QUANTITATIVE METHODS IN ECONOMICS
Vol. XII, 2011, pp. 105–117

EFFICIENCY OF INDIRECT WAYS OF INVESTING IN COMMODITIES IN CONDITIONS OF POLISH CAPITAL MARKET

Monika Krawiec
Department of Econometrics and Statistics
Warsaw University of Life Sciences – SGGW
e-mail: krawiec.monika@gmail.com

Summary: Within last couple of years one could observe record levels of commodity prices and now commodity investments grow in popularity. Although there are possible direct and indirect ways of investing in commodities, the paper focuses on indirect investing through commodity-related stocks and commodity funds. The research aims at assessing their efficiency in comparison to stock market, so the main index of Warsaw Stock Exchange (WIG) is a benchmark. There were calculated basic characteristics of considered assets and there were tested hypotheses of normality of their logarithmic returns and equality of their means and deviations from mean in relation to the benchmark. As no time series followed normal distribution, Mann-Whitney U test was applied.

Keywords: investing in commodities, indirect ways, Mann-Whitney U test

INTRODUCTION

High volatility of financial markets, poor results on stock markets, growing inflation and risk from global crisis incline investors to seek alternative ways of investing capital. Investment in tangible assets is becoming a more and more popular solution. There are many classes of possible alternative investments. Jajuga [2007] in the first place mentioned real estate and then commodities[1]. In this group special attention should be paid to: precious metals, industrial metals, agricultural

[1] Other alternative forms of investing include: investing in art (painting, photography, graphics, design, sculpture or antique) and collector's items (coins, stamps, cars, watches, wine, precious stones, etc.). A more detailed discussion on alternative forms of investing was provided by Jagielnicki (2011), as well as Borowski (2008) and Niedziółka (2008).

goods and energy raw materials. However, taken recession on American mortgage market into account, investing in real estate is not as popular as it used to be. In this situation investors have become interested in commodity markets.

The main reason behind such a state of affairs is the fact that commodities provide one with portfolio diversification, hedge against inflation and generate attractive profit when interest rates are low. Prices of many commodities have recently shown an upward tendency, regardless of correction periods. Investors may choose between direct and indirect forms of investing in commodities. In the case of the former, i.e. purchase of the physical commodity on the cash market, it may be difficult to provide proper storage conditions. The only exception here, are precious metals that do not require special conditions. On the contrary, agricultural goods and energy raw materials are really bothersome in this respect. Hence, individual investors rather prefer indirect investments, e.g. purchase of stocks of companies specialising in commodity production or purchase of participation units in specialized commodity funds. Polish investors also have such an opportunity as such funds operate on Polish market. As a matter of fact, they have recently grown in number.

The present paper is therefore aimed at determining the effectiveness of indirect forms of investing in commodities on Polish capital market. The analysis covers stock quotations of selected companies listed on the Warsaw Stock Exchange and operating on commodity markets. Furthermore, attention is also paid to quotations of participation units in commodity mutual funds. The main index of Warsaw Stock Exchange – WIG, commonly considered a substitute of market portfolio, is a benchmark.

EMPIRICAL DATA AND RESEARCH METHODS

Empirical data used for the purpose of the analysis covers the period from 17 December 2008 to 31 March 2011. These are daily participation unit quotations of selected commodity mutual funds operating on Polish market as well as stock quotations of companies listed on the Warsaw Stock Exchange and functioning on commodity markets. Time horizon was limited due to data availability. Despite the fact that a great number of commodity mutual funds currently function on Polish market, most of them have emerged relatively recently and hence they do not have long quotation records. Detailed analysis of available data allowed selecting the following 8 funds: Idea Surowce Plus, Investor Gold Otwarty, Investor Agrobiznes, Skarbiec Rynków Surowcowych, BPH Globalny Żywności i Surowców, Pioneer Surowców i Energii, PZU Energia Medycyna Ekologia, Opera Substantia.pl. As far as commodity-related companies listed on the Warsaw Stock Exchange are concerned, the analysis covered these belonging to WIG20 index at the moment of the examination as well as companies with the largest shares in sub-index portfolios: WIG Chemia (WIG Chemical), WIG Energia (WIG Energy), WIG Paliwa (WIG Oil&Gas), WIG Spożywczy (WIG Food),

WIG Surowce (WIG Basic Materials), provided that they had not already been included in WIG 20. At the same time, it turned out that three of these companies had been listed for too short period and thus they could not be subject to analysis (Bogdanka since 25 June 2009, PGE since 6 November 2009 and TAURON PE since 30 June 2010). Eventually, the following seven companies were taken into consideration: CEZ, Kernel, KGHM, Lotos, PGNiG, PKN Orlen and Synthos.

In the first step of research there were calculated logarithmic returns becoming a base to evaluate the following characteristics for considered assets: expected rate of return, standard deviation, range, skewness, kurtosis, coefficient of variability and correlation. Then, normality of distributions was tested. In the literature, there are discussed several tests of normality, e.i. chi-squared, Shapiro-Wilk, Lilliefors, Jarque-Bera or Kolmogorov-Smirnov tests. Here, just the two of them were used: Shapiro-Wilk and Jarque-Bera tests.

In order to answer the question whether indirect investing in commodities was an attractive alternative to traditional investments in stock markets in considered period, WIG index was taken as a benchmark. Then hypotheses of equality of expected rates of return and deviations from mean in relation to WIG index were tested for several assets. Due to the fact that such time series usually do not fit normal distribution[2], following Filipowicz [2010], non parametric Mann-Whitney U test was applied. This test, based on ranks, is the most useful in testing equality of means in two populations and is recommended when assumption of distribution normality is not fulfilled as the only assumption demanded is that all observations from both groups are independent to each other and were selected in a random way [Aczel 2000].

First, one should arrange all observations into a single ranked series. If there are any equal values, they receive arithmetic averages of their ranks. Then one should add up the ranks for the observations coming from sample 1. The sum of ranks is denoted by R_1. U is then given by:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1, \tag{1}$$

where n_1 is the sample size for sample 1, and n_2 is the sample size for sample 2.

For large samples, when both n_1 and n_2 are larger than 10, U is approximately normally distributed. In that case, the standardized value Z is given by:

$$Z = \frac{U - \mu_U}{\sigma_U}, \tag{2}$$

[2] Results of research for financial market in Poland reveal that distributions of logarithmic rates of return and logarithmic prices of stocks and indices listed at the Warsaw Stock Exchange do not follow normal distribution (Tarczyński 1997, Kowalewski, Kuziak 2000, Tarczyński 2002, Osińska 2006, Witkowska, Matuszewska, Kompa 2008, Winkler-Drews 2009)

where μ_U and σ_U are the mean and standard deviation of U given by:

$$\mu_U = \frac{n_1 n_2}{2}, \tag{3}$$

and

$$\sigma_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}. \tag{4}$$

It is worth to notice that these calculations are not based on values of separate characteristics. They are based on sample sizes [Mynarski 2006].

RESEARCH RESULTS

On the base of 573 quotations of considered assets, there were calculated logarithmic returns used to evaluate basic characteristics given in tables 1 and 2, for considered stocks and funds respectively. These are: minimal and maximal observed values, range, expected rate of return (mean), standard deviation, skewness, kurtosis and coefficient of variability. Values of Pearson correlation coefficients for all investigated assets are reported in table 3 (bold type denotes values that did not differ significantly from zero at 0,05 level).

Table 1. Basic characteristics of logarithmic returns obtained for considered stocks and WIG index

Measure	Asset							
	CEZ	Kernel	KGHM	Lotos	PGNiG	Orlen	Synthos	WIG
Min	-0,11630	-0,16058	-0,10754	-0,10536	-0,06147	-0,08601	-0,08069	-0,06881
Max	0,06454	0,16058	0,12078	0,17076	0,07719	0,12866	0,14732	0,05799
Range	0,18084	0,32116	0,22833	0,27612	0,13866	0,21466	0,22801	0,12680
Mean	0,00031	0,00299	0,00319	0,00226	0,00012	0,00122	0,00371	0,00101
Std. dev.	0,01800	0,02987	0,02911	0,02578	0,01753	0,02475	0,02778	0,00134
Skewness	-0,30650	0,36032	0,17836	0,84914	0,29007	0,15789	0,76033	0,03073
Kurtosis	3,1466	4,6347	1,4639	5,6283	1,7589	1,6444	2,7123	2,4080
Coeff. of variability	58,2310	9,9741	9,1177	11,4000	139,95	20,354	7,4901	13,895

Source: own calculations

Analysis of results, given in tables 1 and 2, allows to state that in the studied period all considered stocks and funds produced low expected rates of return. In the case of stocks, the highest observed rate of return was that obtained for Synthos (0,37%), and then that for KGHM (0,32%). The lowest noted value was that obtained for PGNiG (0,01%).

Table 2. Basic characteristics of logarithmic returns obtained for considered commodity funds

Measure	Fund							
	Idea Surowce Plus	Investor Gold	Investor Agrobiz-nes	Skarbiec Rynków Surowco-wych	BPH Globalny Żywności i Surow-ców	Pioneer Surowców i Energii	PZU Energia Medycyna Ekologia	Opera Substan-tia
Min	-0,06551	-0,04220	-0,05278	-0,03854	-0,04002	-0,03425	-0,04270	-0,05163
Max	0,06084	0,04562	0,06878	0,05258	0,04976	0,04416	0,05452	0,03782
Range	0,12635	0,08781	0,12156	0,09112	0,08978	0,07841	0,09723	0,08945
Mean	0,00139	0,00069	0,00093	0,00093	0,00092	0,00082	0,00027	0,00066
Std. dev.	0,01415	0,01067	0,01198	0,01048	0,00981	0,01050	0,00717	0,01082
Skewness	-0,17744	0,04037	-0,04865	-0,01071	-0,10480	-0,01833	0,71661	-0,12601
Kurtosis	2,3849	1,5933	3,3771	1,8682	2,3150	1,2664	10,9690	2,4776
Coeff. of volatility	10,145	15,372	12,883	11,268	10,710	12,272	26,097	16,472

Source: own calculations

In the case of funds, Idea Surowce Plus was the one with the highest rate of return equal to 0,14%. However, this result is more than two times lower than the best result obtained for stocks. On the other hand it is worth to notice that the lowest rate of return observed in the group of funds (0,03% for PZU Energia Medycyna Ekologia) was actually higher than the worst result in the group of stocks, generated by PGNiG. While considering standard deviation, the highest value of the measure obtained for stocks was this of Kernel, and the lowest one was this of Synthos. Funds considered in the research were characterised by much lower values of standard deviation in comparison to stocks, as the highest value 1,4% for Idea Surowce Plus was lower than all standard deviations in the group of stocks (it was higher only than the lowest standard deviation of all which was observed in the case of WIG index). The lowest standard deviation among funds equaled 0,7% and was obtained for PZU Energia Medycyna Ekologia.

Values of coefficients of variability revealed higher variability of rates of return of investigated stocks. Nevertheless investing both in considered stocks and funds should be considered risky due to the fact that values of expected rates of return are much lower than values of standard deviations. In all cases there was observed hightened kurtosis (values greater than zero), thus analysed time series are leptokurtic. Hence, the distributions have fatter tails than the normal distribution, indicating a higher occurrence of extreme events. In the case of investigated stocks in most cases we have positive skewness (only for CEZ skewness is negative), which is favorable as indicates that in the considered period there were many more positive rates of return than negative rates of return.

However, two funds only (Investor Gold and PZU Energia Medycyna Ekologia) had positive skewness.

On the base of data reported in table 3 one may notice that the highest positive value of correlation coefficient was that for WIG index and PKN Orlen and then for WIG index and KGHM. It should not be a surprise while remembering that the largest share in WIG portfolio is that of KGHM (9,94%) and the fifth share is that of PKN Orlen (5,485%). The second, third and fourth shares are those of PKO BP, PZU and PeKaO SA – not included in the research due to their activity profiles unrelated to commodity sector. The highest negative correlation (statistically significant) was observed for the following pairs: PZU Energia Medycyna Ekologia – BPH Globalny Żywności i Surowców and PZU Energia Medycyna Ekologia – PGNiG. Generally, the results obtained confirm that between commodities and stocks or bonds there is usually negative or positive weak correlation [Jensen at al. 2000; Gorton, Rouwenhorst 2006; Geman 2007; Schofield 2007; Stockton 2007].

In the next step of research, with the use of Shapiro-Wilk and Jarque-Bera tests, there were verified hypotheses that considered logarithmic returns were normally distributed. The results obtained are reported in table 4. There are also displayed probability values called critical significance levels. If they are higher than the prespecified significance level α, then the null hypothesis on distribution normality cannot be rejected. Additionally, figures 1 and 2 show histograms for logarithmic returns of all investigated assets. On the base of results given in table 4, one can state that distributions of logarithmic returns of all considered assets do not follow normal distribution. Taken significance level α=0,05, allows to notice that in all cases it is higher than p-value, which obliges to reject the null hypothesis that variable under consideration is normally distributed. The decision seems to be unmistakable as it can be changed to the opposite (not rejecting the null hypothesis) at extremely low significance level.

Next, in order to assess efficiency of indirect ways of investing in commodities in the conditions of Polish market, Mann-Whitney U test was used to verify the following hypothesis:

H_0: mean values of logarithmic returns series of X asset and WIG index are equal

against

H_1: mean values of logarithmic returns series of X asset and WIG index differ significantly.

At the significance level 0,05, critical value of standardized normal distribution equals ±1,96, so critical areas for hypothesis formulated above are the following: $(-\infty, -1{,}96)$ and $(1{,}96, +\infty)$. Results of verification, presented in table 5, let us conclude that in the considered period expected rates of return of separate assets and WIG index did not differ significantly as in all cases the null hypothesis cannot be rejected.

Table 3. Correlation coefficients for logarithmic returns of considered stocks, funds and WIG index.

	CEZ	Kernel	KGHM	Lotos	PGNiG	Orlen	Synthos	Idea S.P.	Inv. G.	Inv. Agr.	Skarbiec	BPH	Pioneer	PZU	Opera	WIG
CEZ	1															
Kernel	**0,0558**	1														
KGHM	0,1961	0,1576	1													
Lotos	0,2061	0,0942	0,5148	1												
PGNiG	0,1508	**0,0653**	0,3592	0,3394	1											
Orlen	0,2314	0,1528	0,5797	0,6349	0,4522	1										
Synthos	0,1680	0,1692	0,3780	0,3041	0,1116	0,3850	1									
Idea S.P.	**0,0457**	0,1097	0,3419	0,2574	0,1371	0,204	0,1203	1								
Inv. G.	**-0,0551**	**-0,0773**	**0,0252**	**-0,0063**	**0,004**	**0,0393**	**-0,0116**	**0,0448**	1							
Inv. Agr.	**0,0811**	**0,0628**	0,0934	0,1002	**0,0291**	**0,0746**	**0,082**	0,2405	**-0,0390**	1						
Skarbiec	**0,0696**	**0,0759**	0,4002	0,2935	0,1907	0,2768	0,1179	0,5238	0,2397	0,1289	1					
BPH	0,1079	0,1094	0,4381	0,3186	0,1951	0,3350	0,2029	0,3292	0,1418	**0,0677**	0,6762	1				
Pioneer	**0,0144**	0,0918	0,0961	**0,0323**	**0,0499**	**0,0494**	**-0,0164**	0,6150	**0,0355**	0,2288	0,3582	0,1658	1			
PZU	**-0,0195**	**-0,0096**	**0,0084**	-0,0497	-0,1156	**-0,0658**	**0,0508**	**-0,0355**	**0,0677**	**-0,0087**	**-0,0333**	-0,1667	**-0,0011**	1		
Opera	**0,0709**	**0,0779**	0,2476	0,1749	0,1202	0,1893	**0,0445**	0,5218	0,1378	0,1283	0,4222	0,3496	0,4986	**0,0066**	1	
WIG	0,3005	0,2296	0,7181	0,6575	0,5337	0,7912	0,4622	0,3371	**-0,0322**	0,1408	0,3264	0,3501	0,1074	**-0,0116**	0,2090	1

Source: own calculations

Table 4. Results of testing normality of logarithmic returns of considered assets

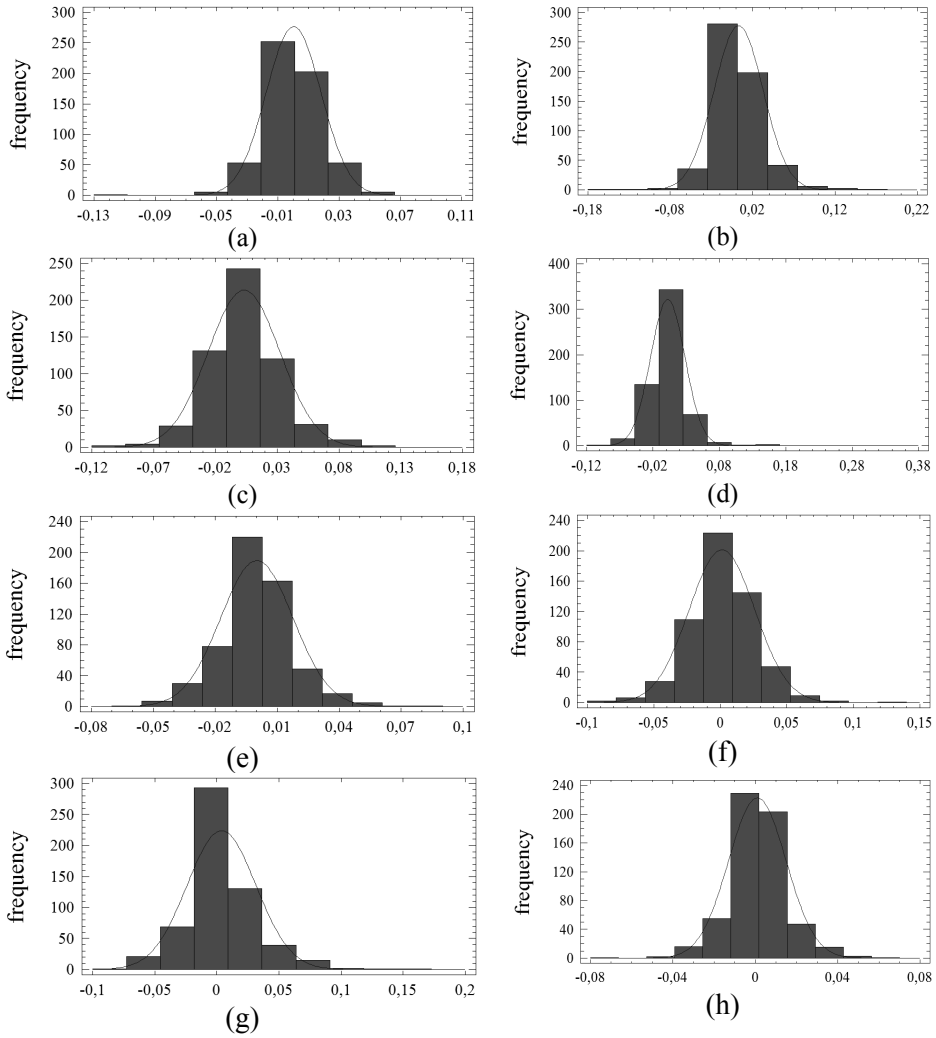
Asset	Statistic	
	Shapiro-Wilk	Jarque-Bera
CEZ	0,976 (3,514E-26)	244,939 (6,487E-54)
Kernel	0,928 (9,197E-0,45)	524,321 (1,397E-114)
KGHM	0,984 (5,931E-6)	54,111 (1,778E-12)
Lotos	0,943 (4,559E-14)	823,720 (1,354E-179)
PGNiG	0,976 (3,725E-8)	81,758 (1,764E-18)
PKN Orlen	0,986 (2,021E-5)	66,821 (3,090E-15)
Synthos	0,953 (1,784E-12)	230,447 (9,099E-51)
Idea Surowce Plus	0,973 (1,161E-8)	139,043 (6,414E-31)
Investor Gold	0,980 (6,223E-7)	60,661 (6,725E-14)
Investor Agrobiznes	0,963 (1,002E-10)	272,043 (8,446E-60)
Skarbiec Rynków Surowcowych	0,981 (9,227E-7)	83,196 (8,593E-19)
BPH Globalny Żywności i Surowców	0,972 (5,362E-9)	128,757 (1,09864E-28)
Pioneer Surowców i Energii	0,986 (3,472E-5)	38,269 (4,897E-9)
PZU Energia Medycyna Ekologia	0,979 (11,166E-20)	2916,690 (0,000)
Opera Substantia	0,966 (2,562E-10)	148,046 (7,115E-38)
WIG	0,969 (1,459E-9)	128,283 (9,382E-31)

Source: own calculations

Apart from the expected rate of return, another basic characteristic of every investment is its level of risk. In the case of commodity investments, it is believed that their returns are less volatile and thus less risky [Akey 2005]. In order to verify the hypothesis with regard to indirect commodity investments, there were

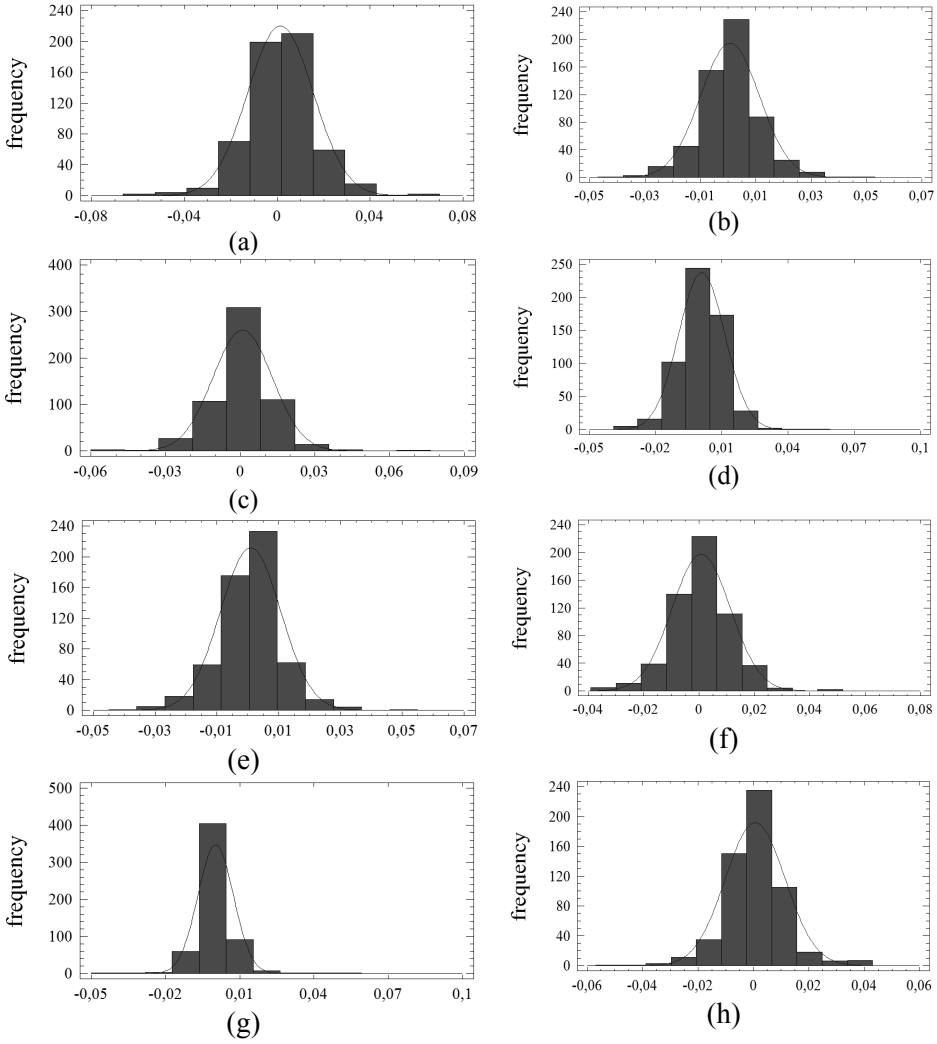
calculated absolute values of returns deviations from the mean. Then, Mann-Whitney U test was applied again, but this time observations were ordered in descendent way (higher absolute deviations received lower rank numbers).

Figure 1. Histograms for logarithmic returns of considered stocks: CEZ (a), Kernel (b), KGHM (c), Lotos (d), PGNiG (e), PKN Orlen (f), Synthos (g) and WIG index (h)



Source: own elaboration

Figure 2. Histograms for logarithmic returns of considered commodity funds: Idea Surowce Plus (a), Investor Gold (b), Investor Agrobiznes (c), Skarbiec Rynków Surowcowych (d), BPH Globalny Żywności i Surowców (e), Pioneer Surowców i Energii (f), PZU Energia Medycyna Ekologia (g) and Opera Substantia (h)



Source: own elaboration

The following hypothesis was formulated and then verified:

H_0: deviations of X asset rates of return from the mean are identical as deviations of WIG index rates of return

against

H_1: deviations of X asset rates of return from the mean differ significantly from deviations of WIG index rates of return.

Results are reported in table 6.

Table 5. Mann-Whitney U test results for logarithmic returns of separate assets and WIG index

Pair	Z statistic	Pair	Z statistic
CEZ-WIG	-0,8525	Inv. Gold-WIG	-0,3655
Kernel-WIG	-0,5042	Inv. Agrob.-WIG	-0,3281
KGHM-WIG	-1,2943	Skarbiec-WIG	-0,2225
Lotos-WIG	-0,4712	BPH-WIG	-0,2668
PGNiG-WIG	-1,2911	Pioneer-WIG	-0,0668
PKN Orlen-WIG	-0,4222	PZU-WIG	-1,3070
Synthos-WIG	-0,8145	Opera-WIG	-0,2966
Idea S. -WIG	-0,8349	×	×

Source: own calculations

Table 6. Mann-Whitney U test results for deviations from mean for separate assets and WIG index

Pair	Z statistic	Pair	Z statistic
CEZ-WIG	-5,5459	Inv. Gold-WIG	-4,3641
Kernel-WIG	-7,8842	Inv. Agrob.-WIG	-2,8860
KGHM-WIG	-11,9122	Skarbiec-WIG	-3,2901
Lotos-WIG	-9,1540	BPH-WIG	-4,9882
PGNiG-WIG	-2,9947	Pioneer-WIG	-3,7103
PKN Orlen-WIG	-9,8481	PZU-WIG	-12,8273
Synthos-WIG	-9,5408	Opera-WIG	-4,2265
Idea S. -WIG	-0,3714	×	×

Source: own calculations

On the base of results given in table 6, one may state that only in the case of pair: Idea Surowce Plus – WIG, the null hypothesis cannot be rejected. In all other cases one should reject the null hypothesis, which implies that deviations of separate assets rates of return from their means differed significantly from the deviations of WIG index rates of return. More detailed analysis leads to the conclusion that in the case of considered stocks, deviations from their means are higher than in the case of WIG index. On the contrary deviations of investigated commodity funds are lower than deviations of WIG index. Thus it is legitimate to conclude that indirect investing in commodities through commodity funds may be attractive to investors due to the lower risk in comparison to the stock market in Poland.

CONCLUDING REMARKS

Although investing in commodities grows in popularity among investors, some experts say that commodity sector still remains undervalued, particularly

when compared with the financial markets and the prices will continue to rise. Within last couple of years we have observed record levels of commodity prices, but Balarie [2007] claims it is not a bubble – it is a reasonable tendency which is going to be continued. Akey [2005] listed several reasons for interest in commodity investments. The most important are the following: growth of consumption of raw materials in developing economies (China, India, Russia, Brasil) creating demand for commodities across all sectors; commodities are valuable hedging instrument for investors with economic view on inflation and weakened currencies; commodities produce similar returns to equities with less historical volatility, commodity returns are not correlated to financial assets like stocks and bonds, so adding commodities to a traditional portfolio can enhance returns and decreases volatility. That is why investors view commodities as a source of both portfolio diversification and investment return.

The research presented here focuses on investments through commodity-related stocks listed at the Warsaw Stock Exchange and commodity funds operating in Poland. On the base of logarithmic returns of selected assets there were calculated basic characteristics, such as expected rate of return, standard deviation, kurtosis, skewness or correlation. Then the normality of distribution of investigated time-series was tested. In all cases one should reject the hypothesis of distribution normality. Thus in the next step Mann-Whitney U test was used to verify the hypotheses of equality of means and deviations from mean of logarithmic returns of analysed assets. The research revealed that in the considered period those commodity-related investments generated returns no different from the stock market (the benchmark was the main index of Warsaw Stock Exchange - WIG). Analysed stock returns were more volatile, while commodity funds returns were less volatile in comparison to the benchmark, so the second investment form generated lower risk. Nevertheless, one could draw the conclusion that those commodity-related investments did not seem much more attractive in comparison to the Polish stock market. Author's earlier research [Krawiec 2010] for German capital market, based on Deutsche Bank Liquid Commodity Index and DAX index led to the similar conclusion. This corresponds with Gilbert's opinion that commodity investments are generally justified more in terms of their contribution to overall portfolio returns than as attractive stand alone investment [Gilbert 2008]. However it is worth to remember that the study presented here covers a specific period when one could observe financial instability in numerous markets all over the world. That undoubtedly influenced Polish capital market. Moreover, the period analysed is quite short due to the fact that many commodity funds have occurred on the Polish market within last 2 – 3 years, so in most cases the track record does not go beyond 3 years.

REFERENCES

Aczel A. D. (2000) Statystyka w zarządzaniu, WN PWN, Warszawa.

Akey R. P. (2005) Commodities: a case for active management, www.dnb.co.in

Borowski K. (2008) Nowe kierunki bankowości inwestycyjnej – rynek przedmiotów kolekcjonerskich, Inwestycje alternatywne, praca zbiorowa pod red. I. Pruchnickiej-Grabias, CeDeWu, Warszawa, 217-266.

Filipowicz E. (2010) Inwestycje w złoto jako alternatywna forma lokowania kapitałów na polskim rynku, Zeszyty Naukowe Uniwersytetu Szczecińskiego Finanse, Rynki Finansowe, Ubezpieczenia nr 29, 329-347.

Geman H. (2007) Commodities and commodity derivatives, John Wiley&Sons, New Jersey.

Gilbert Ch. L. (2008) Commodity speculation and commodity investment, Discussion Paper No. 20, Universita degli Studi di Trento, Dipartimento di Economia, www.unitn.it

Gorton G., Rouwenhorst K. G. (2006) Facts and fantasies about commodity futures, Financial Analyst Journal, 62, 47-68.

Jagielnicki A. (2011) Inwestycje alternatywne. Pierwsze kroki na rynku pozagiełdowym, Helion, Gliwice

Jajuga (2007) On some tendencies in alternative investments. Inwestycje i ubezpieczenia – tendencje światowe a polski rynek, Prace naukowe AE we Wrocławiu nr 1176, Wrocław, 119-128.

Jensen G. R., Johnson R. R., Mercer J.M. (2000) Efficient use of commodity futures in diversified portfolios, The Journal of Futures Markets, Vol. 20, No 5, 489-506.

Kowalewski G., Kuziak K. (2000) Badanie rozkładów stóp zwrotu i cen akcji – badania empiryczne dla GPW w Warszawie, Metody ekonometryczne i statystyczne w analizie rynku kapitałowego, praca zbiorowa pod red. K. Jajugi, Wydawnictwo AE we Wrocławiu, Wrocław, 76-90.

Krawiec M. (2010) Weryfikacja efektywności pośrednich form inwestowania w towary na przykładzie Deutsche Bank Liquid Commodity Index, Metody ilościowe w badaniach ekonomicznych, tom XI, Nr 2, 161-170.

Mynarski S. (2006) Analiza danych rynkowych i marketingowych z wykorzystaniem programu Excel, Wydawnictwo Akademii Ekonomicznej w Krakowie, Kraków.

Niedziółka P. (2008) Inwestycje w sztukę na świecie oraz perspektywy rozwoju rynku sztuki w Polsce, Inwestycje alternatywne, praca zbiorowa pod red. I. Pruchnickiej-Grabias, CeDeWu, Warszawa, 197-215

Osińska M. (2006) Ekonometria finansowa, PWE, Warszawa.

Schofield N. C. (2007) Commodity derivatives, John Wiley&Sons, Chichester, West Sussex.

Stockson K. A. (2007) Understanding alternative investments: the role of commodities in a portfolio, www. vanguard.com

Tarczyński W. (1997) Rynki kapitałowe – metody ilościowe Vol. II, Agencja Wydawnicza Placet, Warszawa.

Tarczyński (2002) Fundamentalny portfel papierów wartościowych, PWE, Warszawa.

Winkler-Drews T. (2009) Zarządzanie ryzykiem zmiany ceny. PWE, Warszawa.

Witkowska D., Matuszewska A., Kompa K. (2008) Wprowadzenie do ekonometrii dynamicznej i finansowej, Wydawnictwo SGGW, Warszawa.