Proceedings of the 2nd International Conference on Financial Technology and Business Analysis
DOI: 10.54254/2754-1169/92/20231307

Russia-Ukraine War

– The Impact of Energy Market Fluctuation on the US Stock Market

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Abstract: The Russia-Ukraine war is a hybrid war that started in 2014 and escalated in 2022 due to territorial disputes and political conflicts between the two countries. This war has serious implications for the global economy, especially the stock market. To explain, "our results highlight a negative and significant effect of the armed conflict between Ukraine and Russia on world stock returns" [1]. Western countries impose sanctions on Russia, prohibiting Russia from exporting their natural resources like natural gas and crude oil. This essay argues that the Russia-Ukraine war has a significant and negative impact on the U.S. stock market, and this impact varies depending on the environmental performance of the companies. In the essay, we take the returns of prices of crude oil as the independent variable and the Dow Jones Industrial Average as the dependent variable. We found a remarkable correlation between the prices of crude oil and the Dow Jones index. The essay also classifies all the companies in the Dow Jones Industrial Average into two categories based on their Environmental, Social, and Governance (ESG) level: green (environmentally friendly) and brown (not environmentally friendly). And find their correlation with the price of crude oil. The result shows that the companies that are classy as green are not affected by the crude oil price fluctuation. The essay concludes the impact of the Russia-Ukraine war on the U.S. stock market and gives recommendations to both economists and investors for encountering any situation similar to the Russia-Ukraine war. The essay also gives advice about the direction for industrial companies to develop.

Keywords: Russia-Ukraine war, U.S. stock market, ESG, Dow Jones Industrial Average, crude oil

1. Introduction

On February 24, 2022, Russia invaded Ukraine, sparking a series of historic policy decisions and market movements. This post focuses on how changes in energy return due to war affect the Dow Jones Industrial Average. It should be clear that Russia is one of the most critical countries in the

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world in terms of energy production and export, especially in the oil and gas fields. "In 2015, Russia supplied 37% of the gas, 29.1% of the crude oil, and 29.1% of the solid fuels imported by the EU"[2].Undoubtedly, Russia is playing a vital role in Europe's energy supply. As a result of the war, several countries have responded with policies on energy, and energy prices have changed dramatically[3].The price has risen over the past year by 60 percent for oil and a remarkable 400 percent for natural gas in Europe[4].Because energy is so vital to factories, businesses, and countries, changes in energy return can lead to changes in stocks, and we use the Dow Jones Industrial Average to examine the relationship between the two precisely. We found in our research that there is an inseparable relationship between the return rate of crude oil and the stock price.

However, with our further consideration, the companies in the Dow Jones have different properties, so this leads us to a question: Will the stocks of different types of companies react differently to changes in the energy yield? If not, which businesses will be more affected? To solve this problem, this paper uses the ESG index to distinguish these 30 companies into green and brown sectors[5]. Based on the analysis, this paper hypothesizes that enterprises belonging to the brown industry will be more affected than those belonging to the green industry. In this post, we use a regression model to validate our ideas.

In conclusion, given the concern of the global community, this will be a subject well worth exploring, and new perspectives can be provided to the understanding of the complex relationship between the return of energy and stock markets, thus helping academics, investors, and policymakers to better cope with market volatility and risk.

The rest of this essay is organized as follows: Section II briefly discusses the relationship between the Dow Jones index and crude oil prices using a linear regression model. Section III then presents the empirical results. Concluding remarks are given at the end of this article.

2. Methodology

To analyses the relationship between the Dow Jones index prices and crude oil price, we estimate a linear regression model[6]:

$$RDJI_t = \beta_1 + \beta_2 ROIL_t + u_t \quad (1)$$

In Equation (1), $RDJI_t$ is daily returns of the Dow Jones index, are calculated as $r_t = [ln(P_t)/ln(P_{t-1}) * 100]$ where r_t is daily return, P_t is price. We collect the daily DJI index price from MarketWatch. The independent variable is $ROIL_t$, which donates the return on the crude oil price.

2.1. Green and Brown Index

Then, we consider separating all companies listed in the Dow Jones index into two groups, in order to show how their relationship with crude oil prices changes due to the Russia-Ukraine war. Our sample consists of daily stock prices of 30 companies in the Dow Jones index and crude oil prices, covering the period between April 26, 2021, and December 23, 2021. We chose the data based on the start date of the Russia-Ukraine war, so we collected the 8-month data before February 24, 2022, and 8-month data after this date. According to our observation, all companies involved in the Dow Jones index have not been removed and no new company entries were made during the sample period. These 30 companies' daily stock prices are downloaded by WRDS. The daily data collected are transformed into natural logarithmic (log) returns for empirical analysis. Quarterly ESG indices for each company listed in the Dow Jones index are downloaded by MSCI during the sample period. We focus on each company's Environmental Pillar Score, which is one of the columns in the list of

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quarterly ESG indices. By comparing the Environmental Pillar Score of each company, we organize companies within the top fifteen ratings in one group, called the 'Green Index', and the bottom fifteenth in another called the 'Brown Index'. Then, two sets of daily average stock returns are calculated from 15 companies' daily stock returns in each group, which are known as 'Green' and 'Brown' respectively.

2.2. Data description

After data selection and process, brief descriptive statistics are provided in Table 1 and Table 2. Table 1 indicates the positive returns of crude oil prices on average, and there are negative returns in the Dow Jones index, the Green index, and the Brown index on average. Over the sample period, the Dow Jones index has the smallest price volatility. The Brown index has a higher standard deviation than the Green index, and the volatility of the Brown index is similar to that of the crude oil market.

Table 1: Descriptive statistics (April 26,2021-December 23,2022)

Indicator	Definition	Mean	Std.dev.	Min.	Max.	Obs.
DJI Index	Log returns	-0.0000238	0.004692	-0.017465	0.0157583	422
Green Index	Log returns	-0.0001037	0.010737	-0.0429895	0.0392935	422
Brown Index	Log returns	-0.0003537	0.0117596	-0.395017	0.0425238	422
Oil price	Log returns	0.0002581	0.0118774	-0.0607948	0.0348465	422

Table 2: Skewness and Kurtosis tests for normality

			----- Joint test-----	
Indicator	**Pr(sknewness)**	**Pr(kurtosis)**	**Adj chi2(2)**	**Prob>chi2**
RDJI	0.1026	0.0012	11.72	0.0029***
Green	0.2392	0.0002	13.75	0.0010***
Brown	0.2737	0.0011	10.79	0.0045***
ROIL	0.0000	0.0000	54.83	0.0000***
Note:	***significant at 1% level			

According to Table 2, the distribution of return on crude oil prices has a zero skewness (symmetric), but that for returns of the other three indexes is positively skewed. Returns of crude oil prices and all indexes returns have fat with a short tail (Kurtosis smaller than 3). Jarque-Bera test strengthens that the distribution for all series is a strong rejection of normality. There is higher turbulence in both the oil and the US stock market.

2.3. Regression models

Based on equation (1), we further introduce the return of the 'Green Index' and the return of the 'Brown Index' as dependent variables in two linear regression models and the independent variable is still the return on the crude oil price. The models are estimated as:

$$Green_t = \beta_1 + \beta_2 ROIL_t + u_t \quad (2)$$

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$$Brown_t = \beta_1 + \beta_2 ROIL_t + u_t \quad (3)$$

In the extension of Equations (2) and (3), we estimate the dummy variable model(G Koop, 2006) detects whether the Russia-Ukraine war changes the relationship between the Green or Brown index's return and return on crude oil price:

$$Green_t = \beta_1 + \beta_2 DUM + \beta_3 ROIL_t + \beta_4 (ROIL_t * DUM) + u_t \quad (4)$$

$$Brown_t = \beta_1 + \beta_2 DUM + \beta_3 ROIL_t + \beta_4 (ROIL_t * DUM) + u_t \quad (5)$$

Equations (4) and (5) are based on the linear regression model, and we add two dummy variables, where $\beta_2 DUM$ and $\beta_4 (ROIL_t * DUM)$ donate the intercept dummy variable and the slope dummy variable respectively. The dummy variable separate the time period into two part. *DUM*=0 if observations before the Russia-Ukraine war (before 24.2.2022), *DUM*=1 if observations after the war (including 24.2.2022).

We consider the Ordinary Least Squares (OLS) method(G Koop, 2006) to estimate the empirical model in all equations above. It is significant to notice that we implement unit root tests to verify the stationarity of all indicators.

3. Result and Discussion

Table 3 provides the OLS estimations' findings for Equation (1). The results indicate that a statistically significant relationship exists between crude oil returns and the Dow Jones index's returns. When the return on crude oil prices rises by 1%, the return on the DJI increases by 7.479%. 3.58% of the total variation in the return of the Dow Jones index is explained by variation in the return of crude oil.

Table 3: the returns function for the Dow Jones index price(RDJI)

	Dependent variable: crude oil returns			
variable		coefficient		
constant		-0.0000431		
		(0.0002246)		
ROL		0.0747914	***	
		(0.0189274)		
R-squared: 0.0358		Number of observations: 422		
Note:	***significant at 1% level			

Tables 4 and 5 report the results for Equations (2) and (3) respectively. Both tables illustrate that the relationship between the return on crude oil and the Green or Brown index's returns actually exists(statistically significant). The crude oil returns are positively related to the Green Index returns (coefficient=0.208), and a similar trend also be shown between the crude oil returns and Brown index returns (coefficient=0.1477).

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Table 4: the returns function for the Green index price(Green)

	Dependent variable: crude oil returns			
variable		coefficient		
constant		-0.0001574		
		(0.0005094)		
ROL		0.2080146	***	
		(0.0429264)		
R-squared: 0.0529		Number of observations: 422		
Note:	***significant at 1% level			

Table 5: the returns function for the Brown index price(Brown)

	Dependent variable: crude oil returns			
variable		coefficient		
constant		-0.0003919		
		(0.0005668)		
ROL		0.1477477	***	
		(0.0477703)		
R-squared: 0.0223		Number of observations: 422		
Note:	***significant at 1% level			

In Table 6, the result from the F-test (smaller than 1% level of significance) shows at least one of the indicators' coefficients in Equation (4) is significant. The results indicate that only the coefficient of crude oil returns is statistically significant (p-value < 0.01), and the coefficients of the intercept dummy variable, and slope dummy variable in Equation (4) are shown as statistically insignificant (p-value>0.01). This means that the Russia-Ukraine war did not affect the relationship between crude oil returns and the Green index returns. The Green index returns did not change when the Russia-Ukraine war happened. Therefore, when the crude oil returns climb by 1%, the Green index returns upward by 34.246%.

Table 6: Dummy variable model for the Green index returns

The estimation sample:1 to 422			no. of parameters		4
	Coefficient	std.Error	t-value	t-prob	
Constant	-0.0004999	0.0007209	-0.69	0.488	
DUM	0.0005577	0.0010176	0.55	0.584	
ROIL	0.3424623	0.0776396	4.41	0.000	***
ROIL*DUM	-0.1920024	0.0931025	-2.06	0.040	
R^2	0.0630	F(3,418)	9.36	[0.0000***]	
Note:	***significant at 1%level				

Table 7 shows the results for Equation (5). The coefficient of returns on crude oil prices and that for the slope dummy variable is statistically significant. This means the relationship between the returns on crude oil and the Brown index returns was changed due to the war, and it changes from a significantly positive relationship (coefficient= 0.3759) to a slightly positive one(coefficient=0.0461). The returns of the Brown index had not been affected by the war, because both the constant and coefficient of intercept dummies are shown as statistically insignificant. (p-value>0.10)

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Table 7: Dummy variable model for the Brown index returns

The estimation sample:1 to 422			no. of parameters		4
	Coefficient	std.Error	t-value	t-prob	
Constant	-0.0002762	0.0007965	-0.35	0.729	
DUM	-0.0004486	0.0011244	-0.40	0.690	
ROIL	0.3759011	0.0857827	4.38	0.000	***
ROIL*DUM	-0.329814	0.1028675	-3.21	0.001	***
R^2	0.0464	F(3,418)	6.78	[0.0000***]	
Note:	***significant at 1%level				

The study demonstrates a correlation between the return on crude oil prices and the Green or Brown index returns during the sample period. Before the Russian-Ukrainian war, the relationship between the price of crude oil and the price of the Green index or the price of the Brown index was very positive. However, due to the outbreak of the Russian-Ukrainian war, a negative impact on the relationship between crude oil prices and the Brown index prices, resulted in the extent of the positive relationship becoming very small. The empirical analysis proves that the increase in the price of crude oil due to the war only increased the price of the Brown index by a little, but it also increased the price of the Green index by a lot.

This means stock prices of heavy industrial companies listed in the Dow Jones index (the Brown index) have negative changes due to the impact of crude oil prices. However, there is no effect on the price of the Green index which contains companies preferring green energy in the Dow Jones index, when the price of crude oil changes a lot due to the war.

4. Conclusion

There was a significant correlation between crude oil price returns and the returns of the Dow Jones Index, the Green Group Index, and the Brown Group Index during the study period. Specifically, crude oil price returns were positively correlated with the returns of the Dow Jones Index and followed a similar trend to the returns of the Green Group Index and the Brown Group Index. However, the outbreak of the Russo-Ukrainian war negatively impacted the relationship between crude oil prices and Brown Group Index returns, weakening the correlation. On the contrary, the impact of crude oil prices on the returns of the Green Group Index was not affected by the war and the relationship between the two remained stable. The results of the study also show that the stock prices of heavy industrial companies in the Dow Jones index are negatively correlated with crude oil prices, while the stock prices of green energy companies are not affected by crude oil prices. This implies that green energy companies are more resilient and stable in the face of crude oil price fluctuations. By analyzing the data before and after the Russo-Ukrainian war, we find that the war did not significantly change the relationship between crude oil prices and green group index returns, but it did affect the relationship between crude oil prices and brown group index returns. Specifically, the war changed the correlation between crude oil prices and brown group index returns from a significant positive correlation to a slightly positive correlation. In conclusion, the results of this study indicate that crude oil price plays an important role in the financial market and there is a significant correlation between it and the returns of the Dow Jones Index, Green Group Index, and Brown Group Index. The findings also reveal the resilience of green energy companies to crude oil prices, the stability of the Green Group Index, and the impact of the Russia-Ukraine war on the relationship between crude oil prices and the Brown Group Index. These findings provide valuable information for investors, policymakers, and market participants to better understand and cope with the impact of crude oil market volatility.

DOI: 10.54254/2754-1169/92/20231307

Acknowledgement

Tianyi Ge, Yingjun Huang, Yuqian Li, Zhefeng Li contributed equally to this work and should be considered co-first authors.

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