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COMPARISON OF INVESTMENT PERFORMANCE MEASURES USING THE EXAMPLE OF SELECTED STOCK EXCHANGES

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Abstract: In this paper the main objective is to examine whether the selection of the performance measure influences the evaluation of individual investments and the performance rankings generated on that basis. This study presents the values of 16 performance indicators along with their detailed descriptions. All calculations were made using the R program, and the source code can be found at the end of the article. Nine selected stock indices were analysed during the period January 1997–December 2015, and the monthly logarithmic rates of return for these indices were calculated. For 14 out of the 16 measures analysed it was shown that the choice of effectiveness measure had no influence on the evaluation of individual investments; therefore it is not important whether the investor uses the Sharpe ratio or the Calmar ratio as an indicator of efficiency since both measures are almost identical in rank for a particular investment. This has not been confirmed for the Upside Potential ratio, which means that using this indicator may lead to different investment decisions in which the objective is to maximize efficiency. Moreover, based on the analysis it was found that the OMXC 20, DAX 30, and OMXS 30 indexes had the highest efficiency during the period January 1997–December 2015, while the AEX, WIG 20, and PSI 20 indexes were characterized with having the lowest levels of efficiency.

Keywords: investment performance, investment portfolio, correlation, R program.

1. Introduction

The study of investment performance (effectiveness) belongs to the so-called complex investment analysis [Perez, Truszkowski 2011], which most often includes the issue of the simultaneous analysis of the rate of return on investment, and the risk that accompanies this rate of return. In the classical approach to investing, the higher the investment risk associated with a given investment, the higher the expected rate of return should be. Performance analysis allows the investor to prioritise investments that are characterized by different levels of risk and rates of return, which is not always possible when dealing with these two factors separately.

This study presents selected performance (or effectiveness) measures. The effectiveness of selected stock exchange indices during the period 1997-2015 was also examined. Moreover, correlation coefficients were determined between the individual efficiency rankings developed for various measures. The main goal of this study is to verify whether the choice of effectiveness measure has an impact on the classification of individual stock exchange indices in terms of effectiveness.

2. Review of the research literature on investment performance

Investment effectiveness research is one of the most frequently discussed topics in today's finance related scientific research. It is emphasized that the study of investment portfolio effectiveness is a very important element of investment analysis [Moy 2002]. There are numerous publications worldwide that deal with this issue (the more important works in this field which introduce the selection of efficiency indicators are listed in column 3 of Table 1). It should be noted here that valuable publications in this field are also being written in Poland, and the purpose of the following paper is to fill the existing gaps concerning the effectiveness of selected stock exchanges.

Performance measures can be assigned to one of four categories [Caporin et al. 2014]:

- relative measures define the ratio of the rate of return on investment to the investment risk;
- absolute measures indicate how a given investment performs in relation to a specific portfolio called a benchmark;
- density-based measures are based on the characteristics of the return on investment's distribution;
- measures based on utility (utility-based).

The subject of the following study concentrates on relative measures which measure the effectiveness of investments as the rate of return on investment divided by the risk for that investment.

The conclusion that the selection of the performance measure remains without a clear impact on the ranking of individual investments is included in Eling's work [2008]. This author analysed the effectiveness of 3,8954 funds that invested their funds in shares, bonds, real estate, raw materials, and other funds (the *fund of funds*). The period covered by the analysis was 1996-2005. During the study of the analysed investments, 11 measures of effectiveness were calculated and the investment rankings that were created based on these led the author to the conclusion presented above. Eling points out that this is a valuable conclusion, assuming the lack of the normal distribution of rate of returns on the investment in funds.

Another research methodology in the field of performance measures is presented in a study by Brigida and Yang [2014]. In their paper the authors constructed investment portfolios containing random 2 to 100-element securities which included shares from the S & P 500 index. The analysis was based on logarithmic rates of return, calculated daily for the period January 2010 to December 2012. The indicators used for the assessment of effectiveness were the Jensen ratio, the Sharpe ratio, the Treynor ratio and the information ratio. That research allowed the statement to be made that measures of effectiveness are sensitive to the number of investments included in the portfolio. The more diversified the portfolio (i.e. the greater the number of investments in the portfolio), the higher its effectiveness. However, the fact that the assessment of effectiveness is affected by the choice of indicator was not confirmed in this work.

The fact that the choice of the performance ratio does not affect the ranking of investments in terms of their effectiveness was also confirmed in a study by Auer [2015]. The author points out that there are no statistically significant differences between the rankings of investments made on the basis of the use of various measures of effectiveness. In that study the author analysed the values of 13 effectiveness indicators for 30 commodity investments.[1] As to the reason for this situation, Auer points out the similarity in the distributions of the rates of return for the analysed investments.

On the domestic market, research related to the measurement of effectiveness is found in a study by Pruchnicka-Grabias [2015]. The article emphasizes that calculating various new measures of investment risk does not contribute to the improvement of the efficiency measurements. The conclusion the author made is based on research into hedge funds that concern the period 2005-2011. Sharpe, Sterling, Calmar, and Burke's efficiency indicators were calculated in this work.

A broader discussion of a lesser known effectiveness ratio is found in a paper by Mikulec [2013], who dedicated his work to the normalized time relation τ Calmar ratio. Based on studies on the effectiveness of open pension funds for the period 2000-2011, it was found that this indicator is insensitive to the selection of the reference portfolio (benchmark). The choice of different benchmark portfolios does not affect the efficiency ranking.

The publication by Krzysztof Borowski [2014] is an interesting national compendium of knowledge about efficiency measures. The author discusses both simple and complex measures of effectiveness in his book. Some of the selected indicators shown in this publication are Treynor's ratio, Jensen's Alpha, and various Sharpe's ratio extensions. The work emphasized the dynamic development of advanced methods of effectiveness assessment and the fact that scientific research and investment practice have not yet developed a universal method for measuring effectiveness.

[1] Auer examined data for 24 investments and 6 indices.

3. Research methodology and data characteristics

The performance measures described in the table below were used to measure the effectiveness of the analysed stock exchange indices. The columns in Table 1 show the name of the indicator along with the publication in which the measure was described. Detailed formulas for calculating the rate of return on investment (column profitability measure) and its risk (column risk measure) have also been provided. In addition, information on the function’s name that were used to calculate a given indicator in the R program, along with its detailed description is included in Appendix A.

For practically every measure of effectiveness, the method of its calculation was exactly the same in the referenced study as it was in the R program. An exception here is the work of Young [1991], which proposes that the Sterling Index be calculated as the ratio of the rate of return on investment, to the average cumulative loss; while in the R program this measure is calculated as the ratio of the rate of return, to the maximum cumulative loss. In both cases, i.e. in the source text and in the R program code, the risk measure is increased by 10 percentage points.

All calculations presented in this work were made using a free program called R.[2] This program is used to create statistical applications, and is an open source program created by users [Kopczewska, Kopczewski, Wójcik 2009]. The basic version of the script that was written to calculate the effectiveness measures contained in Table 1 is presented in Appendix B.

Efficiency ratios were calculated based on the logarithmic rates of return of major indices for nine stock exchanges. The tenth index, whose value was used to calculate some measures, was the global index from the New York Stock Exchange whose values served mainly as a benchmark. A description of the indices, on the basis of which performance measures were calculated, are included in Table 2.

The monthly logarithmic rates of return have been accumulated for all the indices presented above. The research period adopted for the study was January 1997–December 2015. This gives a total of 2,280 calculated rates of return for all the indices considered in the study.

The efficiency ratios for each of the stock exchange indices quoted in Table 2 were calculated on the basis of rates of return. In the next step, based on the determined measures of effectiveness, efficiency rankings were then built. It was assumed that the investment with the highest efficiency would receive the value of 1 in the ranking, while the one with the lowest efficiency level would receive a value of 9. In this way, 16 such rankings were developed, one for each effectiveness indicator. After the development of the above rankings, the value of the correlation coefficients was calculated. For the rankings, the measures of correlation were determined using Spearman’s correlation coefficients [Wiśniewski 2014], which is otherwise called *sequence correlation coefficients* [Pułaska-Turyna 2011].

[2] More information about the R program can be found at https://cran.r-project.org/.

Table 1. Characteristics of selected performance indicators

No.	Performance ratio	Publication in which the indicator is described	Profitability measure	Risk measure
1	Sharpe (StdDev)	[Sharpe 1966]	$i_p - i_f$	σ_p
2	Sharpe (VaR)		$i_p - i_f$	VaR
3	Sharpe (ES)		$i_p - i_f$	ES
4	Sharpe (annualized)	[Sharpe 1994]	$i_p - i_f$	σ_p
5	Sortino	[Sortino, van der Meer 1991]	$i_p - i_{MARR}$	σ_D
6	Calmar	[Young 1991]	i_p	|MDD|
7	Sterling	[Young 1991]	i_p	|ADD-10%|
8	Information ratio	[Goodwin 1998]	$i_p - i_B$	TE
9	Pain Index	[Odo 2006]	$i_p - i_f$	$PI = \frac{\sum_{i=1}^{n} \lvert D_i' \rvert}{n}$
10	Martin	[Martin, McCann 1989]	$i_p - i_f$	$UI = \frac{\sum_{i=1}^{n} \sqrt{D_i'^2}}{n}$
11	Treynor	[Treynor 1965]	$i_p - i_f$	β_p
12	Upside Potential (subset)	[van der Meer, Sortino, Plantinga 2001]	$i_p - i_{MARR}$	σ_D
13	Upside Potential (full)			
14	Burke	[Burke 1994]	$i_p - i_f$	$\sqrt{\sum DD^2}$
15	Burke (Modified)		$i_p - i_f$	$\sqrt{\frac{\sum DD^2}{n}}$
16	D Ratio	[Bacon 2004]	The value of this coefficient is calculated according to the formula: $\frac{-n_d * \sum_{i=1}^{n} \min(r_i,0)}{n_u * \sum_{i=1}^{n} \max(r_i,0)}$	

where: i_p – the rate of return for the portfolio, i_f – the risk-free rate of return, i_{MARR} – the minimum acceptable rate of return, i_B – the rate of return for the benchmark, σ_p – the portfolio risk, measured using the standard deviation of the rate of return, *VaR* – Value at Risk, *ES* – Expected Shortfall, σ_D – Semi-standard Deviation, β_p – the beta coefficient for the portfolio, |MDD| – the maximum drawdown (maximum cumulative loss), *ADD* – the average drawdown (average cumulative loss), *DD* – drawdown (cumulative loss), *TE* – tracking error, *PI* – the pain index, calculated as the average decline value, *UI* – Ulcer Index, n_d – the number of negative return rates, n_u – the number of positive return rates.

Source: own calculations.

Table 2. Description of the analysed indexes

No.	Indices	Stock	The maximum number of enterprises whose quotes influence the value of the index
1	AEX	Euronext Amsterdam	25
2	BEL20	Euronext Brussels	20
3	CAC40	Euronext Paris	40
4	DAX30	Frankfurt Stock Exchange	30
5	FTSE100	London Stock Exchange	100
6	OMXC20	Nasdaq Copenhagen	20
7	OMXS30	Nasdaq Stockholm	30
8	PSI20	Euronext Lisbon	20
9	WIG20	Warsaw Stock Exchange	20
10	DJWORLD	New York Stock Exchange	Calculated on the basis of changes in stock indices for 47 countries*

* For more information, please visit https://www.djindexes.com/globalfamily/?go=literature.

Source: own calculations.

4. Research results – effectiveness concerning examples of selected stock market indices

Table 3 presents the values of selected descriptive statistics for the tested stock indices. The average arithmetic rate of return was the highest for the Stockholm Stock Exchange index with a value of 0.88% per month, while the lowest average rate of return was the investment for the Portuguese Stock Exchange index. For this investment, the average monthly return rate was 0.01% per month. In addition, six of the nine indices that were analysed were characterized by an average rate of return that was lower than the average for the DJWORLD reference index, the average return of which was 0.33% per month during the whole research period. The OMXC20, OMXS30, and DAX30 indices were all higher than the benchmark's average.

Based on the data presented in Table 3 it can be also stated that the lowest investment risk was for the investment in the UK Stock Exchange index, for which the standard deviation value was 4.15 per month. It was the only investment that was characterized by a lower risk level than the designated risk level for the benchmark index. In the remaining eight cases the calculated risk value was higher than in the case of the benchmark, and ranged from 5.13 to 7.61 per month. For all the analysed indices there was a tendency for the rate of return value to group around the average, which meant a leptokurtic distribution for the rate of return. In addition, in each

Table 3. The values of the descriptive statistics for the analysed indexes

No.	Descriptive statistics	*AEX*	*BEL 20*	*CAC 40*	*DAX 30*	*FTSE 100*	*OMXC 20*	*OMXS 30*	*PSI 20*	*WIG 20*	*DJ WORLD*
1	Mean [%]	0.18	0.30	0.31	0.58	0.18	0.88	0.49	0.01	0.11	0.33
2	Median [%]	1.14	1.06	1.21	1.44	0.73	1.12	0.78	0.27	0.22	0.94
3	Standard deviation [p.p.]	6.03	5.13	5.59	6.60	4.15	5.53	6.01	6.16	7.61	4.73
4	Kurtosis	2.05	3.33	0.51	2.44	0.63	1.69	0.96	1.23	2.6	2.35
5	Skewness	–0.96	–1.3	–0.59	–0.88	–0.68	–0.68	–0.51	–0.43	–0.58	–0.98
6	Range [p.p.]	37.2	37.6	31.8	48.7	22.4	39.3	34.5	40.5	57.6	33.4
7	Min. [%]	–22.6	–24.1	–19.2	–29.3	–14.0	–20.8	–18.5	–23.3	–37.3	–22.3
8	Max [%]	14.6	13.5	12.6	19.4	8.5	18.5	16.1	17.2	20.4	11.1
9	Number of observations	228	228	228	228	228	228	228	228	228	228

Source: own calculations.

case a left-skewed distribution was observed for the analysed investments. This means that for each index tested there were more results above the average value than below. The confirmation of this is also that the median value of the rate of return for each index is higher than the average value. In addition, Table 3 shows the value of the empirical volatility area as well as the lowest and highest value for the monthly rate of return. It turned out that the extreme values for all indices are in the range of –37.3 to 20.4. These given range limits were also the extreme values for the investments in the WIG20 index which means that this investment was characterized by the highest rate of return variation, and this was also reflected in the value of the standard deviation. For the WIG20 index, the standard deviation reached its highest value among all the tested indexes.

The following table presents the values of the performance measures for the research period. The following assumptions were made for their calculation:

- the minimum acceptable rate of return (MARR) for the investor is 6% per annum, or 0.5% per month (the values of the ratios that were discussed were also calculated for a MARR = 0% and MARR = –6% per year),
- the risk-free rate of return (if) value is 2% per annum,
- the results are presented with an accuracy to 3 decimal places.

The data presented in Table 4 are the basis for stating that the investment in the Portuguese Stock Exchange was the least effective investment. This is confirmed by the fact that the PSI20 index received the lowest values for eight out of the sixteen measures that were determined for the analysed indices. The Portuguese Stock Exchange was shown to be the least effective on the basis of the index values marked with the numbers 1 to 5, 8, 11, and 16. For the other six effectiveness measures the indicated stock market index was ranked one position lower, this produced a low

Table 4. The values of performance measures for the analysed indices over the research period

No.	Performance measure	*AEX*	*BEL 20*	*CAC 40*	*DAX 30*	*FTSE 100*	*OMXC 20*	*OMXS 30*	*PSI 20*	*WIG 20*
1	Sharpe (StdDev)	0.003	0.025	0.025	0.062	0.004	0.129	0.054	–0.025	–0.007
2	Sharpe (VaR)	0.001	0.014	0.015	0.036	0.002	0.079	0.032	–0.014	–0.004
3	Sharpe (ES)	0.001	0.009	0.011	0.022	0.002	0.052	0.023	–0.010	–0.003
4	Sharpe (annualized)	0.009	0.088	0.088	0.215	0.015	0.447	0.189	–0.086	–0.025
5	Sortino	–0.065	–0.048	–0.044	0.015	–0.094	0.095	–0.001	–0.101	–0.067
6	Calmar	–0.001	0.029	0.028	0.059	0.023	0.155	0.053	–0.028	–0.033
7	Sterling	–0.001	0.025	0.024	0.052	0.019	0.132	0.046	–0.025	–0.029
8	Information ratio	–0.213	–0.055	–0.072	0.122	–0.170	0.451	0.087	–0.286	–0.243
9	Pain Index	–0.005	0.052	0.042	0.154	0.053	0.554	0.103	–0.040	–0.066
10	Martin	–0.004	0.041	0.035	0.109	0.040	0.363	0.079	–0.035	–0.055
11	Treynor	–0.020	–0.001	–0.002	0.020	–0.011	0.086	0.018	–0.049	–0.040
12	Upside Potential (subset)	0.507	0.507	0.598	0.593	0.567	0.628	0.658	0.653	0.689
13	Upside Potential (full)	0.419	0.414	0.475	0.490	0.428	0.560	0.490	0.438	0.456
14	Burke	–0.002	0.019	0.016	0.041	0.015	0.102	0.035	–0.020	–0.020
15	Burke (Modified)	–0.037	0.291	0.237	0.616	0.224	1.543	0.533	–0.298	–0.305
16	D Ratio	0.647	0.557	0.632	0.566	0.684	0.407	0.594	0.960	0.929

Source: own calculations.

average result for this investment. On the other hand, the most effective investment was the investment in the stock index in Copenhagen. For the OMXC20 index, it was observed that the investment had the highest efficiency in 15 out of the 16 analysed efficiency indicators.

In the next step, the rank assignments for the analysed indexes were made based on the calculated measures of effectiveness. Based on the results, individual indices were classified by assigning them the appropriate parameter value. The least-effective investment received a parameter value of 9, while the investment with the highest value of effectiveness was described by a parameter value of 1. In this way, 16 digits were obtained for each of the indices tested (see Appendix C). In addition, the number of times the effectiveness of a given index occupied a specific place in the ranking is indicated for each index in the table below.

Table 5. Listed indices – number of ranking items

Position in the ranking	Number of occurrences in a given position in the ranking								
	AEX	*BEL 20*	*CAC 40*	*DAX 30*	*FTSE 100*	*OMXC 20*	*OMXS 30*	*PSI 20*	*WIG 20*
1	0	0	0	0	0	15	0	0	1
2	0	1	0	12	0	0	3	0	0
3	0	0	0	3	0	0	12	1	0
4	0	9	4	0	1	1	1	0	0
5	0	4	10	0	1	0	0	0	1
6	2	0	2	1	10	0	0	1	0
7	12	0	0	0	3	0	0	0	1
8	2	1	0	0	1	0	0	6	7
9	0	1	0	0	0	0	0	8	6

Source: own calculations.

As presented in Table 5, the three stock indices that should be defined as those having the highest efficiency during the research period are investments in the OMXC20, DAX30, and OMXS30 indices. On the other hand, the AEX, WIG20, and PSI20 indices were characterized by the lowest level of effectiveness, as evidenced by the high number of the lowest positions in the prepared rankings. For all the indices except the PSI20 and WIG20 it can be shown that a minimum of 9 out of the 16 measures positioned each of the indices in the same place.

In order to investigate whether individual measures of efficiency rank the analysed investments in a similar way, a correlation matrix was determined. The values are presented in Table 6.

Table 6. The values of correlation coefficients between individual performance measures for the research period

Number of the effectiveness measure	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	2	3	4	5	6	7	8	9
(1)	1.000							
(2)	**1.000**	1.000						
(3)	**0.967**	**0.967**	1.000					
(4)	**1.000**	**1.000**	**0.967**	1.000				
(5)	**0.917**	**0.917**	**0.917**	**0.917**	1.000			
(6)	**0.983**	**0.983**	**0.950**	**0.983**	**0.867**	1.000		
(7)	**0.983**	**0.983**	**0.950**	**0.983**	**0.867**	**1.000**	1.000	

1	2	3	4	5	6	7	8	9
(8)	**1.000**	**1.000**	**0.967**	**1.000**	**0.917**	**0.983**	**0.983**	1.000
(9)	**0.950**	**0.950**	**0.900**	**0.950**	**0.783**	**0.983**	**0.983**	**0.950**
(10)	**0.950**	**0.950**	**0.900**	**0.950**	**0.783**	**0.983**	**0.983**	**0.950**
(11)	**0.983**	**0.983**	**0.950**	**0.983**	**0.867**	**1.000**	**1.000**	**0.983**
(12)	–0.167	–0.167	–0.050	–0.167	0.083	–0.133	–0.133	–0.167
(13)	0.600	0.600	**0.700**	0.600	**0.750**	0.583	0.583	0.600
(14)	**0.983**	**0.983**	**0.950**	**0.983**	**0.867**	**1.000**	**1.000**	**0.983**
(15)	**0.983**	**0.983**	**0.950**	**0.983**	**0.867**	**1.000**	**1.000**	**0.983**
(16)	0.933	0.933	0.850	0.933	0.800	0.900	0.900	0.933
Number of the effectiveness measure	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)								
(2)								
(3)								
(4)								
(5)								
(6)								
(7)								
(8)								
(9)	1.000							
(10)	**1.000**	1.000						
(11)	**0.983**	**0.983**	1.000					
(12)	–0.167	–0.167	–0.133	1.000				
(13)	0.517	0.517	0.583	0.550	1.000			
(14)	**0.983**	**0.983**	**1.000**	–0.133	0.583	1.000		
(15)	**0.983**	**0.983**	**1.000**	–0.133	0.583	**1.000**	1.000	
(16)	**0.883**	**0.883**	**0.900**	–0.367	0.333	**0.900**	**0.900**	1.000

* Values in bold are statistically significant with a significance level of 0.05.

Source: own calculations.

Based on the data presented in Table 6 it can be concluded that for all indicators except the Upside Potential measures (indexes 12 and 13), there are strong interdependencies between the analysed ratios. The determined correlation coefficient values indicate in most cases (14 out of 16) a strong and positive relationship. This means that if, for a given measure in the ranking of efficiency, the position of an individual investment increased, it was accompanied by a simultaneous increase in the efficiency ranking for another measure. Also, for the effectiveness measure marked as number 13, identical regularity was confirmed; however, it is not statistically significant at a selected significance level of 0.05. Nonetheless, the reverse relation was observed for the measure of efficiency marked as order number 12. For this indicator there was no strong correlation in the efficiency ranking based on this measure when compared to the rankings constructed on the basis of other analysed indicators. It can therefore be concluded that the choice of the efficiency index has no impact on the classification of the examined investments in terms of efficiency. However this principle cannot be unambiguously confirmed for the index referred to as the Upside Potential.

5. Conclusion

The above study shows that for 14 out of the 16 measures analysed, the choice of the measure of effectiveness does not affect the assessment of individual investments. This regularity has been observed for the rate of return of selected stock indices. Therefore, it does not matter whether the investor uses the Sharpe ratio or the Calmar measure in assessing effectiveness, as both measures rank individual investments in an identical way. This regularity has not been confirmed for the coefficient referred to as the Upside Potential, which means that using this indicator may lead to different investment decisions in the context of the goal of maximizing efficiency.

In addition, a detailed description of the 16 measures of effectiveness was presented along with an example of how to calculate these measures using the R program. What is more, the analysis proved that the highest efficiency for the period January 1997–December 2015, were for investments in the OMXC20, DAX30, and OMXS30, whereas the AEX, WIG20, and PSI20 indexes were characterized by the lowest level of efficiency.

Bibliography

Auer B.R., 2015, *Does the choice of performance measure influence the evaluation of commodity investments?*, International Review of Financial Analysis, vol. 38, pp. 142-150.

Bacon C.R., 2004, *Practical Portfolio Performance Measurement and Attribution*, John Wiley & Sons Ltd., New Jersey.

Borowski K., 2014, *Miary efektywności zarządzania na rynkach finansowych*, Difin, Warszawa.

Brigida M., Yang C., 2014, *How Consistent are the Judges of Portfolio Performance?*, http://www.*complete-markets.com*, pp. 1-8.

Burke G., 1994, *A sharper Sharpe ratio*, Futures, 56.

Caporin M., Jannin G.M., Lisi F., Maillet B.B., 2014, *A survey on the four families of performance measures*, Journal of Economic Surveys, vol. 28(5), pp. 917-942.

Eling M., 2008, *Does the measure matter in the mutual fund industry?*, Financial Analyst Journal, vol. 64(3), pp. 1-13.

Goodwin T.H., 1998, *The information ratio*, Financial Analysts Journal, vol. 54(4), pp. 34-43.
Kopczewska K., Kopczewski T., Wójcik P., 2009*, Metody ilościowe w R. Aplikacje ekonomiczne i finansowe*, CeDeWu.PL, Warszawa.
Martin P.G., McCann B.B., 1989, *The Investor's Guide to Fidelity Funds*, John Wiley & Sons, New Jersey.
Mikulec A., 2013, *Znormalizowany względem czasu τ wskaźnik Calmara i jego zastosowanie w analizie efektywności inwestycji*, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, vol. 323, pp. 212-222.
Moy R.L., 2002, *Portfolio performance: Illustrations from morningstar*, Journal of Education for Business, vol. 77(4), pp. 226-229.
Odo M., 2006, *Pain Index and Pain Ratio*, http://www.styleadvisor.com (15.09.2017).
Perez K., Truszkowski J., 2011, *Portfel inwestycyjny*, Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań.
Pruchnicka-Grabias I., 2015, *Zastosowanie miar maksymalnej straty na kapitale w badaniu efektywności funduszy hedgingowych*, Kwartalnik Kolegium Ekonomiczno-Społecznego Studia i Prace, vol. 3(3), pp. 133-145.
Pułaska-Turyna B., 2011, *Statystyka dla ekonomistów* (III), Difin, Warszawa.
Sharpe W.F., 1966, *Mutual fund performance*, The Journal of Business, pp. 119-138.
Sharpe W.F., 1994, *The Sharpe ratio*, The Journal of Portfolio Management, pp. 49-58.
Sortino F., van der Meer R., 1991, *Downside risk*, The Journal of Portfolio Management, vol. 17(4), pp. 27-31.
Treynor J., 1965, *How to rate management of investment funds*, Harvard Business Review, vol. 43, pp. 63-75.
Van der Meer R., Sortino F., Plantinga A., 2001, *The Impact of Downside Risk on Risk-Adjusted Performance of Mutual Funds in the Euronext Markets*, Geneva Papers on Risk and Insurance, pp. 1-14.
Wiśniewski J.W., 2014, *Dylematy stosowania współczynnika korelacji Spearmana*, Studia Ekonomiczne, Uniwersytet Ekonomiczny w Katowicach, vol. 181, pp. 174-184.
Young T.W., 1991, *Calmar ratio: A smoother tool*, Future Magazine, vol. 20(1), p. 40.

Appendix A. Description of the function for determining performance measures in the R program

No.	Performance measure	The name of the R program function	Calculation method in the R program
1	2	3	4
1	Sharpe (StdDev)	Sharpe Ratio We calculate the specific measure by substituting FUN as StdDev, VaR or ES respectively	The average arithmetic rate of return for the investment under investigation, reduced by the risk-free rate of return, is divided by the standard deviation of the rate of return of the investment under examination. The standard deviation is calculated as the standard deviation of the sample (the nominative is N-1).
2	Sharpe (VaR)		The average arithmetic rate of return for the investment under investigation, reduced by the risk-free rate of return, is divided by VaR (Value at risk).
3	Sharpe (ES)		The average arithmetic rate of return for the investment under examination, reduced by the risk-free rate of return, is divided by the value of ES (called „Expected Short-fall”).
4	Sharpe (annualized)	SharpeRatio. annualized	The average geometric rate of return for the examined investment (annualized) minus the annual risk-free rate of return is divided by the standard deviation of the rate of return of the investment under review (in annual terms).
5	Sortino	SortinoRatio	The average arithmetic rate of return reduced by the minimum acceptable rate of return (MARR) is divided by the standard semi-deviation, where instead of the average rate of return the MARR value is substituted. The standard semi-deviation is calculated based on the number of all observations (the N is in the denominator).
6	Calmar	CalmarRatio	The average arithmetic rate of return (on an annual basis) is divided by the absolute value of the maximum accumulated loss.
7	Sterling	SterlingRatio	The average arithmetic rate of return (on a yearly basis) is divided by the absolute value of the maximum cumulative loss increased by 10 percentage points by default (the last value is under user control).
8	Information ratio	InformationRatio	The rate of return (on a yearly basis) calculated as the difference between the average geometric rate of return on a given investment and the geometric mean rate of return on investment fulfilling the benchmark role is divided by the tracking error (given on an annual basis).
9	Pain Index	PainRatio	The average geometric rate of return for the investment examined, minus the risk-free rate of return, is divided by the index referred to as Pain Index (PI).
10	Martin	MartinRatio	The average geometric rate of return for the investment examined, minus the risk-free rate of return, is divided by the index referred to as the Ulcer Index (UI).

1	2	3	4
11	Treynor	TreynorRatio	The average geometric rate of return (annualized) for the investment examined, minus the risk-free return rate, is divided by the value of the Beta coefficient calculated on the basis of the rates of return from the analysed investment and the rate of return on investment referred to as a benchmark.
12	Upside Potential (subset)	UpsidePotentialRatio (with argument method = "subset")	The average arithmetic rate of return (only for those observations in which ip> MARR) decreased by the minimum acceptable rate of return (MARR) [to calculate the mean divided by the number of observations meeting the condition ip> MARR] is divided by the standard semi-deviation, where instead of the mean the rate of return is the MARR rate. The standard semi-deviation is calculated based on the number of only those observations in which ip <MARR.
13	Upside Potential (full)	UpsidePotentialRatio (with argument method = "full")	The average arithmetic rate of return (only for those observations in which ip> MARR) decreased by the minimum acceptable rate of return (MARR) [to calculate the average divided by the number of all cases] is divided by the standard semi-deviation, where instead of the average rate of return the value is substituted by MARR rate. The standard semi-deviation is calculated based on the number of all observations.
14	Burke	BurkeRatio	The rate of return on investment (in annual terms) calculated as the difference between the rate of return on investment and the rate of return on risk-free investment is divided by the square root of the sum of squares of all accumulated losses.
15	Burke (Modified)	BurkeRatio (with argument modified=TRYE)	The rate of return on investment (in annual terms) calculated as the difference between the rate of return on investment and the rate of return on risk-free investment is divided by the square root of the sum of squares of all accumulated losses divided by the number of observations.
16	D Ratio	dRatio	The sum of the negative return rates multiplied by their number and minus one is divided by the sum of the positive return rates multiplied by their number. Return rates equal to zero are not included in the calculations.

Appendix B. R program procedure for calculating performance indicators

```
install.packages("PerformanceAnalytics")
install.packages("fPortfolio")

library(PerformanceAnalytics)
library(fPortfolio)

dane <- read.csv(file = "D:/R/dane.csv", header = TRUE,
sep=";", dec=",")
dane <- ts(dane, start=c(1997, 1), end=c(2015, 12),
frequency=12)
danets <- as.timeSeries(dane)

#Defined variables for indicators
MARR <- -0.06/12
RF <- 0.02/12
Benchmark <- danets[,2]
RlubRa <- danets[,3:11]
dig <- 4

#Calculation of indicators
Sharpe <- SharpeRatio (R=RlubRa, Rf=RF)
Sharpe2 <- round (SharpeRatio.annualized (R=RlubRa, Rf=RF,
scale = 12, geometric = FALSE), digits=dig)
Sortino <- round (SortinoRatio (R=RlubRa,MAR=MARR),dig-
its=dig)
Calmar <- round (CalmarRatio (R=RlubRa), digits = dig)
Sterling <- round (SterlingRatio (R=RlubRa), digits = dig)
InfrormationRatio <- round (InformationRatio (Ra =RlubRa,
Rb = Benchmark), digits = dig)
Pain <- round (PainRatio (R=RlubRa, Rf=RF), digits = dig)
Martin <- round (MartinRatio (R=RlubRa, Rf=RF), digits = dig)
Treynor <- round (TreynorRatio (Ra = RlubRa, Rb = Benchmark,
Rf=RF),digits= dig)
UPR <- round (UpsidePotentialRatio (R=RlubRa, MAR = MARR,
method = "subset"), digits = dig)
UPR2 <- round (UpsidePotentialRatio (R=RlubRa, MAR = MARR,
method = "full"), digits = dig)
Burke <- round (BurkeRatio (R=RlubRa, Rf=RF), digits = dig)
Burke2 <- round (BurkeRatio (R=RlubRa, Rf=RF, modified =
TRUE), digits = dig)
DeRatio <- round (DRatio (R=RlubRa), digits = dig)
```

```
tabela <- rbind.data.frame(Sharpe, Sharpe2, Sortino, Calmar,
Sterling, InfrormationRatio, Pain,
Martin, Treynor, UPR, UPR2, Burke, Burke2, DeRatio, make.row.
names = TRUE)

#Saving calculations
write.table(tabela, file = "efektywnosc.csv", row.names =
TRUE, col.names = TRUE, sep = ";", dec=",")
```

Appendix C. Values of assigned parameters for the analysed investments, based on the calculated performance indicators

No.	Performance measure	AEX	BEL 20	CAC 40	DAX 30	FTSE 100	OMXC 20	OMXS 30	PSI 20	WIG 20
1	Sharpe (StdDev)	7	4	5	2	6	1	3	9	8
2	Sharpe (VaR)	7	5	4	2	6	1	3	9	8
3	Sharpe (ES)	7	5	4	3	6	1	2	9	8
4	Sharpe (annualized)	7	4	5	2	6	1	3	9	8
5	Sortino	6	5	4	2	8	1	3	9	7
6	Calmar	7	4	5	2	6	1	3	8	9
7	Sterling	7	4	5	2	6	1	3	8	9
8	Information ratio	7	4	5	2	6	1	3	9	8
9	Pain Index	7	5	6	2	4	1	3	8	9
10	Martin	7	4	6	2	5	1	3	8	9
11	Treynor	7	4	5	2	6	1	3	9	8
12	Upside Potential (subset)	8	8	5	6	7	4	2	3	1
13	Upside Potential (full)	8	9	4	3	7	1	2	6	5
14	Burke	7	4	5	2	6	1	3	8	9
15	Burke (Modified)	7	4	5	2	6	1	3	8	9
16	D Ratio	6	2	5	3	7	1	4	9	8

PORÓWNANIE MIAR EFEKTYWNOŚCI INWESTYCJI NA PRZYKŁADZIE WYBRANYCH GIEŁD PAPIERÓW WARTOŚCIOWYCH

Streszczenie: W opracowaniu za cel główny przyjęto zbadanie, czy wybór wskaźnika efektywności ma wpływ na ocenę poszczególnych inwestycji i tworzone na tej podstawie rankingi efektywności. Do badania wykorzystano wyliczone wartości 16 wskaźników efektywności wraz z ich szczegółowym opisem. Wszystkie wyliczenia przeprowadzono w programie R, a kod źródłowy zamieszczono na końcu artykułu. Badaniu poddano 9 wybranych indeksów giełdowych w okresie styczeń 1997 – grudzień 2015, dla tych indeksów wyliczono miesięczne logarytmiczne stopy zwrotu. Dla 14 z 16 analizowanych miar wykazano, że ich wybór do badania efektywności nie ma wpływu na ocenę poszczególnych inwestycji. Nie ma więc znaczenia, czy inwestor w ocenie efektywności posługuje się wskaźnikiem Sharpe'a, czy współczynnikiem Calmara, gdyż obie te miary w niemalże identyczny sposób rangują poszczególne inwestycje. Prawidłowości tej nie potwierdzono dla współczynnika określanego jako Upside Potential, co oznacza że posługiwanie się tym wskaźnikiem może prowadzić do odmiennych decyzji inwestycyjnych w kontekście celu, jakim jest maksymalizacja efektywności. Co więcej, na podstawie przeprowadzonej analizy stwierdzono, że najwyższą efektywnością w okresie styczeń 1997 – grudzień 2015 odznaczała się inwestycja w indeksy OMXC 20, DAX 30 oraz OMXS 30. Natomiast indeksy AEX, WIG 20 oraz PSI 20 cechowały się najniższym poziomem efektywności.

Słowa kluczowe: efektywność inwestycji, portfel inwestycyjny, korelacja, program R.