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INVESTMENT RISK MANAGEMENT BASED ON QUOTATIONS OF OIL COMPANIES, OIL AND THE DOLLAR

ZARZĄDZANIE RYZYKIEM INWESTYCYJNYM NA PODSTAWIE NOTOWAŃ SPÓŁEK PALIWOWYCH, ROPY I DOLARA

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Abstract: With the non-random movement of the prices of exchange trading objects in mind, by means of the methods and tools of chaos theory, it is possible to show that price changes are subject to the laws of deterministic chaos. This is a new look at this subject compared to the statistical methods that have been used for years, which in most cases assume that the distribution of the rate of returns of the examined series is normal. The aim of the study is to determine the nature of the changes in oil, dollar and Polish fuel prices: whether they are random or determined. In addition, the second aim is to investigate the cause and effect relationship between the price changes of the above-mentioned stocks. Tools such as rescaled range analysis, mean and variance stability analysis and technical analysis will be used. Conclusions resulting from the examination of the three indicated values should be interesting for capital market participants. The article ends with a short-term forecast for WIG-oil&gas.
Keywords: chaos theory, technical analysis, rescaled range analysis

Streszczenie: Mając na uwadze nieprzypadkowy ruch cen przedmiotów handlu giełdowego, metodami i narzędziami teorii chaosu można pokazać, że zmiany cen podlegają prawom chaosu deterministycznego. Jest to nowe spojrzenie na ten temat w porównaniu z metodami statystycznymi stosowanymi od lat, które w większości przypadków zakładają, że rozkład stopy zwrotu z badanej serii jest normalny. Celem pracy jest określenie charakteru zmian cen ropy, dolara i polskich spółek paliwowych: czy są losowe czy zdeterminowane. Ponadto drugim celem jest zbadanie związku przyczynowo skutkowego między zmianami cen wyżej wymienionych walorów giełdowych. Wykorzystane zostaną narzędzia takie jak analiza przeskalowanego zakresu, analiza stabilności średniej i wariancji oraz analiza techniczna. Wnioski wynikające ze zbadania trzech wskazanych walorów powinny być interesujące dla uczestników rynku kapitałowego. Na końcu zamieszczono krótkookresową prognozę WIG-paliwa.
Słowa kluczowe: teoria chaosu, analiza techniczna, analiza przeskalowanego zakresu

Introduction

In spite of a large body of research, it has proved difficult to integrate the existing data concerning the laws governing the capital market into a cohesive theoretical framework.

Research on the distribution of rates of return has been going on since the beginning of the 20th century. When considering the current state of knowledge, it is worth mentioning a number of studies. In 2007, Scalas E. and Kim K. examined the DJIA and MIBTEL indices for a stable distribution with a different result for each index. In 2010, Barunik J. rejected the normality of the WIG, PX and BUX index distributions. In 2009, Ghahfarokhi M. and P., when examining 6 stock indices of different countries, showed that the Value at Risk measure calculated from the stable distribution is a better fit than the normal or t-student distribution (Borkowski, 2017). However, research conducted with the use of chaos theory tools remains marginal.

The first tool used in the article will be the R/S analysis, strongly related to the chaos theory. This analysis examines the normality of the distribution or how price changes are determined. Then, a technical analysis will be employed in order to investigate the impact of price changes of one stock on another and to estimate the forecast of price changes in the future.

The Efficient Market Hypothesis

Louis Bachelier, an analyst from the turn of the 19th and 20th centuries, promoted the assumption that "the market, the aggregate of speculators, at a given instant can believe in neither a market rise not a market fall, since, for each quoted price, there are as many buyers as sellers" (Bernstein, 1998, p. 18) (Hagstrom, 2013, p. 22). Therefore the probability of a market fall and rise is equal to 50%. Bachelier proved that the distribution of returns is normal, which was also confirmed by Kendal in 1953 (he also noticed the leptokurticity of a distributional act – a situation when the distribution of empiric data is higher, with a narrower central peak and with tails that are significantly taller and fatter than one would observe in a normal distribution) and Osborne in 1959. The above premises laid the foundations for the Efficient Market Hypothesis, methods of stock price analysis similar to Markowitz's portfolio theory, the CAPM model, the Black-Scholes option-pricing model, the Arbitrage Pricing Theory (APT), and other models assuming the use of normal distribution and finite variance (Peters, 1997, p. 25, 103). Research on return rate distribution clearly showed that they do not have a normal distribution; among others, Borkowski carried out research in this area for the stock market in Poland. The obtained results relied on the analysis of WIG20, mWIG40 and sWIG80 indexes. The conclusion seems inescapable that the data gathered challenge the legitimacy of using the above-mentioned models. It has been confirmed that the return rates on the Polish stock market do not have a normal distribution over a long time interval, i.e. at least several years (Borkowski, 2017). In connection with the research undermining the occurrence of the normal distribution on the stock exchange (and thus: questioning the legitimacy of using tools based on this distribution), it seems reasonable to look for other market models, for example based on the Fractal Market hypothesis.

Justification for applying chaos theory in the price forecasting of stock exchange values

Due to growing doubts about the effective market mechanism, a proposal of a fractal market hypothesis has been put forward. B. Mandelbrot is the author of the concept of fractals, while E. Peters propagated this concept into the capital market. The market efficiency hypothesis was based on stochastic assumptions (random wandering) and investors' linear response to new information. This flies in the face of an established scientific approach towards fractals, one which adopts deterministic assumptions closely related to chaos theory and nonlinear systems (Prusak, 2015, p. 65-66).

One of chaos theory's most popular theorems is the butterfly effect. Edward Lorenz used this expression to describe the results of his calculations. In layman's terms, it relates to the cause-effect relationship between the flutter of a butterfly's wings and a sandstorm that is gathering on the other side of the world (Tempczyk, 2012, p. 70).

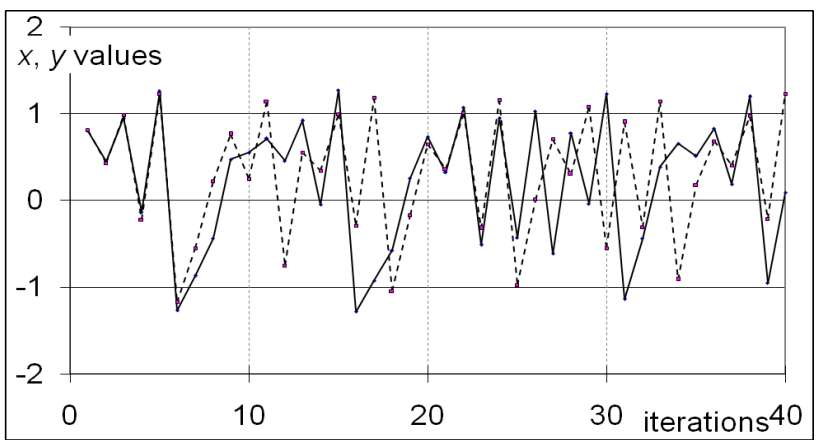

Figure 1. Hénon's map as an example of the Butterfly effect; parameters a = 1.4, b = 0.3
Source: own study.

The Butterfly effect is a term that Edward Lorenz attributed to the feature of dynamic nonlinear systems, namely a sensitivity to changes in initial conditions.

A basic example of a system sensitive to changes in initial conditions is the mapping developed in 1976 by Michel Hénon. The formula is as follows (Tempczyk, 2012, pp. 71):

$$x_{n+1} = 1 - ax_n^{\ 2} + y_n \qquad (1)$$
$$y_{n+1} = bx_n$$

The values of parameters *a* and *b* were adopted at the levels of 1.4 and 0.3. Initial conditions: x_1= 0.8, y_1 = 0.35 (continuous line on Figure 1). 1 000 iterations of the indicated recursive equation were obtained, yielding different values of x, y. Then the whole procedure was repeated, changing one initial condition x_1 = 0.8 + 0.01 = 0.81, without changing y_1 (dotted line). In Figure 2 only the first 40 iterations are marked. While the results of the first few iterations were very similar, after these few iterations the results diverged completely.

R/S methodology

R/S analysis was established at the beginning of the twentieth century by hydrologist Harold E. Hurst for the purpose of the changes in the River Nile's water levels. The exponent named after him is the result of R/S analysis calculations; in other words the rescaled range analysis. It allows us to determine whether a given time series is stochastic or deterministic and it does not matter if the series has a normal distribution. The method used to obtain the Hurst exponent is divided into several steps and was described in detail by A. and R. Weron (Weron, 2018) and E. Peters (Peters, 1997, p. 65). The interpretation of the Hurst exponent is as follows:

- *H* = 0,5 – the examined series is random. The subsequent return rates are not correlated, therefore today's events will not have any effect on the future, and the data distribution is likely to be normal.
- 0 δ *H* < 0,5 – the results from this range rarely appear in the capital market ranks. E. Peters presents us with the following example: *H* = 0.39 for daily return rates S&P 500 from 1945 to 1990 (Peters, 1997, p. 117). This series obtained an R/S analysis result of an anti-persistent range, which means that it has a tendency to return to an average value. Low results in the current series suggest high results in the next series.
- 0,5 < *H* δ 1 – persistent series, the closer H is to 1, the more visible the trend, and the fewer distortions. The current interpretations of *H* persistent series is as follows: *H* = 0.7 signifies that there is a 70% probability that the changes in the future will be similar to those of the current ones – the current trend (growing or falling) has a chance of being replicated in the future with a probability of 0.7.

The interpretation of the R/S analysis graph also allows us to find the length, i.e. the cycle – that is to say the time after which the series "forgets" the initial conditions or its memory of them decreases to a non-measurable degree. Hurst exponent will help answer the question whether rates of return are dependent on each other and there is a long-term memory effect or are independent and we are dealing with random walk characteristic of the theory of market efficiency.

R/S analysis results

▪ ***Brent Oil***

Brent Oil, traded on the ICE Futures Europe fuel exchange in London, was chosen to analyse oil prices. It is one of the three main types of this resource alongside REBCO (also known as URAL Oil) and WTI (West Texas Intermediate). Brent Oil comes from the North Sea oil fields. In comparison to REBCO and WIT, it has a medium density and medium sulphur content, which is why it is said to be a "medium-heavy crude oil" (TMS). Its valuation is established in USD.

Figure 2 presents an R/S analysis for Brent Oil's daily stock prices. Log(N) = 3.18 was assumed as the end of the cycle, that is for 1 526 daily quotes. This stems from the fact that after that moment the value of the Hurst exponent drops sharply, i.e. the series becomes decorrelated. From Log(N) = 3.18, the Hurst exponent decreases and approaches the value of H = 0.5, i.e. to a random series, and then it seems to become an anti-persistent one. Even at Log(N) = 2.6, certain R/S analysis results approach a line with a directional factor equal to 0.5 (dashed, purple line). The black line refers to a linear regression of the R/S analysis from the beginning to the end of the cycle. What is more, a linear equation has also been included and its direction factor is both the Hurst coefficient and, depending on the measure, R^2.

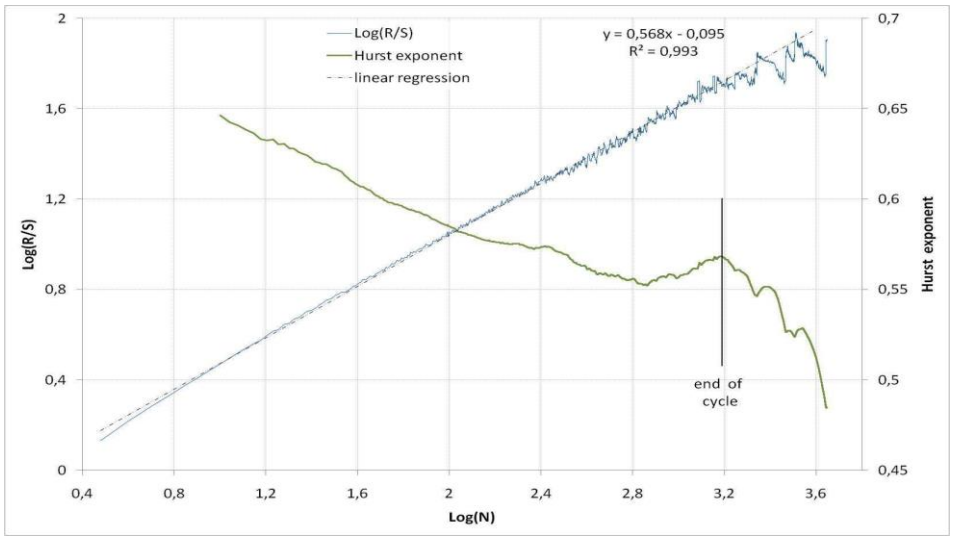

Figure 2. R/S analysis of Brent Oil, daily interval, data gathered: 8 879; from 30/03/1983 to 04/05/2018
Source: own analysis.

▪ ***The US Dollar Index***

For an analysis of currency exchange rates, the US Dollar Index (abbreviation: Dollar Index) was chosen, which shows the strength of US Dollar relative to six other currencies significant on the Forex market: the euro, the Japanese Yen, the British pound, the Canadian dollar, the Swedish krona, and the Swiss franc. The average exchange rate of these currencies reflects the strength of the American dollar quite well and, what is more, it corresponds to the USD/PLN exchange rate. Out of the three items analysed in this paper, the Dollar Index has been listed for the longest period of time, therefore it was necessary to format a large amount of data. Figure 3 presents an R/S analysis for the dollar's daily prices. Hurst's exponent for this series equals H = 0.6, and the cycle ends at Log(N) = 2.43, which is equal to N = 267 (0.89 years). It is worth noticing that despite the steady fall of the Hurst exponent, it never actually reached H = 0.5 and always remained above 0.57. This means that the series of return rates of the Dollar Index is more persistent than that of Brent Oil in the same daily interval.

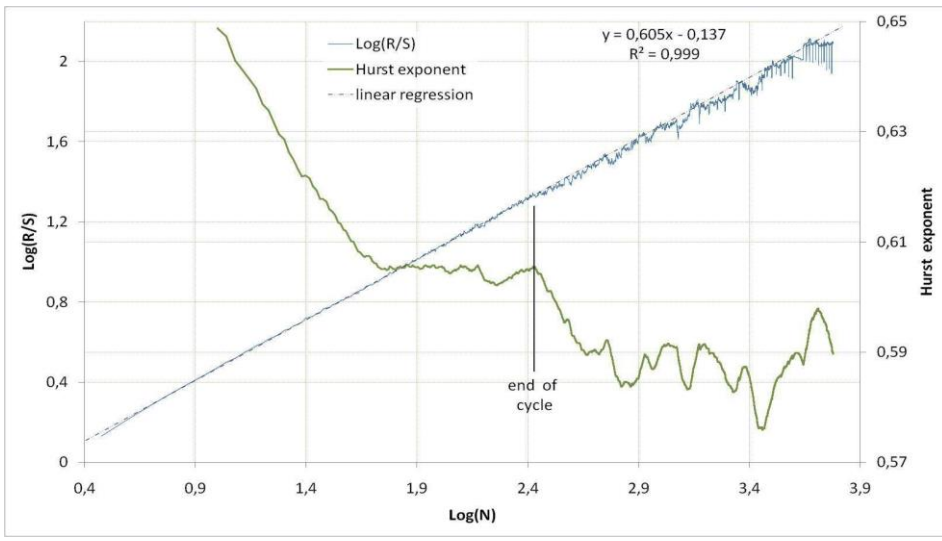

Figure 3. R/S analysis of the Dollar Index, daily interval, data gathered: 12 002; from 31/01/1967 to 04/05/2018
Source: own analysis.

▪ ***Warsaw Stock Exchange index (WIG) for fuel companies***

WIG-paliwa is an index of fuel companies listed on the Warsaw Stock Exchange. The precise translation is WIG-fuel, but the official English equivalent is WIG-oil&gas (GPW). The above-mentioned WIG-oil&gas index was used to analyze the stock prices of Polish fuel companies.

In order from largest to smallest percentage share in the index are as follows: PKN Orlen (61%), PGNiG (24%), Lotos (12%), MOL (2%), Unimot (0,1%) and Serinus (0,1%) – percentage share in the index from May 4, 2018.

Figure 4 presents the results of an R/S analysis of the WIG-oil&gas daily interval. What is interesting to note is that it is difficult to determine the cycle due to the fact that the Hurst coefficient, after having reached H=0.56 at Log(N)=2.6, begins to rise again. This makes the series non-periodic, which may stem from the paucity of data or, quite simply, a lack of cyclicity. Out of the three series, this one is the "youngest". There is no one interpretation for such a situation. Based on the regression of all results, the Hurst coefficient equals H = 0.59 - this proves that visible trends do exist.

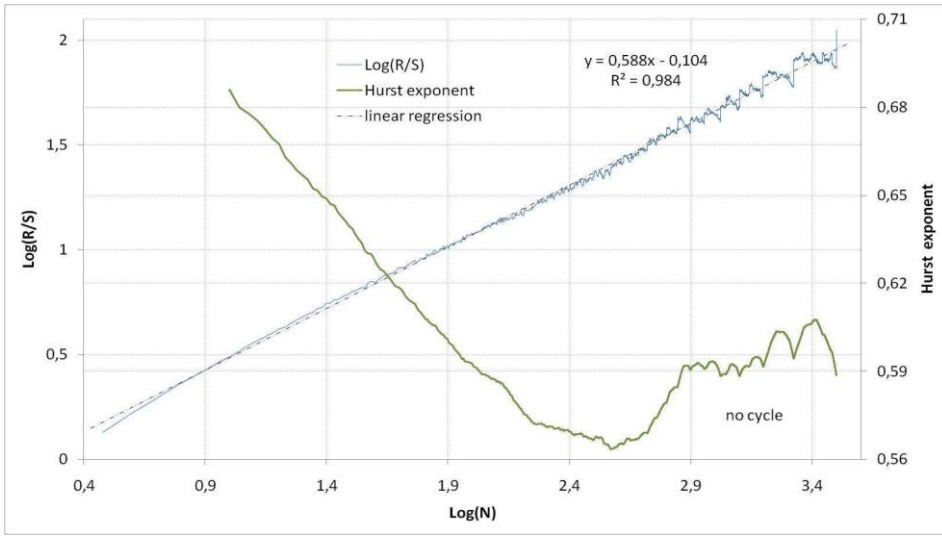

Figure 4. R/S analysis of WIG-oil&gas, daily interval, data gathered: 6 316; from 16/04/1991 to 04/05/2018
Source: own analysis.

Technical analysis of analysed assets

▪ ***Brent Oil and Dollar Index summary***

There is a simple correlation between the prices of oil and the US dollar - oils sales are made in dollars. Taking this into account, can it be understood that the price of a US dollar dictates the price of a barrel of oil? The answer is yes; and it does so in a very simple way. Many countries who are the recipients of oil use different currencies to the US dollar. Therefore, when buying oil, they must take the dollar exchange rate into account. The higher the dollar, the less the investors want to spend on oil, which automatically lowers its price. One must remember, of course, that this is not a simple arrangement between two trading items: dollar/oil. This relation can be compared to the solar system - it's not just a relationship between the sun and the Earth – there are other planets. The dollar value is not the only factor influencing oil prices. In fact, all factors can be brought down to two general ones, that is: demand and supply. The dollar value influences the demand. Yet another factor influencing demand are the weekly oil resource reports published in the U.S.A. The key difference is between the expected (forecasted) resource supply and the real supply, which is published. If the supply is lower than expected, the demand for oil increases. It drops only when the supplies suggest a surplus. The supply factor that influences oil price is the level of extraction, which is measured in millions of barrels[3] per day. In 2016, oil prices dropped lower than 30 USD – this was due to, among others, the above-average worldwide oil-extraction. As a result of this, the OPEC countries, in cooperation with Russia, signed an agreement that was supposed to prevent oil prices from dropping any lower.

An example from the second half of September 2019 is described below. The close price of Brent Oil on Monday, 16 September 2019 increased by over 14% compared to Friday's close price. The highest price on Monday was 19.5% higher than Friday's close. This represented the strongest growth since 1991. The reason was information about the attack on oil installations in Saudi Arabia, which reduced 5% of global supply (Balcerowski, 2019). At the same time, the Dollar Index rose by

[3] One barrel is equal to about 159 litres (42 gallons).

only 0.36%; in this case, macro-environmental factors were the strongest.

Figure 5 presents the weekly quotes of the two aforementioned factors in the same time period (gathered from 14/09/2009 to 11/06/2018). This period has been divided into 9 parts. Each part contains a comparison of chart shapes. (1) In reference to the significant rise of the Dollar Index, the horizontal oil prices demonstrate that there exist other, stronger factors than that of currency risk (which would be suggested by demand dominance). (2) Over the span of 315 days (45 candlesticks on the chart) it is possible to observe a strong, negative correlation between the quotes. The dollar sale presents the buyers with more opportunities to buy oil. (3) The long period of time without any visible trends on either side – the dollar consolidation causes oil consolidation. The only exception is the period of 119 days with negative correlation. The third factor is the "small" rise in the Dollar Index rate which was responsible for a significant oil rise. (4) The fourth period lasted 115 days and presented a negative correlation. (5) The fifth confirmed the hypothesis regarding the inversely proportional price movement of two assets. At first the correlation is negative, after that it moves horizontally. (6) The sixth period presents a very visible cause and effect relationship. Over the span of 259 days oil prices registered falls for 210 of them. (7) During this period, different factors, stronger than that of the US dollar exchange rate, came into the equation. The dollar itself moved horizontally. As was mentioned before, 2016 was the year in which the OPEC countries signed the oil pact, which influenced its rise. (8) The sudden fall of the dollar had a lesser impact on the increase in oil prices which, in the first 203 days, dropped only slightly. (9) The last period presents the rise of both assets – positive correlation.

Out of nine uneven periods, only two negate the clear relationship between the Dollar Index and Brent Oil.

Figure 5. Compilation of weekly quotes of Dollar Index and Brent Oil; period: 14/09/2009 to 11/06/2018
Source: own analysis.

▪ ***Brent Oil and WIG-oil&gas summary***

Polish fuel companies (especially the largest Polish company, PKN Orlen) are not oil producers, but merely processors and distributors. They are intermediaries between the producer and the client. Low oil prices are beneficial for such companies; and this is due to the low costs of processing raw material for sale. What is more, when the world price of oil falls, so does its retail price. However, these falls do not occur in unison.

The delay is caused by many factors, including the sale of oil purchased earlier at higher prices; however, with the right delay manipulation it is possible for the company to return a profit. In order to maximise profit, the delay of retail prices in comparison to world prices will be smaller. Another advantage of cheaper oil is the possibility to economise during sales. Lower prices at gas stations may generate bigger sales (Torchała, A., 2016).

Taking the above into account, it is worth observing the data on Figure 6. The presented quotations (gathered from 14/09/2009 to 11/06/2018) have been divided into eight parts. Each of these parts will be discussed in view of the hypothesis of a positive influence of cheap oil on fuel company stock prices. (1) During the first period one can observe a visible rise in oil prices and a steady but slow rise of stock prices. Positive correlation does not confirm the aforementioned hypothesis. (2) The price fall of each asset, similarly as it was in the first period, shows positive correlation. (3) At the beginning of the third period oil prices at first recorded a sudden fall, only then to become stable. Taking into account the small rise of the index, it can be assumed that the aforementioned hypothesis was applicable in this period. (4) Horizontal movement was recorded in both cases. The results were neutral. (5) Negative correlation which was present for 420 days confirms the hypothesis. (6) Positive correlation, negative result. (7) First a slight rise in oil prices was recorded, then a horizontal stabilization; the WIG-oil&gas reached a new peak and a so-called speculative bubble effect took place. The results were neutral. (8) The negative correlation confirms inverse correlation between Brent Oil and WIG-oil&gas.

Out of eight marked parts, three supported the hypothesis, two were neutral, and three contradicted it. As was explained earlier, the weaker result of the oil/shares relation can be explained by it being not as simple as the oil/dollar relation.

Figure 6. Compilation of weekly quotes of WIG-oil&gas and Brent Oil; period: 14/09/2009 to 11/06/2018.
Source: own analysis.

▪ ***Comparison of the Brent Oil price, the Dollar Index, and WIG-oil&gas prices***

Figure 7 presents compiled weekly quotes for the three analysed series. Seeing as the price technical analysis method is not the main issue of this paper, the prognoses presented in the figures below have been simplified by using only one type of tool, i.e. price determination by means of support and resistance levels. (Murphy, 1999, p. 43). In the case of the Dollar Index, at the beginning of 2018

a price rise was noted, for which the nearest important resistance level was about 100 points. In recent weeks, the maximum price of over 99 points has been reached.

Starting from October 2018, futures contracts for Brent Oil noted a sudden fall, which stopped at $52.20. After a four-month correction wave, which lifted over 62% of the previous drop, prices began to fall further towards next significant support at around $44. Such a scenario would coincide with the assumption of a negative correlation between oil prices and the Dollar Index. Attacks on oil refineries in Saudi Arabia stopped this decline by creating an upward price gap. If the Saudi energy minister's assurance that the oil production level is restored to pre-attack levels, prices may stabilize or go to the $44 support level. If the assurances of Saudi Arabia's energy minister about bringing oil production back to pre-attack levels by the end of September 2019 come true (PAP), prices may stabilize or go to the $44 support level.

WIG-oil&gas from October 2017 to Jan 2019 reached a peak of over 8 500 points twice with subsequent troughs shaping higher and higher, thus creating a bullish triangle. If oil prices fell further, the situation would be easier. The uncertain situation in Saudi Arabia weakened the strength of the bullish triangle. If the WIG-oil&gas does not approach the resistance level of 8 500 points, the course should remain in the lateral trend in the range 6 500 to 7 500 or 8 500 points. Any further continuation of the bullish triangle should result in a breakthrough up 8 500 points.

Figure 7. Compilation of weekly quotes of the Dollar Index, Brent Oil, and WIG-oil&gas; period: 16/09/2015 to 18/09/2019
Source: own analysis.

Conclusions

After analysing the results of this paper, it is safe to say that its goals have been achieved, containing as it does an explanation regarding the mutual interactions pertaining to the dollar/oil/fuel companies relation.

This three-element system is an analogy of the butterfly effect, – the change of one, seemingly small, factor in the relation resulted in a radical change of magnitude, which is not necessarily related to this factor. An example of this could be the dollar which has no direct connection to PKN Orlen. Considering the US dollar and oil prices, it is very likely that the prices of fuel companies in Poland may largely depend on the political situation in Saudi Arabia.

The results of the technical analysis of the oil/dollar and oil/share relations presented us with interesting observations. It was proven that, in

most cases, the dollar influences oil price in the following way: the dollar index exchange rate is inversely correlated with the oil price. The oil/shares relation was not confirmed as much as the oil/dollar relation due to the fact that out of nine periods that were noted, three supported the hypothesis, two returned neutral results, and three contradicted the hypothesis. This is caused by the greater complexity of interactions. The horizontal trend prognosis is a compromise between the analysis of the WIG-oil&gas and the hypothesis of an inversely proportional influence of oil prices on fuel company share prices.

The results obtained have the following significance for investors. Based on the results of the R/S analysis, it was possible to confirm the occurrence of the effect of long-term memory in the series of rates of return - they are persistent, prone to trends. Thanks to this, the use of technical analysis (common in short-term forecasts, especially in day trading) is justified - contrary to the hypothesis of an effective market. As the R/S analysis is heuristic, it is worth engaging in research which looks at the long-term memory of return rates, using, for example, estimators based on a fractional modeling of the Brown motion (Weron, 2018). In connection with emerging doubts about efficiency-based (normal distribution) methods, including Markowitz's portfolio theory, the CAPM model, the Black-Scholes option-pricing model and other models, we need to look for methods that will complement the existing scientific achievements in this area. It is worth pointing out that where Peters (1997) rejects variance and standard deviation as risk measures, Buła assesses the usefulness of this dimension as a measure of risk, so writing that the quantification of risk using only classical measures is incomplete, thus making the fractal dimension an important measure of investment risk (Buła, 2019).

Traders interested in investing in shares of Polish fuel companies in the period from September to October 2020 should expect that the average of these companies will continue to form the bullish triangle aiming to break the 8500 level or stay in the side trend of 6 500 up to 7 500 or up to 8 500 points.

References

Bernstein, P. (1998). *Intelektualna historia Wall Street* [Capital Ideas. The Improbable Origins of Modern Wall Street]. Warszawa: WIG-Press.

Borkowski, K. (2017). Rozkład normalny stóp zwrotu z akcji wchodzących w skład następujących indeksów giełdowych: WIG20, mWIG40 i sWIG80 [Normal distribution of rates of return on shares included in the following stock indexes: WIG20, mWIG40 and sWIG80]. *Quantitative Methods in Economics*, 18(4): 541-5.

Buła, R. (2019). *Implikacje teorii rynku fraktalnego dla oceny ryzyka inwestycji finansowych* [Implications of Fractal Market theory for Financial Investment Risk Assessment]. Warszawa: KNF.

Hagstrom, R. (2013). *Investing: The Last Liberal Art.* New York: Columbia University Press.

Murphy, J. (1999). *Analiza techniczna rynków finansowych* [Technical Analysis of the Financial Market. Warszawa: WIG-Press.

Peters, E. (1997). *Teoria chaosu a rynki kapitałowe* [Chaos and Order in the Capital Markets]. Warszawa: WIG-Press.

Prusak, B. (2015). *Wielokryterialna analiza rekomendacji giełdowych* [Multi-criteria Analysis of Stock Market Recommendations]. Warszawa: CeDeWu.

Schwager, J. (2012). *Czarodzieje rynku. Rozmowy z wybitnymi traderami* [Market Wizards. Interview with Top Traders]. Warszawa: Linia.

Tempczyk, M. (2012). *Teoria chaosu dla odważnych* [Chaos Theory for the Brave]. Warszawa: PWN.

Weron, A., Weron., R. (2018). *Inżynieria finansowa: wycena instrumentów pochodnych, symulacje komputerowe, statystyka rynku* [Financial Engineering: derivative valuation, computer simulations, market statistics]. Warszawa: PWN.

Internet sources

Balcerowski, A. (2019). Polska ucierpi na atakach w Arabii (Poland will suffer from attacks in Arabia). Available at: https://stooq.pl/n/?f=1314109& search=+brent+ (18 Sep 2019).

GPW. WIG-oil&gas. Available at https://www.gpw.pl/index-factsheet?isin=PL9999999722 (16 Sep 2019).

PAP Serwis Ekonomiczny. Cena ropy się stabilizuje – wkrótce na rynek może trafić 70 proc. utraconego saudyjskiego surowca (The price of oil is stabilizing - soon 70% of Saudi raw material may hit the market). Available at: http://biznes.pap.pl/pl/news/all/info/2789962,cena-ropy-sie-stabilizuje---wkrotce-na-rynek-moze-trafic-70-proc-utraconego-saudyjskiego-surowca (19 Sep 2019).

TMS. Oil WTI. Available at: https://www.tms.pl/oil-wti (access 5 May 2019).

Torchała, A. (2016). Bliskie związki Orlenu i ropy czyli o cenach paliw słów kilka (The Close Relationship Between Orlen and Oil, So Few Words About Fuel Prices). Available at: https://www.bankier.pl/wiadomosc/Bliskie-zwiazki-Orlenu-i-ropy-czyli-o-cenach-paliw-slow-kilka-7489742.html (5 May 2019).