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CORRELATION BETWEEN OIL AND U.S. STOCK PRICES, WHAT COMPANIES ARE RESILIENT THE MOST IN ENERGY SECTOR

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Abstract. *As OPEC could not recently find an agreement to contain the dramatic oil prices drop, the US, but also worldwide, stock markets have experienced a new decline, limited not only to energy sectors.*
In this paper we examine the statistical correlation of oil prices (Brent) and US energy sector stocks for the past five years (2011-2015). The analysis is carried out on public available data, such as FRED database (Federal Reserve Bank of St. Louis), with a weekly granularity. The output highlights which companies have the highest degree of resistance to oil price volatility. It puts then in comparison those resilient companies with their degree of integration along the energy operations.
As falling oil prices may have impact in different manner on the sub-sectors, some companies may eventually benefit from their positioning along the value chain (downstream vs. upstream segments).

Key words: *Oil Prices, Stock Markets, Statistical Analysis, Data Series Correlation*

1. LITERATURE REVIEW

This paper examines the statistical correlation of oil prices (Brent) and the US energy sector stocks in the past five years. An understanding of interactions between commodity and equity markets can be useful in portfolio diversification strategies for investors. This relation is of particular relevance in a period of great instability in stock and bond markets on the one hand and great price drop in oil prices on the other.

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There was some research in literature on the relations between oil prices and stock market returns. Usual assumption is that this relation is negative: increases in oil prices raises costs in many industries, depressing stock prices by lowering expectations about future earnings and dividends. According to this logic, current situation in which the oil price is falling, should lead to rising expectations about future earnings and dividends.

There are very few studies that examine the relationship between oil price and stock prices of the oil industries. In the article from 1993 Al-Mudhaf and Goodwin examined the returns from 29 oil companies listed on the New York Stock Exchange. Their findings suggest positive impact of oil price shocks on ex post returns for firms with significant assets in domestic oil production. Huang, Masulis and Stoll (1996) used regression analysis and examined the link between daily oil future returns and daily United States stock returns. Their results provide some evidence that oil future prices have a direct impact on oil sector stock prices. Shaharudin, Samad and Bhat (2009) examined the effect of oil prices movements on the stock price of Oil and Gas companies in three different markets, the US, India and the UK. The results suggest that there are significant short- and long run relationships between oil price and the oil stocks, including the effect of the other variables such as interest rate and the stock index. The oil price volatility transmission has a persistent effect on the volatility of the stocks of the oil companies in all the countries that were studied. Limitation of this study is the fact that stocks of the two major companies in each country in the field of oil and gas industry are analyzed, which makes total of six stocks. Finally, Gilmore, Mc Manus, Sharma and Tezel (2016) investigated dynamic relationships between WTI crude oil prices, two oil sector stock price indices and three stock market price indices representing large, mid and small capitalization stocks. A vector error-correction (VEC) model reveals that the stock prices of companies in the integrated oil and gas sector have a long run negative relationship with oil prices, while those in the oil and gas exploration and production sector have a long-run positive relationship with oil prices.

2. INTRODUCTION

As any other commodity, oil price is regulated by rules of supply and demand. The expectations have significant impact on oil price. Price of a barrel of oil has fallen more than 70 percent since June 2014, when the barrel cost USD 110. Prices recovered a few times last year, but a barrel of oil has already sunk this year to its lowest level since 2004. In the beginning of February, the main international benchmark, Brent crude, was trading at around USD 35 per barrel.

Many economist and analysts emphasize several main reasons for a fall in oil prices. Demand is low due to weak economic activities in China and all over the world in general. The economies of Europe and developing countries are weak and vehicles are becoming more energy efficient, so demand for fuel is dropping. Also, mild winter temperatures have not boosted demand.

The United States domestic production has nearly doubled over the last several years, pushing out oil imports that need to be sold elsewhere. Saudi, Nigerian and Algerian oil that was once sold in the United States is suddenly competing for Asian markets and the producers are forced to drop prices. Canadian and Iraqi oil production and exports are rising year after year. Even the Russians, with all their economic problems, manage to raise their production.

However, the Saudis have decided not to sacrifice their own market share to curb the falling prices of oil, since this process is most beneficial for Russia and Iran. Their costs of getting oil from the ground are very low USD 5-6 per barrel, much cheaper than other oil producing countries. Thus, they started new strategy, letting the price fall and putting high costs producers out of business.

Previously stipulated circumstances have some specific effects. American frackers who have borrowed heavily on expectation of continuing high prices and who have already constructed more than 20,000 oil wells in the expectations of high oil prices are now in trouble. In trouble are also other Western oil companies with high cost projections involving drilling in deep water or in the Arctic.

Hard hit fell on the regimes and nations who are dependent on a high oil price to pay for costly foreign adventures and social programmes, such as Russia and Iran. Russia is already hit by the Western sanctions, following its meddling in Ukraine and Iran which is paying to keep the Assad regime afloat in Syria. Nigeria has been forced to raise interest rates and devalue the naira. Venezuela is closer than ever to defaulting on its debt.

Big importing countries in the Euro zone, Japan and India, are enjoying especially big windfalls. Since these savings are more likely to be spent than stashed in a sovereign wealth fund, global GDP should rise. The falling oil price will reduce already low inflation still further, and so may encourage central bankers towards looser monetary policy.

Central factor in the sharp price drop, analysts claim, is the continuing unwillingness of OPEC, a cartel of oil producers, to intervene to stabilize the markets that are widely viewed as oversupplied. Iran, Venezuela, Ecuador and Algeria have been pressing the cartel to cut the production to firm up prices, but Saudi Arabia, the United Arab Emirates and other Gulf allies are refusing to do so. At the same time, Iraq is pumping more and Iran is expected to become a major exporter again. Saudi officials have said that if they cut production and price goes up they will lose the market share and merely benefit their competitors. If prices remain low, for another year or longer, the newly crowned King Salaman may find it difficult to persuade other OPEC members to keep steady against the financial strains. The International Monetary Fund estimates that the revenues of Saudi Arabia and its Persian Gulf Allies will fall for approximately USD 300 billion this year. Some oil executives are quietly noting that the Saudis want to hurt Russia and Iran, and so does the United States, so the two oil producing nations are trying to force down the prices. If we analyze the history, one of the important factors in bringing down the Soviet Union was dropping the oil prices in 1980s.

While market surplus is expected to continue in 2016, some analysts predict an increasing drop in oil prices for the months to come.

On the demand side, 2015 has seen oil consumption slightly increasing to 93.8 Mb/d (million barrels per day) according to EIA - Energy Information Administration. This trend should continue in 2016, where developed economies appear to be modestly recovering and the Chinese economy, the world's second largest oil consumer, is slowing down.

On the supply side, oil supply reached 95,7 Mb/d in 2015, and forecasts provide a slight increase in 2016 to 95.9 Mb/d over 2016. More specifically OPEC crude oil production is expected to increase by almost 1 Mb/d as Iran sanctions are suspended. Moreover, inventories are at a high level, which also explains the oversupply, and stocks are equivalent to 66 days consumption.

At the same time, the US production is already falling as the drop in oil price has weakened the US producers with high impacts on their margins. The US crude oil production is forecast to fall from 9.4 Mb/d in 2015 to 8.7 Mb/d in 2016, according to EIA estimates.

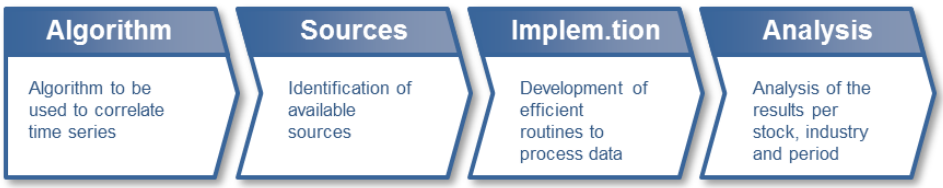
The low oil price situation is affecting oil producers already weakened in 2015 by the sudden price decreases. This trend is progressively impacting the whole value chain in the oil-energy sector.

As a consequence, global stock markets, traditionally resilient to oil prices fluctuations, have started to decline, showing a growing interconnection with oil prices volatility. This paper explores the statistical correlation of oil prices (Brent) and the US energy sector stocks for the past five years and tries to identify what companies/sub-segments of the value chain are more resilient to the oil price volatility.

3. METHODOLOGY

This paper investigates the statistical correlation of oil prices (Brent) and US energy sector stocks for the past five years (2011-2015).

As a first step we have defined the approach used in this paper, described as follows:



Phase	Key criteria
Algorithm selection	▪ efficient enough to process large series data in short time; ▪ providing a degree of correlation together with a level of significance.
Sources Identification	▪ official and auditable; ▪ retrievable on-line; ▪ covering the chosen observation period.
System Implementation	▪ able to retrieve data on-line, process data and present results; ▪ quick enough to run the exercise several times in a short period.
Results Analysis	▪ Output data including correlation metrics; ▪ 3 analysis dimensions: stock, industry and period.

In order to highlight which companies and industries have the highest correlation with oil price trends, we had to analyze the problem by looking at hundreds of time series, and comparing them against a given one. This system is called 'Market Price Trends Analyzer' (MPTA).

MPTA relies on a batch process to find stocks that correlate to the given price time series. It searches thousands of candidate series in under 900ms in order to find the best matches for a target time series.

The input series of MTPA consist of weekly average end-of-the-day price points. Initially we investigated the use of brute force search for the correlated series, but it resulted immediately too expensive. So we have opted for a statistical algorithms that may result much more performing in terms of speed.

The developed approach has then been applied to series of the stock prices within the energy sector, provided by Nasdaq and NYSE, comparing them against the time series of Oil price (Brent price).

All data are represented as vectors of prices. Each vector represents a stock, each element of the vector the average weekly end-of-the-day price of that stock in a given week.

We chose to compare vectors using the standard definition for Pearson correlation between two time series, specifically:

$$r(u,v) = \frac{\sum_{i=1}^{n}[(u_i - \mu(u))(v_i - \mu(v))]}{\sqrt{\sum_{i=1}^{n}(u_i - \mu(u))^2}\sqrt{\sum_{i=1}^{n}(v_i - \mu(v))^2}}$$

If two vectors u and v are perfectly correlated, then r(u, v) = 1. The distance in this case is equal to zero, so we use the standard definition of Pearson correlation distance.

$$d_p = 1 - r(u,v)$$

Stocks prices series may have some 'holes' in their data. This may happen when a stock is listed during the observation period, when stock trade is temporary suspended for whatever reason, or in a number of other cases. For this reason we needed support for 'holed' periods.

When a vector has missing values (i.e. not real or negatives) we exclude that value for both vectors.

$$(u;i) and\ (v;i)\ where\ v \in Q^+, u \in Q^+, i \in \{1,2,\dots n\}$$

As reported in (4), we considered then only positive values (i.e. belonging to Q^+) within the observation period. When a value is 'missing' in one of the series, then the corresponding week data are not computed by the algorithm.

The correlation level has been evaluated on the basis of the following table.

R-Value	Correlation	Relationship
0.00-0.20	none	none
0.20-0.40	very low	not appreciable
0.40-0.60	low	slightly visible
0.60-0.80	high	visible
0.80-1.00	very high	intense

As a significance test we used the t-Student distribution with n-2 degrees of freedom (minimum value - critical R), a=0,05.

As described, sources must be:

- Official
- Auditable
- Retrievable on-line
- Able to cover the chosen observation period

There are a number of sources (paid and free) that correspond to some of the previous criteria, but only few that fit to all of them.

For the purpose of this paper we have chosen the following sources:

- Crude Oil Prices
  - Data: Brent Europe price
  - Description: end of the day price expressed in USD
  - Source: Federal Reserve Bank of St. Louis, US (FRED database)
  - Frequency: weekly
  - https://research.stlouisfed.org/fred2/series/DCOILBRENTEU# (free)
- Oil-Energy
  - Data: Stock ticker
  - Description: set of 630 tickers (including sector, industry and Exchange) related to energy companies listed in NYSE and Nasdaq
  - Source: Zacks Investment Research
  - Frequency: none, sample taken in January 2016, active companies
  - http://www.zacks.com/screening/stock-screener (paid)
- Stocks
  - Data: Stock Prices
  - Description: end of the day price expressed in USD
  - Source: Yahoo Finance (source: Nasdaq and NYSE)
  - Frequency: weekly
  - http://real-chart.finance.yahoo.com/table.csv?s=[TICKER]&a=00&b=01&c=2011&d=11&e=31&f=2015&g=w (free)

In the observed period, oil price showed different dynamics moments. So we split the observation period into different temporal segments that we wanted to investigate in terms of correlation with stocks. The resulting 4 temporal periods are described here below (and graphically in (Figure 1.)):

(1) 2011-2015: last 5 years, a trend with ups and downs
(2) Jan15-May15: 5 months, sharp drop
(3) May15-Jul15: 3 months, sharp increase
(4) Aug15-Dec-15 : 5 months, sharp drop

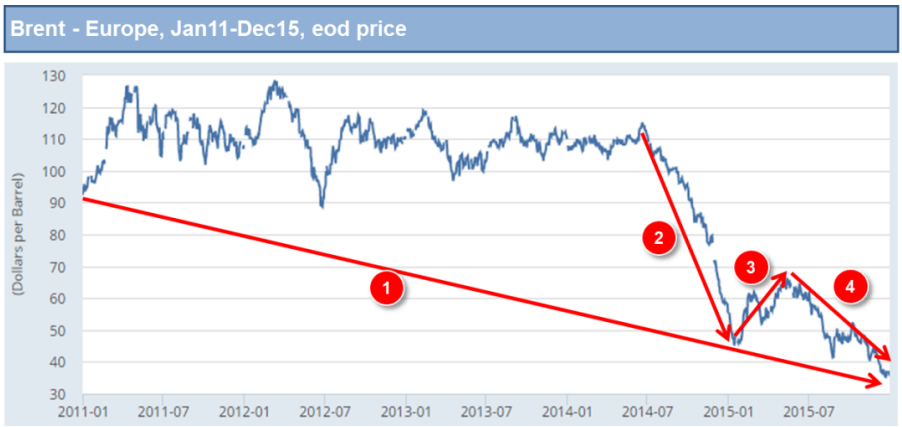


Fig. 1 Temporal periods chosen for the analysis

The resulting data set is large, but still storable in a single database memory: a sample of more than 68,000 data representing the weekly end-of-the-day average price in the last 5 years of 303 companies listed in NYSE and Nasdaq, under the sector 'Oil-Energy'. Each stock is represented by a vector that consists of 260 weeks of data retrieved on-line.

The process provides the following steps:

One-off activities

(1) Storage of the list of tickers representing the stocks listed at Nasdaq and NYSE under the chosen sector

Recurring activities

(2) On-line data retrieval per each ticker
(3) Data series storage into vectors
(4) Vectors cleaning (the system checks validity of data and discards non-valid points)
(5) Comparison with the Brent price equivalent vector: calculation of r coefficient (Pearson correlation) and the R_c threshold (critical value for two-tailed test, a=0,05)
(6) Representation of resulting data together with the following dimensions: stock, industry and period.

Points 5 and 6 are processed 4 times, according to the 4 different temporal segments (Jan11-Dec15, Jan15-May15, May15-Jul15, Aug15-Dec-15), that represent different moments of oil price trends.

Processing efficiently such an amount of data required the development of software that could replicate the process previously described. So we have chosen to develop the MTPA software as follows:

- Developed in Dot Net (Microsoft Visual Studio 2012 Development Platform)
- Hosted on web server machine that can run faster all process phases
- Performances sent via FTP to localhost

It took 3 minutes for the server to complete the data gathering phase, and another 5 minutes to calculate correlation and significance, for a total processing time of 8 minutes. The algorithm is on-line and can be run at:

http://www.marchitelli.net/BBA-correlate-oil-stocks.aspx

4. Empirical Results

As shown in Figure 2, the sample is largely represented by Oil & Gas Production industry companies (54%), followed by Integrated Oil companies (9%), Oilfield Services/Equipment (8%) and Natural Gas Distribution (8%). Less important in the sample are the other industries: Industrial Machinery/Components (6%), Oil Refining/Marketing (5%) and Coal Mining (4%) and Metal Fabrications (4%). A marginal presence of Consumer Electronics/Appliances (1%) and Electric Utilities (1%) completes the sample.

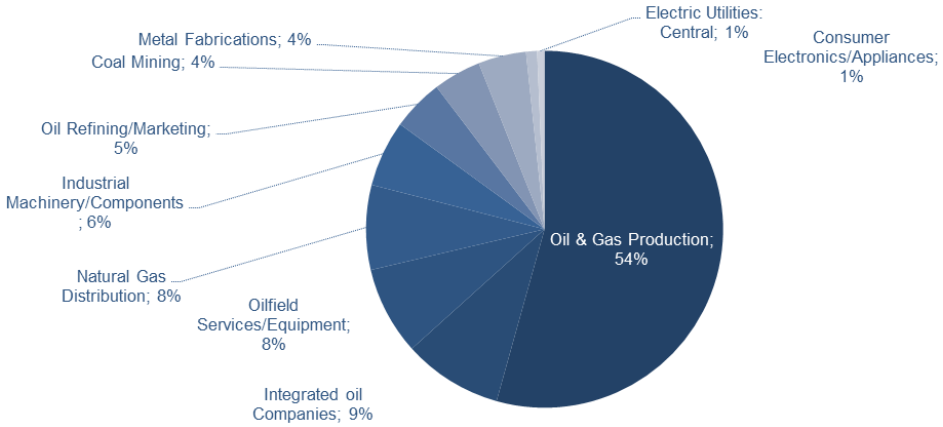


Fig. 2 Sample composition

We have considered significant only those stocks that present very high correlation (i.e. R>=0.8) with oil price series and that passed the significance test (R>= Rc).

If we consider the whole period (5 years), there are only few industries that show a high number of stocks correlated. These industries belong to the upstream segment of the value chain: Oil&Gas Production is impacted for 2/3 of its companies, Metal/Coal and Utilities for more than a half.

On the other hand, downstream segments show a small number of stocks with high correlation. Consumer Electronics and Industrial machinery appear to be highly resilient to oil price fluctuations.

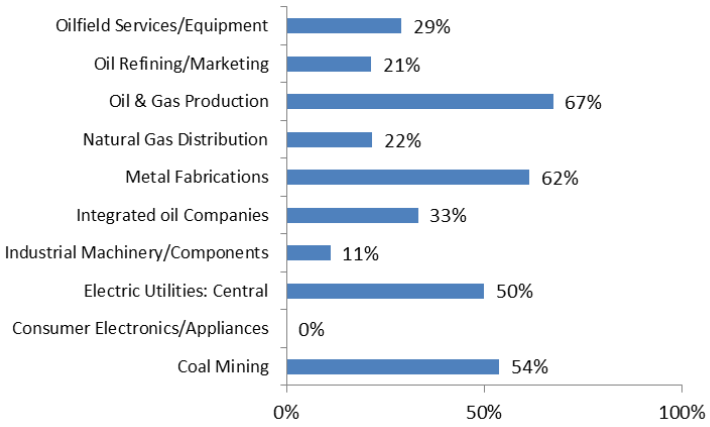


Fig. 3 Percentage of companies with high correlation, split by industry, in period 2011-2015

When it comes to the first semester of 2015 (January to May), the behavior of stocks changes significantly. In this temporal period oil prices were cut by 2 in only a few months. The impact on the sector is expected then to be quite significant.

In fact, for both upstream and downstream segments, the correlation is growing and almost all industries are correlated for more than half of their companies. But the most impacted industries are linked to production, mining and metals. Oil refining and distribution appears to be less impacted and utilities show no correlation at all.

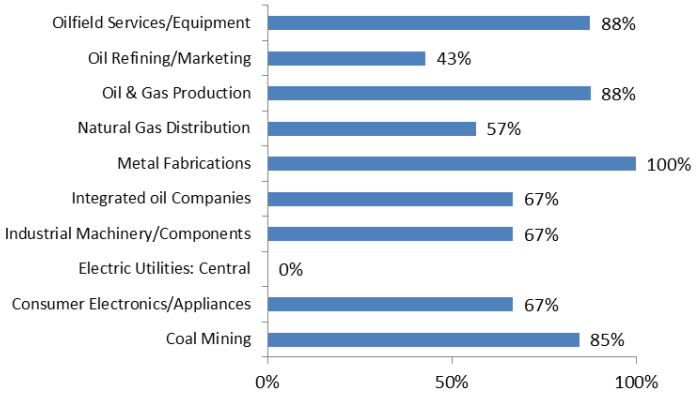


Fig. 4 Percentage of companies with high correlation, split by industry in period January 2015-May 2015

From May to June 2015 oil price had a sudden increase, in the order of 40%. As the volatility increases, the correlation shows a higher impact for all industries. The vast majority of companies of the sample show a high correlation with oil prices. Only Coal Mining industry shows a better resilience.

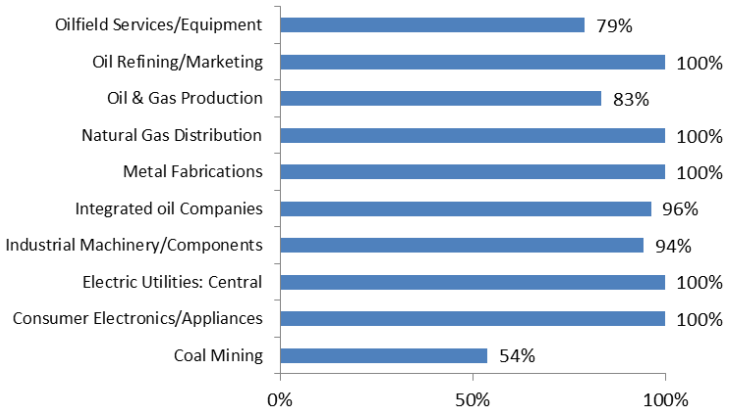


Fig. 5 Percentage of companies with high correlation, split by industry, in period May 2015-July 2015

In the last part of 2015 oil price had again a sudden drop, moving from almost USD 70 to approximately USD 35.The almost totality of the sample shows a full correlation for this last observation period. Even the most resilient industries are now basically following the sharp Brent drop. Only Coal Mining shows a slightly lower level of correlated stocks.

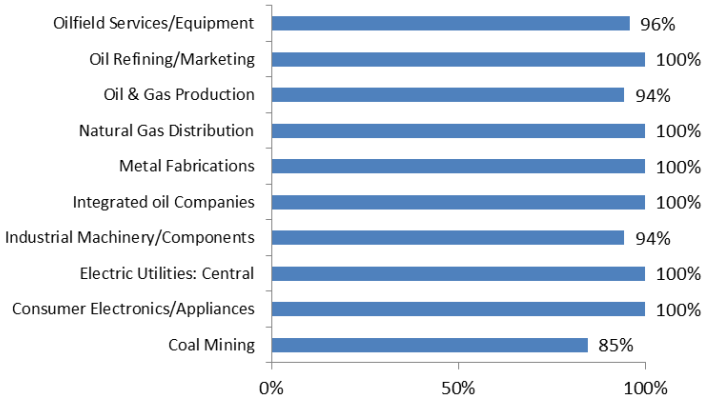


Fig. 6 Percentage of companies with high correlation, split by industry, in period August 2015-December 2015

CONCLUSION

In this paper we analyzed statistical correlation between oil prices (Brent) and US energy sector for the past five years and tried to identify what companies/sub-segments of the value chain are more resilient to the oil price volatility.

We analyzed 4 periods. In period Jan 2011-Dec 2105, some sectors belonging to the downstream segment of the value chain show a little number of stocks with high correlation, and upstream segments show higher correlation. In period Jan 2015-May 2015, for both upstream and downstream segments the correlation is growing, almost all industries are correlated for more than half of their companies. In period May 2015- Jul 2015 the correlation is growing for all industries, the vast majority of companies of the sample show a high correlation with oil prices. Finally, in the last five months of 2015 almost all companies are highly correlated to Brent trend. Even the most resilient industries are basically following the sharp Brent drop. Interesting finding is that for the whole period from January 2011 to December 2015 about 51% of companies show high correlation with Brent, but in the sub-periods this correlation is stronger, 80% in the first, 87% in the second and 96% in the third sub-period. In short periods oil prices have strong impact on stock prices, but in relatively longer time period, changes in stock prices are less related to changes in oil prices, which could be result of many factors influencing the stock prices, such as structural factors.

These findings should be useful to investors in their attempts to appropriately structure their overall portfolios. Analysis of oil price changes can be used as indicator of stock prices, especially stock prices from oil industry. Investors that want to buy stocks, especially stocks from oil industry should be well informed about the oil prices. If they want to invest in something highly correlated, they have to pay attention to oil prices.

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KORELACIJA IZMEĐU CENA NAFTE I CENA AMERIČKIH AKCIJA, KOJE KOMPANIJE U ENERGETSKOM SEKTORU SU NAJOTPORNIJE

S obzirom da zemlje OPEK-a nisu postigle dogovor u cilju zaustavljanja dramatičnog pada cene nafte, cene akcija na američkoj berzi, ali i cene akcija na berzama širom sveta su ponovo pale. Taj pad cena akcija nije bio ograničen isključivo na energetski sektor.

U ovom radu se analizirala statistička korelacija cene nafte (Brent) i akcije američkih kompanija koje pripadaju sektoru energetike u prethodnih 5 godina (2011-2015). U analizi su korišćeni javno dostupni podaci , poput FRED baze podataka, sa nedeljnom frekvencijom.

Rezultati analize izdvajaju kompanije koje pokazuju najviši stepen otpornosti na volatilnost cene nafte, a zatim se najotpornije kompanije stavljaju u odnos sa njihovim stepenom integracije duž proizvodnog procesa energetskog sektora.

Kako pad cene nafte može na različit način uticati na podsektore, neke kompanije mogu imati određene koristi od pozicioniranja duž lanca vrednosti (uzvodni i nizvodni segmenti).

Ključne reči: *Cena nafte, berze, statistička analiza, korelacija serije podataka*