rate in the past. Anomaly analysis is based on analyzing long-term financial time series for the observed effect and on the expectation of its continuation. The length of the time series is crucial because its extension reduces the likelihood of identifying incidental and fast-expiring phenomena. In turn, the continuation of the phenomenon is a necessary condition for its profitable use in the future. As a result of observed contradictions, among others Majewski [2012, p. 81] and Czekaj [*Efektywność giełdowego*..., 2014, p. 220] believe that the statement about the ineffectiveness of the Polish securities market is justified.

Actually, also the behavioral approach to finance undermines the principle of rational expectations, pointing to a number of restrictions that the human mind makes in the process of prediction and information processing. Proponents of this

approach argue that psychological errors are widespread and can have a significant impact on the development of financial values. Negating the concept of an effective market means that the market valuation of securities is not always adequate to their actual value and the relationship between the expected rate of return and the standard deviation is being undermined as the primary criterion for investment decisions. Classical models of financial markets, e.g. CAPM [Sharpe, 1964] or portfolio theory [Markowitz, 1952], assume that investors are characterized by risk aversion. This means that their utility function from utility theory [von Neumann, Morgenstern, 1944] is concave. Behavioral finance, however, emphasizes that investors do not have a stable risk attitude, but it depends on whether the investor has recently suffered losses or made a profit, and the probability of payments being considered The variability and ambiguity of the research results also confirm the results of many other empirical works [Nurunnabi, 2012].

The results of many studies and market observations have shown that investors commonly show deviations from rationality, both in the sphere of beliefs and in the sphere of consistency of preferences. Some examples of an unexpected explosion of emotional investment decisions that have no explanation in the fundamental situation of a company, industry or country economy can be cited. Examples widely discussed in the literature are speculative bubbles and subsequent stock market crashes, such as those initiated in October on the US stock exchanges in 1929 and 1987. The first crash went down in history due to the discount of most reputable companies reaching 95 percent or more, which initiated the most devastating economic recession in American history (and not only) [Malkiel, 2003, pp. 26-27]. In turn, the crash of 1987 went down in history due to the fact that in two days shares lost almost 30% of value without any valid premise confirmed by macroeconomic indicators [Shiller, 1987, p. 1]. Another example of irrational emotions was the so-called speculative bubble of technology companies in 2000 around the world, which resulted in the bankruptcy of many companies [Gorlewski, 2004, p. 99]. Many psychological factors can also be found at the root of the 2008 financial crisis, such as investor and management greed, underestimation of risk due to overconfidence, herd behavior or limited rationality and mistakes of rating agencies. In addition to psychological factors listed as potential causes of busting in financial markets, the disadvantages of transaction mechanisms (market structure) and automatic transactions are also given [Szyszka, 2009, pp. 283-292].

Methods based on technical analysis, also referred to as direct tests [Siwek, 2005, p. 113], use only information from the market to predict future quotations, including o: historical exchange rates, trading volume, open positions, quotations of market and industry indices. Many early empirical studies regarding the effectiveness of technical analysis carried out, among others by Fama and Blume [1966], van Horne and Parker [1967], James [1968], Jensen and Benington [1970] and the later ones by Fong and Yong [2005] contain the conclusion that in investment strategies analysis technical is not useful to achieve above-average profits. Therefore, popular investment strategies that only use historical data cannot beat the market. On the other hand, studies by Allen and Taylor [1990] and Neftci [1991] confirm that

technical analysis has significant predictive power. The work of Brock et al. [1992] proves that relatively simple investment strategies based on technical analysis allow achieving a significant opportunity to forecast changes in the DJIA index throughout the entire ten-year research period. Bessembinder and Chan [1995] came to similar conclusions using the same strategy with regard to rates of return of indices of the group of Asian capital markets.

It can be assumed that modern research on the profitability of technical analysis have begun with the publication of the work by Lukac et al. [1988], who conducted a very comprehensive analysis of the futures market. The results of the simulations showed that four transaction systems generated a statistically significant monthly rate of return (net) of 1.89% to 2.78% after deducting transaction costs, and the passive strategy brought a negative rate of -2.31%. One of the most influential papers on technical analysis-based investment strategies is the work by Brock et al. [1992], which included only the two simplest and most popular methods of moving average as well as support and resistance lines. The authors provide a general conclusion that technical analysis helps to predict future price changes.

In 2007, in the Journal of Economic Surveys, Park and Irwin presented an overview of empirical research which had been published in 1988-2004 on the profitability of strategies based on technical analysis. Of the 95 analyzes, 56 studies showed the profitability of technical trade, 20 studies gave negative results, and 19 studies gave different results. The results of recently published studies also do not give unequivocal results, however, a shift in evidence in the direction of the profitability of technical trade can be observed. Such evidence is provided, among others, by research by Chong and Ng [2008], Rosillo et al. [2013], Subramanian and Balakrishnan [2014], Cohen and Cabiri [2015], Gold [2015]. Different positions are presented, among others, by: Yu et al. [2013], Tharavanij et al. [2015], Hejase et al. [2017]. According to them, most popular technical trading strategies cannot generate statistically significant returns.

3. Methodology and results of empirical research

3.1. Research methodology

Investment strategies based on moving average are one of the simplest strategies created in technical analysis. At the same time, they are objective strategies and can be automated due to the use of quantitative indicators. In addition, the use of moving average combined with different value and structure of funds allocation gives enormous portfolio building possibilities. The construction and results of the three simplest investment portfolios based on the exponential moving average (EMA) are presented below, i.e. a one-component portfolio consisting of socially responsible companies, a two-component portfolio consisting of 50% cash and 50% of shares of socially responsible companies and a multi-component portfolio (in

equal parts; approx. 3.22% each) from 31 companies included in the RESPECT index as at August 30 this year. corrected from September 20, 2019.

TABLE 1

Trade rules and portfolios composition based on exponential moving average (EMA)

Portfolio feature	Portfolio 1	Portfolio 2	Portfolio 3
Date Range	2009.12.30 – 2019.09.30	2009.12.30 – 2019.09.30	2009.12.30 – 2019.09.30
Positions	only trade long	only trade long	only trade long
Signal positions at using one moving average	buys/sells when the closing price goes above/below a moving average of the closing price	buys/sells when the closing price goes above/below a moving average of the closing price	buys/sells when the closing price goes above/below a moving average of the closing price
Signal positions at using two moving averages	buys/sells when a shorter moving average goes above/below a longer moving average	buys/sells when a shorter moving average goes above/below a longer moving average	buys/sells when a shorter moving average goes above/below a longer moving average
Trade Execution Options	buy/sell price: close, delay to open 1	buy/sell price: close, delay to open 1	buy/sell price: close, delay to open 1
Portfolion structure	100% in shares of one company	50% – cash, 50% in shares of one company	Index RESPECT shares – approx 3,22% each
Portfolio initial value	100 000 PLN	100 000 PLN	100 000 PLN for each instrument (total 3 100 000 PLN)
Reinvesting profits	yes	yes	yes

Source: own elaboration using the Metastock program.

All empirical research was conducted on socially responsible companies included in the RESPECT index on data from the Thompson Reuters database. The Metastock XVI program was used to carry out the necessary tests. The study was conducted on daily data (according to the closing rate) covering the period of 30.12.2009 – 30.09.2019 (2418 sessions). The exponential moving average (EMA) was used as a better tool than the ordinary moving average, according to the following recursive form [Elder, 2013, p. 95]:

$$EMA_{n,t} = P_t \cdot k + EMA_{n,t-1} \cdot (1 - k)$$

where:
$k = 2 / (n + 1)$;
P_t – closing price at t;
$EMA_{n,\,t-1}$ – value of the n-session moving average weighted exponentially at closing prices at t-1.

All tests included only long positions, not including transaction costs and any hedging rules. Buy and sell signals were generated only using the appropriate average in accordance with generally accepted interpretation. The strategies used to build the portfolios were optimized (by choosing the optimal moving average lengths) and assumed closing the last open position at the closing of the last analyzed trading session (30/09/2019). The opening and closing of the position followed the opening price on the day following the day on which the buy/sell signal was generated. The rate of return and an average annual rate of return were used to assess effectiveness, while the result of the buy and hold strategy and changes in the WIG20, WIG30, WIG and RESPECT indices were used as the benchmark.

3.2. Portfolios based on one moving average

All the above portfolios have been optimized in terms of moving average length in the range from 20 to 200, with an optimization step of 5 periods (sessions). Based on the results of the tests carried out, it turned out that a different moving average length was generated for each portfolio (in the analyzed period) giving the best results. For portfolio 2, it was the average of 200 sessions, and for portfolio 3, the average of 120 sessions, while single-component portfolios had different lengths.

TABLE 2

Portfolio results based on EMA120 and EMA200

Instrument	% Gain	Annualized Performance (%)	Buy & Hold Annualized Performance (%)	% Gain	Annualized Performance (%)	Buy & Hold Annualized Performance (%)
	Portfolio 1 (EMA120)			Portfolio 2 (EMA200)		
Agora	-24.58	-2.52	-5.8	6.51	0.67	-2.9
AmRest Holdings	139.28	14.28	45.41	122.51	12.56	22.70
Apator	23.48	2.41	4.02	-14.94	-1.53	2.01
Bank Santander	15.36	3.18	-8.86	3.45	0.71	-4.43
Bank Millennium	-24.29	-2.49	3.60	4.88	0.50	1.80
Bank Pekao	-27.97	-2.87	-3.80	-33.41	-3.42	-1.90
BOŚ	-9.88	1.01	-9.39	-21.93	-2.93	-4.69
Budimex	76.68	7.86	7.00	36.62	3.75	3.50
CCC	61.24	6.28	18.56	79.18	8.12	9.28
Elektrobudowa	9.63	0.99	-9.86	23.65	2.42	-4.93
Energa	-1.27	-0.22	-10.38	36.62	-3.22	-5.19
Forte	419.42	42.99	7.61	169.83	17.41	3.80
GPW	-7.02	-0.79	-2.88	-25.14	-2.83	-1.44
Grupa Azoty	-24.62	-2.52	16.74	7.80	0.80	8.32
LOTOS	77.05	7.9	21.40	16.97	1.74	10.70
Bank Handlowy	7.51	0.77	-2.84	-25.14	-2.50	-1.42

Instrument	% Gain	Annualized Performance (%)	Buy & Hold Annualized Performance (%)	% Gain	Annualized Performance (%)	Buy & Hold Annualized Performance (%)
	Portfolio 1 (EMA120)			Portfolio 2 (EMA200)		
ING Bank Śląski	50.62	5.19	15.95	46.47	4.76	7.98
Inter Cars	-24.83	-2.54	15.65	29.86	3.06	7.82
JSW	10.27	1.25	-10.19	175.63	21.31	-5.09
KGHM	-20.36	-2.09	-0.70	-19.48	-2.00	-0.35
ZEW Kogeneracja	-17.07	-1.75	-6.21	2.99	0.31	-3.10
LW Bogdanka	-28.98	-2.97	-5.12	-5.77	-0.59	-2.56
mBank	63.33	6.49	5.18	3.15	0.32	2.58
Orange Polska	-0.86	-0.09	-6.68	-19.60	-2.01	-3.34
PCC Rokita	1.32	0.25	8.78	59.85	11.36	4.39
PGE	-21.10	-2.16	-6.87	-32.41	-3.32	-3.43
PKN Orlen	-18.76	-1.92	19.55	32.70	3.35	9.77
PGNiG	7.85	0.80	2.21	3.01	0.31	1.10
PZU	-4.14	-4.14	0.41	4.80	0.51	0.20
Tauron PE	-8.08	-0.87	-7.49	-16.91	-1.83	-3.75
Trakcja	72.01	7.38	-9.64	42.88	4.40	-4.82
Portfel 3	**24.88**	**2.55**	**4.53**	**20.65**	**2.12**	**4.53**
WIG20	**-20.20**	**-2.07**	**-0.94**	**-18.27**	**-1.87**	**-0.46**
WIG30	**-29.34**	**-4.74**	**0.42**	**2.59**	**0.42**	**0.2**
RESPECT	**5.09**	**0.52**	**4.53**	**3.78**	**0.39**	**2.27**
WIG	**23.62**	**2.42**	**3.53**	**9.64**	**0.99**	**1.77**

Source: own elaboration using the Metastock program.

The obtained effects of one-component portfolios based on EMA 120 did not give unequivocal results. 17 portfolios out of 31 portfolios generated better results than the buy and hold strategy, 19 out of 31 portfolios were better than changes in the WIG20 index, 15 portfolios generated higher income than changes in the WIG30 index, and 8 portfolios proved to be better than changes in the WIG and RESPECT indices.

The best results of two-component portfolios were generated by the long-term average based on 200 sessions. Of the 31 portfolios analyzed, 15 portfolios generated better results than the buy and hold strategy, 11 portfolios were better than changes in the WIG20, WIG and RESPECT indices, and 20 portfolios generated a higher income than the change in the WIG30 index.

In case of Portfolio 3, which included all socially responsible companies, the best result was generated by an average of 120 sessions, which was better than both the buy and hold strategy and the change of each index. Interestingly, for 33 average lengths, Portfolio 3 generated positive values, with the 20 best results (table 3) much

better than changes in the WIG20, WIG30 and RESPECT indices. Negative values generated systems based on the shortest averages (up to 35 inclusive).

TABLE 3

Portfolio 3 optimization results (top 5)

ID	Avg. Net Profit (PLN)	Total Profit (PLN)	Avg. % Gain	Avg. Trades	Periods in EMA
1.	24878.52	771233.99	24.88	31	120
2.	24408.72	756670.18	24.41	30	125
3.	21702.85	672788.30	21.70	31	115
4.	19686.45	610280.07	19.69	28	135
5.	16518.75	512081.29	16.52	24	180

Source: own elaboration using the Metastock program.

In addition, after conducting several tens of thousands of tests, it occurred that for each of the one-component portfolios in the examined period a different optimal moving average length could have been determined (table 4).

TABLE 4

One-component portfolios optimization results

Instrument	OPT EMA	Net Profit (PLN)	% Gain	Annualized Performance (%)
Agora	65	18658.37	18.66	1.91
AmRest Holdings	105	154200.99	154.20	15.81
Apator	150	42073.23	42.07	4.31
Bank Santander	30	29921.13	29.92	6.20
Bank Millennium	135	40419.52	40.12	4.14
Bank Pekao	65	-24029.20	-24.03	-2.46
BOŚ	95	33804.90	33.80	3.46
Budimex	195	192057.75	192.06	19.69
CCC	65	109650.26	109.65	11.24
Elektrobudowa	35	113372.79	113.37	11.62
Energa	40	4733.18	4.73	0.82
Forte	120	419420.37	419.42	42.99
GPW	40	49370.35	49.37	5.55
Grupa Azoty	70	23646.32	23.65	2.42
LOTOS	140	126461.25	126.46	12.96
Bank Handlowy	85	19198.40	19.20	1.97
ING Bank Śląski	195	137777.92	137.78	14.12
Inter Cars	35	57590.13	57.59	5.90
JSW	115	17531.78	17.53	2.13
KGHM	20	33004.37	33.00	3.38
ZEW Kogeneracja	50	413555.40	41.36	4.24

Instrument	OPT EMA	Net Profit (PLN)	% Gain	Annualized Performance (%)
LW Bogdanka	95	47503.01	47.50	4.87
mBank	90	77972.33	77.97	7.99
Orange Polska	85	2660.59	2.66	0.27
PCC Rokita	85	32660.49	32.66	6.20
PGE	90	-1765.80	-1.77	-0.18
PKN Orlen	25	48434.11	48.43	4.96
PGNiG	25	92465.24	92.47	9.48
PZU	125	78171.57	78.17	8.32
Tauron PE	25	9170.21	9.17	0.99
Trakcja	50	112486.80	112.49	11.53

Source: own elaboration using the Metastock program.

The analysis of the above results clearly indicates that in relation to socially responsible companies there is no single optimal length that would allow to generate above average profits. It is also clearly visible that in the analyzed period the use of an appropriate moving average (especially long-term one) on some companies was extremely profitable (e.g. Forte, Budimex), but also gave mediocre effects also gave mediocre effects when applied in some companies (e.g. PEKAO, PGE).

3.3. Portfolios based on two moving averages

According to the literature on the subject, the use of two moving averages should limit the number of signals generated, reduce the risk, but also, due to the longer delay in relation to the change in course, should limit the potential profit. In order to verify this thesis, the same portfolios as above were analyzed. The only difference is the way the signals are generated – for the following portfolios the buy/sell signal is the intersection from the bottom/top of the longer average by the shorter average. As in the case of portfolios based on one medium, portfolios based on two mediums have been optimized. For EMA1 the optimization range was 5-50, with a step of 5, while for EMA2 it was 20-200, 5 respectively. A total of 6200 tests were carried out, the best results of which are presented in table 5.

As in the case of one- and two-component portfolios based on one moving average, in the case of one- and two-component portfolios based on two moving averages, the results obtained are also inconclusive. There is no one medium combination that could be used with equally good effect for each company. Nevertheless, the use of two averages often improves investment efficiency. In the case of one-component portfolios, the use of two EMA improved their efficiency in 16 cases (even several dozen times, e.g. JSW, PCC Rokita), and in 15 case a slight deterioration occurred.

TABLE 5

Portfolio results based on the intersection of two EMAs (20; 110) and EMA (15; 130)

Instrument	Portfolio results based on the intersection of two EMAs (20; 110)		Portfolio results based on the intersection of two EMAs (15; 130)	
	Annualized Performance (%)	Buy & Hold Annualized Performance (%)	Annualized Performance (%)	Buy & Hold Annualized Performance (%)
Agora	-2.22	-5.80	-0.17	-2.90
AmRest Holdings	29.02	45.41	16.32	22.70
Apator	-3.88	4.02	-1.42	2.01
Bank Santander	2.26	-8.86	1.41	-4.43
Bank Millennium	7.01	3.60	2.63	1.80
Bank Pekao	-5.16	-3.80	-2.81	-1.9
BOŚ	-2.62	-9.39	-1.29	-4.69
Budimex	12.77	7.00	5.80	3.50
CCC	20.04	18.56	10.80	9.28
Elektrobudowa	3.03	-9.86	1.85	-4.93
Energa	5.26	-10.38	2.27	-5.19
Forte	41.14	7.61	20.91	3.80
GPW	-4.06	-2.88	-3.74	-1.44
Grupa Azoty	17.10	16.47	10.14	8.23
LOTOS	4.05	21.40	3.69	10.70
Bank Handlowy	-0.38	-2.84	-0.21	-1.42
ING Bank Śląski	17.36	15.95	8.20	7.98
Inter Cars	2.38	15.65	2.92	7.82
JSW	57.25	-10.19	32.15	-5.09
KGHM	5.70	-0.70	2.84	-0.35
ZEW Kogeneracja	-3.74	-6.21	-1.55	-3.10
LW Bogdanka	-2.68	-5.12	-0.16	-2.56
mBank	1.17	5.18	1.18	2.58
Orange Polska	-2.72	-6.68	-1.67	-3.34
PCC Rokita	21.32	8.78	11.77	4.39
PGE	-4.95	-6.87	-3.03	-3.43
PKN Orlen	17.71	19.55	8.33	9.77
PGNiG	0.48	2.21	0.44	1.10
PZU	1.08	0.41	1.10	0.20
Tauron PE	-4.09	-7.49	-1.23	-3.75
Trakcja	3.14	-9.64	4.38	-4.82
Portfel 3	6.82	4.53	6.82	4.53
WIG20	-2.91	-0.94	-2.26	-0.94
WIG30	-2.65	0.42	-2.61	0.42
RESPECT	3.47	4.53	3.89	4.53
WIG	1.30	3.53	1.74	3.53

Source: own elaboration using the Metastock program.

Two-component portfolios (Portfolio 2) based on two EMAs improved their effects in 24 cases, but they were not as spectacular as in the case of one-component portfolios. It is important to note that the use of the best combinations of medium lengths for one- and two-component portfolios, in relation to the multi-component portfolio (Portfolio 3) gave almost the same effect and they were not optimal combinations. The best effects of multi-component portfolios (table 6) were obtained when using short-term averages from 15-25 with long-term averages from 100-130, while the combination alone did not significantly affect the final portfolio result.

TABLE 6

Portfolio 3 optimization results based on two EMA (top 5)

ID	Avg. Net Profit (PLN)	Total Profit (PLN)	Avg. % Gain	Avg. Trades	Avg. Profit/Avg. Loss	Periods in EMA1	Periods in EMA2
1.	66512.59	2061890.22	66.51	13	4.20	20	110
2.	66460.63	2060279.64	66.46	13	6.26	15	130
3.	65812.70	2040193.76	65.81	14	4.56	15	120
4.	64031.53	1984977.47	64.03	11	4.92	25	110
5.	63425.84	1966201.04	63.43	13	5.46	25	100

Source: own elaboration using the Metastock program.

The literature often indicates the use of two means based on lengths of 50 and 200 periods. In the tests carried out on the above portfolios, this combination did not appear in any case among the top 20 (and in the case of portfolio 3 even in the top 50) combinations. The use of these book averages for portfolio 3 gave an effect (total profit 1 321 312.90 PLN; avg. % gain: 42.62) by over 1/3 worse than the best combination (20; 110).

4. Conclusions

The tests conducted clearly indicated that definitely higher rates of return can be achieved by using two moving averages than one. Multi-component portfolios based on two averages generated better results than the buy and hold strategy and compared stock indexes: RESPECT, WIG20, WIG30 and WIG. The results also indicate that there is no universal optimal length of the averages that should be used to maximize the rate of return. Each studied portfolio had a different best average length, which shows the need to optimize the strategy to determine the right length for the instrument or portfolio. Interestingly, for the multi-component portfolio, medium ranges emerged (15-25, 100-130), among which the combinations used give a similar effect. However, the validity of using the classic combination of two EMAs, i.e. 50, 200, has not been confirmed.

Owing to the results obtained, the work indicates that there are simple investment strategies that allow achieving above-average returns in the long run, which

undermines hypothesis of information-efficient markets in a weak form. Therefore, the information-efficient market hypothesis should not be the sole basis for empirical research on the financial market. Hence the need to use technical analysis for testing, among others the profitability of investor decision making as well as the process of formulating expectations based on their behavior.

References

Allen H., Taylor M., 1990, *Charts, Noise and Fundamentals in the London Foreign Exchange Market*, "The Economic Journal", vol. 100, no. 4, pp. 49-59.

Bessembinder H., Chan K., 1995, *The Profitability of Technical Trading Rules in the Asian Stock Markets*, "Pacific-Basin Finance Journal", vol. 3, iss. 2-3, pp. 257-284, DOI: 10.1016/0927-538X(95)00002-3.

Brock W., Lakonishok J., LeBaron B., 1992, *Simple Technical Trading Rules and the Stochastic Properties of Stock Returns*, "Journal of Finance", vol. 47, iss. 5, pp. 1731-1764, DOI: 10.1111/j.1540-6261.1992.tb04681.x.

Chong T.T.-L., Ng W.-K., 2008, *Technical analysis and the London stock exchange: testing the MACD and RSI rules using the FT30*, "Applied Economics Letters", vol.15, iss. 14, pp. 1111-1114, DOI: 10.1080/13504850600993598.

Cohen G., Cabiri E., 2015, *Can technical oscillators outperform the buy and hold strategy?*, "Applied Economics", vol. 47, no. 30, pp. 3189-3197, DOI: 10.1080/00036846.2015.1013609.

Efektywność giełdowego rynku akcji w Polsce z perspektywy dwudziestolecia, 2014, Czekaj J. (red.), PWE, Warszawa.

Fama E.F., Blume M., 1966, *Filter Rules and Stock Market Trading Profits*, "Journal of Business", vol. 39, iss. 1, pp. 226-241.

Fong W.M., Yong L.H.M., 2005, *Chasing Trends: Recursive Moving Average Rules and Internet Stocks*, "Journal of Empirical Finance", vol. 12, iss. 1, pp. 43-76.

Gold S., 2015, *The Viability of Six Popular Technical Analysis Trading Rules in Determining Effective Buy and Sell Signals: MACD, AROON, RSI, SO, OBV, and ADL*, "Journal of Applied Financial Research", vol. 2, pp. 8-29.

Gorlewski B., 2004, *Finanse behawioralne – czy decyzje inwestycyjne są racjonalne?*, „Studia i Prace Kolegium Zarządzania i Finansów", z. 47, s. 98-112.

Hejase A.J., Srour R.M., Hejase H.J., Younis J., 2017, *Technical Analysis: Exploring MACD in the Lebanese Stock Market*, "Journal of Research in Business, Economics and Management", vol. 8, iss. 4, pp. 1493-1502.

van Horne J.C., Parker G.G.C., 1967, *The Random-Walk Theory: An Empirical Test*, "Financial Analysts Journal", vol. 23, iss. 6, pp. 87-92, DOI: 10.2469/faj.v23.n6.87.

James F.E., 1968, *Monthly Moving Averages: An Effective Investment Tool?*, "Journal of Financial and Quantitative Analysis", vol. 3, iss. 3, pp. 315-326.

Jensen M., Benington G., 1970, *Random Walks and Technical Theories. Some Additional Evidence*, "Journal of Finance", vol. 25, iss. 2, pp. 469-482, DOI: 10.1111/j.1540-6261.1970.tb00671.x.

Lukac L.P., Brorsen B.W., Irwin S.H., 1988, *A Test of Futures Market Disequilibrium Using Twelve Different Technical Trading Systems*, "Applied Economics", vol. 20, iss. 5, pp. 623-639, DOI: 10.1080/00036848800000113.

Majewski S., 2012, *Wpływ czynników behawioralnych na rynkową wycenę akcji. Ujęcie ilościowe*, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin.

Markowitz H.M., 1952, *Portfolio Selection*, „Journal of Finance", vol. 7, no. 1, pp. 77-91, DOI: 10.1111/j.1540-6261.1952.tb01525.x.

Malkiel B.G., 2003, *Błądząc po Wall Street*, WIG-Press, Warszawa.

Neftci S.N., 1991, *Naive Trading Rules in Financial Markets and Wiener-Kolmogorov Prediction Theory: A Study of Technical Analysis*, "Journal of Business", vol. 64, no. 4, pp. 549-571.

von Neumann J., Morgenstern O., 1944, *Theory of Games and Economic Behavior*, Princeton, Princeton University Press.

Nurunnabi M.R., 2012, *Testing Weak-Form Efficiency of Emerging Economies: A Critical Review of Literature,* „Journal of Business, Economics and Management", vol. 13(1), pp. 167-188, DOI: 10.3846/16111699.2011.620140.

Park Ch., Irwin S.H., 2007, *What do we know about the profitability of technical analysis?*, "Journal of Economic Surveys", vol. 21, iss. 4, pp. 786-826, DOI: 10.1111/j.1467-6419.2007.00519.x.

Rosillo R., de la Fuente D., Brugos J.A.L., 2013, *Technical analysis and the Spanish stock exchange: testing the RSI, MACD, momentum and stochastic rules using Spanish market companies*, "Applied Economics", vol. 45, iss. 12, pp. 1541-1550, DOI: 10.1080/00036846.2011.631894.

Sharpe W. F., 1964, *Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk*, "Journal of Finance", vol. 19, iss. 3, pp. 425-442, DOI: 10.1111/j.1540-6261.1964.tb02865.x.

Shiller R.J., 1987, *Investor Behaviour in the October 1987 Stock Market Crash: Survey Evidence*, "NBER Working Papers", no. 2446, pp. 1-41.

Siwek P., 2005, *Praktyka pierwszych ofert publicznych w Polsce,* CeDeWu, Warszawa.

Subramanian V., Balakrishnan K.P., 2014, *Efficacy of Refined MACD Indicators: Evidence from Indian Stock Markets,* "The IUP Journal of Applied Finance", vol. 20, no. 1, pp. 76-91.

Szyszka A., 2009, *Finanse behawioralne. Nowe podejście do inwestowania na rynku kapitałowym*, Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań.

Tharavanij P., Siraprapasiri V., Rajchamaha K., 2015, *Performance of technical trading rules: evidence from Southeast Asian stock markets*, "SpringerPlus", vol. 4(552), pp. 1-40, DOI: 10.1186/s40064-015-1334-7.

Yu H., Nartea G.V., Gan C., Yao L.J., 2013, *Predictive ability and profitability of simple technical trading rules: recent evidence from Southeast Asian stock markets*, "International Review of Economics & Finance", vol. 25, iss. C, pp. 356-371, DOI: 10.1016/j.iref.2012.07.016.