Relationship between alternative energy stocks, oil prices and oil volatility

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Abstract

This research investigates the relationship between alternative energy stocks, oil prices and oil volatility. The alternative energy stocks are categorized into two sub-sectors: renewable energy equipment stocks and alternative fuels stocks.

The main empirical results suggest that most alternative energy stocks have positive relationship with oil prices, but negative relationship with oil volatility.

Particularly, the results suggest that most renewable energy equipment stocks have significant relationship with oil prices, and oil volatility; many of them have positive relationship with oil prices, and most of them have negative relationship with oil volatility. However, there are some alternative fuels stocks have significant relationship with oil prices, and oil volatility; few of them have positive relationship with oil prices, and few of them have negative relationship with oil volatility.

The results seem to reveal that renewable energy equipment stocks have stronger relationship with oil prices and oil volatility than alternative fuels stocks.

Keywords: Alternative energy stocks, renewable energy equipment stocks, alternative fuels stocks, oil prices, oil volatility, stock market.

JEL classification: G10, Q4

1 Introduction

To achieve the scenario of net zero emissions by 2050, the economy is nowadays moving to low carbon economy. The low carbon economy encourages all organizations, corporates, individuals, and governments to use energy products that produce low levels of greenhouse gas emission. As we know crude oil products, such as gasoline, diesel, and other forms of petrochemicals are important inputs for economy; the oil price changes affect significantly the economy. The goal of low carbon economy suggests that alternative energy products which produce low carbon must be encouraged to use. Therefore, governments, policy-makers, and other organizations have provided convenient conditions and encouragements for development and expanding businesses in alternative energy products.

Governments can decide a wide range of policy interventions to support the transformation of energy, solve environmental pollution, and prevent harmful natural capital; e.g., green taxes on harmful environmental activities, loans and grants for green investments, renewable energy businesses, and so on.

Green policies aim to increase the use of green energy products and reduce the use of crude oil products. Therefore, understanding the relationship between alternative energy prices and oil prices are important for policy-makers to plan appropriate policies and decisions to encourage the development of alternative energy businesses. Consequently, there are a vast body of research on the relationship between oil prices and green energy. The previous findings are not consensus; some suggest a negative relationship, some suggest a positive relationship; some suggest a dynamic relationship (see Nunes & Catalão-Lopes, 2020; Reboredo, Rivera-Castro, & Ugolini, 2017; Dutta, Jana, & Das, 2020; Henriques & Sadorsky, 2008; Pham, 2019; Geng, Liu, Ji, & Zhang, 2021; Zhang, Cai, & Yang, 2020; Bondia, Ghosh, & Kanjilal, 2016; Troster,

Shahbaz, & Uddin, 2018; Maghyereh, Awartani, & Abdoh, 2019; Managi & Okimoto, 2013; Kumar, Managi, & Matsuda, 2012; and He et al., 2021). However, some other research suggests that there is no relationship between them (see Dutta et al., 2020 and Sadorsky, 2012)

The alternative energy stocks are categorized into two sub-sectors: renewable energy equipment stocks and alternative fuels stocks as showed in Euronext stock exchange. However, the previous research focuses on alternative energy sector, but not consider the sub-sectors.

It might be expected that oil prices and oil volatility have different levels of relationship with renewable energy equipment stocks and alternative fuels stocks. Finding the relationship between oil prices and alternative energy sub-sectors might help policy-makers to provide the most appropriate policies to encourage the development of alternative energy stocks for each specific sub-sector.

In order to fill in the gap, this research will therefore examine the relationship between alternative energy stocks with oil prices, and oil volatility considering two sub-sectors of alternative energy stocks: renewable energy equipment stocks and alternative fuels stocks, separately.

The main empirical results suggest that most alternative energy stocks have positive relationship with oil prices, but negative relationship with oil volatility. There is only one renewable energy equipment stock has negative relationship with oil prices and one alternative fuels stock has positive relationship with oil volatility.

Particularly, the results suggest that most renewable energy equipment stocks have significant relationship with oil prices, and oil volatility; many of them (8 stocks) have positive relationship with oil prices, and most of them (10 stocks) have negative relationship with oil volatility. However, there are some alternative fuels stocks have significant relationship with oil prices, and oil volatility;

few of them (3 stocks) have positive relationship with oil prices, and few of them (3 stocks) have negative relationship with oil volatility.
The results seem to reveal that renewable energy equipment stocks have stronger relationship with oil prices and oil volatility than alternative fuels stocks.
The paper is structured as follows. The next section will explain data, variables, and methodology. Then, it will state the tests for variables and regressions. Next, it will show the empirical results. Finally, it will summarize and conclude the research.

2 Data, Variables, and Methodology

2.1 Data

In this research, we employ data of 29 alternative energy stocks collected from Euronext stock market. They are categorized into renewable energy equipment stocks and alternative fuels stocks according to the stock market; there are 18 renewable energy equipment stocks and 11 alternative Fuels stocks.
Renewable energy equipment stocks include AGRIPOWER, BLUE SHARK POWER, BOOSTHEAT, BW IDEOL, CHARWOOD ENERGY, CORRE ENERGY B.V., ENERTIME, ENOGIA, ENTECH, HYDROGENPRO, JSA TECHNOLOGY, MAGNORA, MCPHY ENERGY, NEL, NHOA, SCATEC, SIF HOLDING, VERGNET.
Alternative fuels stocks include ENERGEIA, EO2, EVERFUEL, GLOBAL BIOENERGIES, HYDROGEN REFUELING, HYNION, HYON, LHYFE, TECO 2030, WAGA ENERGY, WEYA.
We also collect Brent-Europe Oil prices proxy for oil prices and CBOE Crude Oil Volatility Index (OVXCLS) proxy for oil volatility from FRED. The dataset

can be found here [1].

All the datasets is collected until 17 March 2023.

2.2 Variables

This research examine the relationship between alternative energy stock returns, oil prices and oil volatility.

Variables are computed as the following formulae.

Alternative energy stock returns will be calculated as function (1).

$$R_{it} = ln(P_{it}) - ln(P_{i,t-1}) \quad (1)$$

where, subscripts (it) are stock i, and time being daily time intervals. R_{it} is return of stock i at time t. P_{it} is stock price at current time, $P_{i,t-1}$ is stock price at previous time.

Changes in oil prices:

$$D\_oilprice_t = ln(P\_oil_t) - ln(P\_oil_{t-1}) \quad (2)$$

where, $D\_oilprice_t$ is changes in oil price; P_oil_t is oil price at time t; P_oil_{t-1} is oil price at previous time.

Changes in oil volatility index:

$$D\_oilVol_t = ln(Vol_t) - ln(Vol_{t-1}) \quad (3)$$

where, D_oilVol_t is changes in oil volatility index; Vol_t is oil volatility index at time t; Vol_{t-1} is oil volatility index at previous time.

2.3 Methodology

We use the Ordinary Least Squares (OLS) method to examine the relationship between returns on alternative energy stocks, including renewable energy equipment and alternative fuels stocks, oil prices and oil volatility. The OLS models

[1] Alternative energy stocks: https://live.euronext.com/en;
Brent-Europe Oil pprices: https://fred.stlouisfed.org/series/DCOILBRENTEU;
CBOE Crude Oil ETF Volatility Index: https://fred.stlouisfed.org/series/OVXCLS.

are presented below.

System of regressions of renewable energy equipment stocks

$$R_{it} = \alpha + \beta_1 D\_Oilprice_t + \beta_2 D\_oilVol_t + \epsilon_t \qquad (1)$$

$$D\_Oilprice_t = \alpha + \beta_1 R_{it} + \beta_2 D\_oilVol_t + \epsilon_t \qquad (2)$$

$$D\_oilVol_t = \alpha + \beta_1 R_{it} + \beta_2 D\_Oilprice_t + \epsilon_t \qquad (3)$$

where, R_{it} is returns on renewable energy equipment stocks calculated as formula (1).

System of regressions of alternative fuels stocks

$$R_{it} = \alpha + \beta_1 D\_Oilprice_t + \beta_2 D\_oilVol_t + \epsilon_t \qquad (1)$$

$$D\_Oilprice_t = \alpha + \beta_1 R_{it} + \beta_2 D\_oilVol_t + \epsilon_t \qquad (2)$$

$$D\_oilVol_t = \alpha + \beta_1 R_{it} + \beta_2 D\_Oilprice_t + \epsilon_t \qquad (3)$$

where, R_{it} is returns on alternative fuels stocks calculated as formula (1).

Each alternative energy stock have three regressions as showing in the OLS models. Therefore, there are 87 regressions in total for both sub-sectors; there are 54 for the sub-sector of renewable energy equipment stocks, and 33 regressions for the sub-sector of alternative fuels stocks.

The summaries of data of renewable energy equipment stocks, oil price and oil volatility under each system of regressions are presented in Tables 1 and 2; the summary of data of renewable energy equipment stocks, oil price and oil volatility under each regression is presented in Table 3.

The number of observations for each regression depends on the number of observations of each stock, which depend on how long the stock listed on the exchange. All the datasets is collected until 17 March 2023.

Table 1: Summary data of regressions: Renewable Energy Equipment stocks, oil price and oil volatility

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Pctl(25)**	**Pctl(75)**	**Max**
Data for system regression 1	*Data of AGRIPOWER, Oil Price, and Oil volatility*						
R_AGRIPOWER	777	−0.000	0.02	−0.1	−0.01	0.01	0.2
D_oilprice	777	0.000	0.05	−0.6	−0.01	0.02	0.4
D_oilVol	777	−0.000	0.1	−0.6	−0.04	0.03	0.9
Data for system regression 2	*Data of BLUE, Oil Price, and Oil volatility*						
R_BLUE	220	−0.000	0.1	−0	0	0.02	0
D_oilprice	220	0.000	0.03	−0.1	−0.01	0.01	0.1
D_oilVol	220	0.001	0.1	−0.6	−0.03	0.04	0.3
Data for system regression 3	*Data of BOOSTHEAT, Oil Price, and Oil volatility*						
R_BOOSTHEAT	727	−0.01	0.1	−0.9	−0.03	0.01	0.6
D_oilprice	727	0.001	0.05	−0.6	−0.01	0.02	0.4
D_oilVol	727	−0.000	0.1	−0.6	−0.04	0.03	0.9
Data for system regression 4	*Data of BW, Oil Price, and Oil volatility*						
R_BW	437	−0.004	0.04	−0.1	−0.02	0.02	0.1
D_oilprice	437	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	437	−0.001	0.1	−0.3	−0.03	0.02	0.3
Data for system regression 5	*Data of CCORRE, Oil Price, and Oil volatility*						
R_CCORRE	285	0.005	0.03	−0.2	−0.01	0.02	0.1
D_oilprice	285	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	285	−0.003	0.1	−0.3	−0.03	0.02	0.2
Data for system regression 6	*Data of CHARWOOD, Oil Price, and Oil volatility*						
R_CHARWOOD	157	−0.001	0.03	−0.1	−0.02	0.01	0.1
D_oilprice	157	−0.001	0.02	−0.1	−0.02	0.02	0.05
D_oilVol	157	−0.002	0.04	−0.1	−0.03	0.02	0.2
Data for system regression 7	*Data of ENERTIME, Oil Price, and Oil volatility*						
R_ENERTIME	1,585	−0.001	0.05	−0.5	−0.02	0.01	0.9
D_oilprice	1,585	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	1,585	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 8	*Data of ENOGIA, Oil Price, and Oil volatility*						
R_ENOGIA	391	−0.003	0.02	−0.2	−0.01	0.01	0.1
D_oilprice	391	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	391	−0.001	0.1	−0.3	−0.03	0.03	0.2
Data for system regression 9	*Data of ENTECH, Oil Price, and Oil volatility*						
R_ENTECH	337	0.000	0.02	−0.1	−0.01	0.01	0.1
D_oilprice	337	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	337	−0.001	0.1	−0.3	−0.03	0.02	0.2
Data for system regression 10	*Data of HYDROGENPRO, Oil Price, and Oil volatility*						
R_HYDROGENPRO	560	0.000	0.05	−0.1	−0.03	0.02	0.4
D_oilprice	560	0.002	0.02	−0.1	−0.01	0.02	0.1
D_oilVol	560	−0.001	0.1	−0.3	−0.03	0.02	0.3
Data for system regression 11	*Data of JSA, Oil Price, and Oil volatility*						
R_JSA	1,297	−0.002	0.2	−4.9	−0.02	0.01	5.7
D_oilVol	1,297	−0.003	0.1	−0.4	−0.03	0.02	0.3
D_oilVol	1,297	−0.003	0.1	−0.4	−0.03	0.02	0.3

Table 2: Summary data of regressions: Renewable Energy Equipment stocks, oil price and oil volatility

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Pctl(25)**	**Pctl(75)**	**Max**
Data for system regression 12	*Data of MAGNORA, Oil Price, and Oil volatility*						
R_MAGNORA	3,641	−0.001	0.05	−0.9	−0.02	0.01	0.5
D_oilprice	3,641	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	3,641	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 13	*Data of MCPHY, Oil Price, and Oil volatility*						
R_MCPHY	2,130	−0.000	0.04	−0.2	−0.02	0.01	0.4
D_oilprice	2,130	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	2,130	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 14	*Data of NEL, Oil Price, and Oil volatility*						
R_NEL	3,732	−0.001	0.1	−0.5	−0.02	0.02	0.6
D_oilprice	3,732	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	3,732	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 15	*Data of NHOA, Oil Price, and Oil volatility*						
R_NHOA	1,867	−0.000	0.03	−0.2	−0.01	0.01	0.2
D_oilprice	1,867	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	1,867	−0.002	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 16	*Data of SCATEC, Oil Price, and Oil volatility*						
R_SCATEC	1,983	0.001	0.03	−0.2	−0.01	0.02	0.2
D_oilprice	1,983	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	1,983	−0.001	0.1	−0.6	−0.03	0.03	0.9
Data for system regression 17	*Data of SIF, Oil Price, and Oil volatility*						
R_SIF	1,621	−0.000	0.02	−0.2	−0.01	0.01	0.2
D_oilprice	1,621	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	1,621	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 18	*Data of SIF, Oil Price, and Oil volatility*						
R_VERGNET	3,549	−0.004	0.1	−0.7	−0.02	0.01	1.5
D_oilprice	3,549	−0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	3,549	−0.001	0.1	−0.6	−0.03	0.02	0.9

Table 3: Summary data of regressions: Alternative Fuels stocks, oil price and oil volatility

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Pctl(25)**	**Pctl(75)**	**Max**
Data for system regression 1	*Data of ENERGEIA, Oil Price, and Oil volatility*						
R_ENERGEIA	55	−0.01	0.1	−0.2	−0.03	0.01	0.1
D_oilprice	55	0.000	0.02	−0.1	−0.01	0.02	0.04
D_oilVol	55	−0.002	0.04	−0.1	−0.03	0.02	0.2
Data for system regression 2	*Data of EO2, Oil Price, and Oil volatility*						
R_EO2	3,367	−0.000	0.04	−0.3	−0.01	0.01	0.4
D_oilprice	3,367	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	3,367	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 3	*Data of EVERFUEL, Oil Price, and Oil volatility*						
R_EVERFUEL	549	0.001	0.1	−0.2	−0.03	0.03	0.3
D_oilprice	549	0.002	0.02	−0.1	−0.01	0.02	0.1
D_oilVol	549	−0.002	0.1	−0.3	−0.03	0.02	0.3
Data for system regression 4	*Data of GLOBAL, Oil Price, and Oil volatility*						
R_GLOBAL	2,790	−0.001	0.03	−0.2	−0.01	0.01	0.4
D_oilprice	2,790	0.000	0.03	−0.6	−0.01	0.01	0.4
D_oilVol	2,790	−0.001	0.1	−0.6	−0.03	0.02	0.9
Data for system regression 5	*Data of HYDROGEN_REF, Oil Price, and Oil volatility*						
R_HYDROGEN_REF	491	−0.001	0.03	−0.2	−0.02	0.01	0.2
D_oilprice	491	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	491	−0.001	0.1	−0.3	−0.03	0.03	0.3
Data for system regression 6	*Data of HYNION, Oil Price, and Oil volatility*						
R_HYNION	441	−0.004	0.1	−0.3	−0.03	0.02	0.5
D_oilprice	441	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	441	−0.000	0.1	−0.3	−0.03	0.03	0.2
Data for system regression 7	*Data of HYON, Oil Price, and Oil volatility*						
R_HYON	240	−0.01	0.1	−0.7	−0.03	0.02	0.2
D_oilprice	240	−0.001	0.03	−0.1	−0.02	0.02	0.1
D_oilVol	240	−0.001	0.04	−0.1	−0.03	0.02	0.2
Data for system regression 8	*Data of LHYFE, Oil Price, and Oil volatility*						
R_LHYFE	186	−0.001	0.02	−0.1	−0.01	0.01	0.1
D_oilprice	186	−0.001	0.02	−0.1	−0.02	0.02	0.05
D_oilVol	186	−0.001	0.04	−0.1	−0.03	0.02	0.2
Data for system regression 9	*Data of TECO, Oil Price, and Oil volatility*						
R_TECO	562	0.000	0.1	−0.2	−0.03	0.02	0.2
D_oilprice	562	0.002	0.02	−0.1	−0.01	0.02	0.1
D_oilVol	562	−0.001	0.1	−0.3	−0.03	0.02	0.3
Data for system regression 10	*Data of WAGA, Oil Price, and Oil volatility*						
R_WAGA	320	−0.001	0.03	−0.1	−0.01	0.01	0.1
D_oilprice	320	0.001	0.03	−0.1	−0.01	0.02	0.1
D_oilVol	320	−0.001	0.1	−0.3	−0.03	0.02	0.2
Data for system regression 10	*Data of WEYA, Oil Price, and Oil volatility*						
R_WEYA	615	−0.003	0.1	−1.6	−0.02	0.02	1.0
D_oilprice	615	0.001	0.02	−0.1	−0.01	0.01	0.2
D_oilVol	615	−0.002	0.1	−0.3	−0.03	0.03	0.3

3 Tests for variables and regressions

In this section, we will state some tests showing that the results of all regressions are accepted. Firstly, we test if all variables are stationary; secondly, we test the correlation between renewable energy equipment stocks, oil price and oil volatility, and between alternative fuels stocks, oil price and oil volatility; finally, we test serial correlation for each regression after running the OLS regressions.

Stationary variables

All variables: Renewable energy equipment stocks, alternative fuels stocks, oil price and oil volatility are tested for stationarity based on the augmented Dickey–Fuller. The tests suggest that all variables are stationary at the significance level of 1%.

Correlation between variables

The correlation between variables: Renewable energy equipment stocks, oil price and oil volatility for each regression are presented in Tables 4 and 5 which illustrate that these variables have very low correlation.

The correlation between variables: Alternative fuels stocks, oil price and oil volatility for each regression are presented in Table 6 which illustrates that these variables have very low correlation.

Serial correlation

After running each regression, we test if the regression has serial correlation problem based on the Durbin Watson test. All the serial correlation tests suggest that all regressions have no problem with serial correlation at the significance level of 5%.

Table 4: Correlation between Renewable Energy Equipment stocks, oil price and oil volatility

System regression 1	R_AGRIPOWER	D_oilprice	D_oilVol
R_AGRIPOWER	1	0.052	-0.089
D_oilprice	0.052	1	-0.417
D_oilVol	-0.089	-0.417	1
System regression 2	R_BLUE	D_oilprice	D_oilVol
R_BLUE	1	-0.061	0.038
D_oilprice	-0.061	1	-0.334
D_oilVol	0.038	-0.334	1
System regression 3	R_BOOSTHEAT	D_oilprice	D_oilVol
R_BOOSTHEAT	1	0.039	-0.082
D_oilprice	0.039	1	-0.415
D_oilVol	-0.082	-0.415	1
System regression 4	R_BW	D_oilprice	D_oilVol
R_BW	1	0.032	0.017
D_oilprice	0.032	1	-0.198
D_oilVol	0.017	-0.198	1
System regression 5	R_CCORRE	D_oilprice	D_oilVol
R_CCORRE	1	0.037	0.023
D_oilprice	0.037	1	-0.134
D_oilVol	0.023	-0.134	1
System regression 6	R_CHARWOOD	D_oilprice	D_oilVol
R_CHARWOOD	1	-0.147	-0.100
D_oilprice	-0.147	1	-0.401
D_oilVol	-0.100	-0.401	1
System regression 7	R_ENERTIME	D_oilprice	D_oilVol
R_ENERTIME	1	0.055	-0.066
D_oilprice	0.055	1	-0.388
D_oilVol	-0.066	-0.388	1
System regression 8	R_ENOGIA	D_oilprice	D_oilVol
R_ENOGIA	1	-0.020	-0.044
D_oilprice	-0.020	1	-0.228
D_oilVol	-0.044	-0.228	1
System regression 9	R_ENTECH	D_oilprice	D_oilVol
R_ENTECH	1	0.101	-0.033
D_oilprice	0.101	1	-0.155
D_oilVol	-0.033	-0.155	1

Table 5: Correlation between Renewable Energy Equipment stocks, oil price and oil volatility

System regression 10	R_HYDROGENPRO	D_oilprice	D_oilVol
R_HYDROGENPRO	1	0.046	-0.077
D_oilprice	0.046	1	-0.269
D_oilVol	-0.077	-0.269	1
System regression 11	R_JSA	D_oilprice	D_oilVol
R_JSA	1	0.018	-0.025
D_oilprice	0.018	1	-0.302
D_oilVol	-0.025	-0.302	1
System regression 12	R_MAGNORA	D_oilprice	D_oilVol
R_MAGNORA	1	0.135	-0.100
D_oilprice	0.135	1	-0.333
D_oilVol	-0.100	-0.333	1
System regression 13	R_MCPHY	D_oilprice	D_oilVol
R_MCPHY	1	0.119	-0.127
D_oilprice	0.119	1	-0.371
D_oilVol	-0.127	-0.371	1
System regression 14	R_NEL	D_oilprice	D_oilVol
R_NEL	1	0.074	-0.100
D_oilprice	0.074	1	-0.335
D_oilVol	-0.100	-0.335	1
System regression 15	R_NHOA	D_oilprice	D_oilVol
R_NHOA	1	0.076	-0.067
D_oilprice	0.076	1	-0.383
D_oilVol	-0.067	-0.383	1
System regression 16	R_SCATEC	D_oilprice	D_oilVol
R_SCATEC	1	0.103	-0.115
D_oilprice	0.103	1	-0.378
D_oilVol	-0.115	-0.378	1
System regression 17	R_SIF	D_oilprice	D_oilVol
R_SIF	1	0.153	-0.140
D_oilprice	0.153	1	-0.389
D_oilVol	-0.140	-0.389	1
System regression 18	R_VERGNET	D_oilprice	D_oilVol
R_VERGNET	1	0.041	-0.027
D_oilprice	0.041	1	-0.339
D_oilVol	-0.027	-0.339	1

Table 6: Correlation between Alternative Fuels stocks, oil price and oil volatility

System regression 1	R_ENERGEIA	D_oilprice	D_oilVol
R_ENERGEIA	1	-0.222	0.320
D_oilprice	-0.222	1	-0.353
D_oilVol	0.320	-0.353	1
System regression 2	R_EO2	D_oilprice	D_oilVol
R_EO2	1	0.059	-0.038
D_oilprice	0.059	1	-0.336
D_oilVol	-0.038	-0.336	1
System regression 3	R_EVERFUEL	D_oilprice	D_oilVol
R_EVERFUEL	1	0.099	-0.120
D_oilprice	0.099	1	-0.250
D_oilVol	-0.120	-0.250	1
System regression 4	R_GLOBAL	D_oilprice	D_oilVol
R_GLOBAL	1	0.079	-0.116
D_oilprice	0.079	1	-0.361
D_oilVol	-0.116	-0.361	1
System regression 5	R_HYDROGEN_REF	D_oilprice	D_oilVol
R_HYDROGEN_REF	1	0.017	-0.111
D_oilprice	0.017	1	-0.232
D_oilVol	-0.111	-0.232	1
System regression 6	R_HYNION	D_oilprice	D_oilVol
R_HYNION	1	-0.039	-0.043
D_oilprice	-0.039	1	-0.244
D_oilVol	-0.043	-0.244	1
System regression 7	R_HYON	D_oilprice	D_oilVol
R_HYON	1	0.011	-0.031
D_oilprice	0.011	1	-0.085
D_oilVol	-0.031	-0.085	1
System regression 8	R_LHYFE	D_oilprice	D_oilVol
R_LHYFE	1	0.114	-0.039
D_oilprice	0.114	1	-0.404
D_oilVol	-0.039	-0.404	1
System regression 9	R_TECO	D_oilprice	D_oilVol
R_TECO	1	0.063	-0.082
D_oilprice	0.063	1	-0.268
D_oilVol	-0.082	-0.268	1
System regression 10	R_WAGA	D_oilprice	D_oilVol
R_WAGA	1	0.068	-0.093
D_oilprice	0.068	1	-0.159
D_oilVol	-0.093	-0.159	1
System regression 11	R_WEYA	D_oilprice	D_oilVol
R_WEYA	1	-0.052	-0.012
D_oilprice	-0.052	1	-0.333
D_oilVol	-0.012	-0.333	1

4 Empirical results

4.1 Empirical results for the regressions of Renewable Energy Equipment stocks

In this section, we will investigate the relationship between renewable energy equipment stocks with oil prices and oil volatility. We employ OLS method to test the relationship between 18 renewable energy equipment stocks with oil prices and oil volatility. For each renewable energy equipment stock, there is a system of three regressions as showed in the methodology part. Therefore, there are 54 regressions for testing the relationship between renewable energy equipment stocks with oil prices and oil volatility. As suggested in the testing part, all these regressions have no problem with serial correlation at the significance level of 5%.

The results for each system of regressions are presented in Tables 7, 8 and 9.

In these tables, there are three equations (1), (2), and (3) showing three regressions with different dependent variable for each system of regressions for each renewable energy equipment stock; e.g., regression 1 has three regressions (1), (2), and (3) with R_AGRIPOWER, D_oilprice, and D_oilVol as dependent variable, respectively.

The results in Tables 7, 8 and 9 indicate that many renewable energy equipment stocks (8 stocks) have significant positive relationship with oil prices, such as ENTECH, MAGNORA, MCPHY, NEL, NHOA, SCATEC, SIF, and VERGNET; only one stock (CHARWOOD) has significant negative relationship with oil prices; most renewable energy equipment stocks (10 stocks) have significant negative relationship with oil volatility, such as AGRIPOWER, BOOSTHEAT, CHARWOOD, ENERTIME, MAGNORA, MCPHY, NEL, NHOA, SCATEC, and SIF.

The results in Tables 7, 8 and 9 seem to suggest that renewable energy equipment stocks have strong relationship with oil prices and oil volatility.

4.2 Empirical results for the regressions of Alternative Fuels stocks

In this section, we investigate the relationship between alternative fuels stocks, oil prices, and oil volatility. We employ OLS method to test the relationship between 11 alternative fuels stocks, oil prices, and oil volatility. For each alternative fuels stock, there is a system of three regressions. Totally, we run 33 regression to find the relationship. As suggested in the testing part, all these regressions have no problem with serial correlation at the significance level of 5%.

The results for each system of regressions are presented in Tables 10 and 11.

Tables 10 and 11 show the results of 11 systems of regressions for each alternative fuels stock.

In these tables, there are three equations (1), (2), and (3) showing three regressions with different dependent variable for each system of regressions for each renewable energy equipment stock; e.g., system regression 1 has three regressions (1), (2), and (3) with R_ENERGEIA, D_oilprice, and D_oilVol as dependent variable, respectively.

The results in Table 10 indicate that some alternative fuels stocks have significant positive relationship with oil prices, such as EO2, EVERFUEL, GLOBAL; some have negative relationship with oil volatility, such as EVERFUEL, GLOBAL, and HYDROGEN_REF; only one stock (ENERGEIA) has significant positive relationship with oil volatility at the significance level of 10%.

The results in Table 11 suggest that the alternative fuels stocks have no significant relationship with oil prices and oil volatility. The results of in Tables

Table 7: Systems of regressions: Renewable Energy Equipment stocks, oil price and oil volatility

	Dependent variables: Y		
Equations	(1)	(2)	(3)
System regression 1	R_AGRIPOWER	D_oilprice	D_oilVol
D_oilprice	0.010		-0.714^{***}
	(0.020)		(0.056)
R_AGRIPOWER		0.029	-0.225^{**}
		(0.063)	(0.108)
D_oilVol	-0.025^{**}	-0.240^{***}	
	(0.012)	(0.019)	
System regression 2	R_BLUE	D_oilprice	D_oilVol
D_oilprice	-0.183		-1.042^{***}
	(0.243)		(0.201)
R_BLUE		-0.014	0.017
		(0.019)	(0.059)
D_oilVol	0.022	-0.106^{***}	
	(0.078)	(0.020)	
System regression 3	R_BOOSTHEAT	D_oilprice	D_oilVol
D_oilprice	0.010		-0.717^{***}
	(0.068)		(0.059)
R_BOOSTHEAT		0.003	-0.069^{**}
		(0.020)	(0.035)
D_oilVol	-0.077^{**}	-0.239^{***}	
	(0.039)	(0.020)	
System regression 4	R_BW	D_oilprice	D_oilVol
D_oilprice	0.053		-0.469^{***}
	(0.071)		(0.111)
R_BW		0.024	0.038
		(0.032)	(0.076)
D_oilVol	0.015	-0.084^{***}	
	(0.030)	(0.020)	
System regression 5	R_CCORRE	D_oilprice	D_oilVol
D_oilprice	0.048		-0.269^{**}
	(0.071)		(0.118)
R_CCORRE		0.034	0.047
		(0.050)	(0.100)
D_oilVol	0.017	-0.068^{**}	
	(0.036)	(0.030)	
System regression 6	R_CHARWOOD	D_oilprice	D_oilVol
D_oilprice	-0.294^{**}		-0.745^{***}
	(0.113)		(0.129)
R_CHARWOOD		-0.143^{**}	-0.217^{**}
		(0.055)	(0.098)
D_oilVol	-0.142^{**}	-0.239^{***}	
	(0.064)	(0.041)	
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 8: Systems of regressions: Renewable Energy Equipment stocks, oil price and oil volatility

	Dependent variables: Y		
Equations	(1)	(2)	(3)
System regression 7	R_ENERTIME	D_oilprice	D_oilVol
D_oilprice	0.049		-0.720^{***}
	(0.039)		(0.043)
R_ENERTIME		0.020	-0.059^{*}
		(0.016)	(0.030)
D_oilVol	-0.041^{*}	-0.207^{***}	
	(0.021)	(0.012)	
System regression 8	R_ENOGIA	D_oilprice	D_oilVol
D_oilprice	-0.028		-0.516^{***}
	(0.047)		(0.111)
R_ENOGIA		-0.033	-0.120
		(0.055)	(0.123)
D_oilVol	-0.020	-0.102^{***}	
	(0.021)	(0.022)	
System regression 9	R_ENTECH	D_oilprice	D_oilVol
D_oilprice	0.070^{*}		-0.321^{***}
	(0.039)		(0.114)
R_ENTECH		0.137^{*}	-0.052
		(0.076)	(0.161)
D_oilVol	-0.006	-0.072^{***}	
	(0.019)	(0.026)	
System regression 10	R_HYDROGENPRO	D_oilprice	D_oilVol
D_oilprice	0.055		-0.650^{***}
	(0.086)		(0.100)
R_HYDROGENPRO		0.013	-0.080
		(0.021)	(0.051)
D_oilVol	-0.056	-0.109^{***}	
	(0.035)	(0.017)	
System regression 11	R_JSA	D_oilprice	D_oilVol
D_oilprice	0.139		-0.743^{***}
	(0.346)		(0.065)
R_JSA		0.001	-0.004
		(0.002)	(0.006)
D_oilVol	-0.103	-0.122^{***}	
	(0.140)	(0.011)	
System regression 12	R_MAGNORA	D_oilprice	D_oilVol
D_oilprice	0.190^{***}		-0.643^{***}
	(0.029)		(0.031)
R_MAGNORA		0.062^{***}	-0.067^{***}
		(0.009)	(0.019)
D_oilVol	-0.052^{***}	-0.164^{***}	
	(0.015)	(0.008)	
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 9: Systems of regressions: Renewable Energy Equipment stocks, oil price and oil volatility

	Dependent variables: Y		
Equations	(1)	(2)	(3)
System regression 13	R_MCPHY	D_oilprice	D_oilVol
D_oilprice	0.090***		−0.676***
	(0.025)		(0.038)
R_MCPHY		0.067***	−0.145***
		(0.019)	(0.035)
D_oilVol	−0.056***	−0.194***	
	(0.013)	(0.011)	
System regression 14	R_NEL	D_oilprice	D_oilVol
D_oilprice	0.086***		−0.649***
	(0.032)		(0.030)
R_NEL		0.022***	−0.080***
		(0.008)	(0.016)
D_oilVol	−0.081***	−0.168***	
	(0.016)	(0.008)	
System regression 15	R_NHOA	D_oilprice	D_oilVol
D_oilprice	0.052**		−0.697***
	(0.022)		(0.039)
R_NHOA		0.056**	−0.080*
		(0.024)	(0.044)
D_oilVol	−0.022*	−0.207***	
	(0.012)	(0.012)	
System regression 16	R_SCATEC	D_oilprice	D_oilVol
D_oilprice	0.057***		−0.682***
	(0.020)		(0.038)
R_SCATEC		0.074***	−0.174***
		(0.026)	(0.047)
D_oilVol	−0.039***	−0.202***	
	(0.011)	(0.011)	
System regression 17	R_SIF	D_oilprice	D_oilVol
D_oilprice	0.076***		−0.703***
	(0.017)		(0.043)
R_SIF		0.153***	−0.235***
		(0.035)	(0.066)
D_oilVol	−0.033***	−0.200***	
	(0.009)	(0.012)	
System regression 18	R_VERGNET	D_oilprice	D_oilVol
D_oilprice	0.085**		−0.666***
	(0.042)		(0.031)
R_VERGNET		0.013**	−0.011
		(0.007)	(0.013)
D_oilVol	−0.018	−0.172***	
	(0.021)	(0.008)	
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 10: systems of regressions: Alternative Fuels stocks, oil price and oil volatility

	Dependent variables: Y		
Equations	(1)	(2)	(3)
System regression 1	R_ENERGEIA	D_oilprice	D_oilVol
D_oilprice	−0.333		−0.595**
	(0.373)		(0.257)
R_ENERGEIA		−0.045	0.190*
		(0.051)	(0.096)
D_oilVol	0.368*	−0.157**	
	(0.186)	(0.068)	
System regression 2	R_EO2	D_oilprice	D_oilVol
D_oilprice	0.064***		−0.651***
	(0.022)		(0.032)
R_EO2		0.038***	−0.028
		(0.013)	(0.026)
D_oilVol	−0.012	−0.172***	
	(0.012)	(0.008)	
System regression 3	R_EVERFUEL	D_oilprice	D_oilVol
D_oilprice	0.159*		−0.587***
	(0.095)		(0.101)
R_EVERFUEL		0.032*	−0.109**
		(0.019)	(0.047)
D_oilVol	−0.090**	−0.099***	
	(0.039)	(0.017)	
System regression 4	R_GLOBAL	D_oilprice	D_oilVol
D_oilprice	0.049**		−0.709***
	(0.023)		(0.035)
R_GLOBAL		0.033**	−0.155***
		(0.016)	(0.031)
D_oilVol	−0.058***	−0.178***	
	(0.012)	(0.009)	
System regression 5	R_HYDROGEN_REF	D_oilprice	D_oilVol
D_oilprice	−0.010		−0.564***
	(0.052)		(0.107)
R_HYDROGEN_REF		−0.008	−0.234**
		(0.039)	(0.095)
D_oilVol	−0.052**	−0.095***	
	(0.021)	(0.018)	
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 11: Systems of regressions: Alternative Fuels stocks, oil price and oil volatility

	Dependent variables: Y		
Equations	(1)	(2)	(3)
System regression 6	R_HYNION	D_oilprice	D_oilVol
D_oilprice	−0.129		−0.570***
	(0.122)		(0.107)
R_HYNION		−0.020	−0.049
		(0.019)	(0.043)
D_oilVol	−0.059	−0.106***	
	(0.052)	(0.020)	
System regression 7	R_HYON	D_oilprice	D_oilVol
D_oilprice	0.018		−0.124
	(0.143)		(0.095)
R_HYON		0.004	−0.020
		(0.030)	(0.043)
D_oilVol	−0.046	−0.057	
	(0.097)	(0.044)	
System regression 8	R_LHYFE	D_oilprice	D_oilVol
D_oilprice	0.115		−0.698***
	(0.079)		(0.117)
R_LHYFE		0.100	0.012
		(0.068)	(0.119)
D_oilVol	0.005	−0.233***	
	(0.046)	(0.039)	
System regression 9	R_TECO	D_oilprice	D_oilVol
D_oilprice	0.091		−0.645***
	(0.090)		(0.100)
R_TECO		0.020	−0.078
		(0.020)	(0.049)
D_oilVol	−0.059	−0.108***	
	(0.037)	(0.017)	
System regression 10	R_WAGA	D_oilprice	D_oilVol
D_oilprice	0.053		−0.310***
	(0.054)		(0.112)
R_WAGA		0.056	−0.175
		(0.058)	(0.117)
D_oilVol	−0.040	−0.076***	
	(0.027)	(0.027)	
System regression 11	R_WEYA	D_oilprice	D_oilVol
D_oilprice	−0.370		−0.810***
	(0.250)		(0.092)
R_WEYA		−0.010	−0.012
		(0.007)	(0.016)
D_oilVol	−0.081	−0.138***	
	(0.103)	(0.016)	

Note: *p<0.1; **p<0.05; ***p<0.01

10 and 11 seem to indicate that 11 alternative fuels stocks do not have strong relationship with oil prices and oil volatility.

In short, the results of the relationship between renewable energy equipment stocks with oil prices and oil volatility, and the results of the relationship between alternative fuels stocks with oil prices and oil volatility suggest that most alternative energy stocks have positive relationship with oil prices, buy negative relationship with oil volatility.

The results in this research reveal that only one renewable energy equipment stock (CHARWOOD) has negative relationship with oil prices and only one alternative fuels stock(ENERGEIA) has positive relationship with oil volatility.

In addition, the results imply that renewable energy equipment stocks have stronger relationship with oil prices and oil volatility than alternative fuels stocks.

5 Summary and conclusion

This research investigates the relationship between alternative energy stocks, oil prices and oil volatility. The alternative energy stocks are categorized into two sub-sectors: renewable energy equipment stocks and alternative fuels stocks as showed on Euronext stock market. We employ 29 alternative energy stocks, in which 18 are renewable energy equipment stocks and 11 are alternative fuels stocks, and use the ordinary least squares method to test the relationship. In total, there are 87 regressions are run.

The main empirical results suggest that most alternative energy stocks have positive relationship with oil prices, but negative relationship with oil volatility. There is only one renewable energy equipment stock has negative relationship with oil prices and one alternative fuels stock has positive relationship with oil

volatility.

Particularly, the results suggest that most renewable energy equipment stocks have significant relationship with oil prices, and oil volatility; many of them (8 stocks) have positive relationship with oil prices, and most of them (10 stocks) have negative relationship with oil volatility.

There are some alternative fuels stocks have significant relationship with oil prices, and oil volatility; few of them (3 stocks) have positive relationship with oil prices, and few of them (3 stocks) have negative relationship with oil volatility. The results seem to reveal that renewable energy equipment stocks have stronger relationship with oil prices and oil volatility than alternative fuels stocks.

The finding that most alternative energy stocks have positive relationship with oil prices and negative relationship with oil volatility, seems to suggest that demands in alternative energy products move the same direction as the movement of oil prices and inverse direction with the movement of oil volatility. That is, if oil prices increase, demands in alternative energy products increase and vice versa.

In order to achieve low carbon economy, one could expect that demand in carbon products will reduce and demand in alternative energy products will increase in future; the more volatile oil price, the more increase in demands in alternative energy products. However, the results in this research reveal that only one stock has negative relationship with oil prices, and only one stock has positive relationship with oil volatility.

The findings in this research, therefore, suggest that policy-makers, governments, companies and other organizations should act more to achieve the low carbon economy. They are also very important for policy-makers to consider appropriate key policies, such as tax credits, cash grants and others, to encourage alternative fuels businesses to be more development in future.

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