IMPACT OF CRUDE OIL PRICES ON RENEWABLE ENERGY STOCKS IN INDIA

AN EMPIRICAL STUDY

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Abstract: This study analyses the impact of global crude oil prices on five renewable energy company shares and the NIFTY 50 index. The objective of the study is to analyze if there is a relationship between crude oil prices and these shares, and if there is, to further study the direction and degree of this relationship. The independent variables would be the close prices of WTI Crude Oil futures, and the dependent variables are the NSE close prices of five companies: Indosolar, Websol, Suzlon, Ujaas, and Orient Green Power. The period of the observations extends from January, 2012 to December, 2018. The study would help understand if the market treats oil and renewables as substitute goods, and if an increase in the price of one would make the other one more attractive to markets.

IndexTerms **– Renewable Energy, Crude Oil, Share Prices.**

I. INTRODUCTION

Energy security and clean energy have recently become issues of global concern, with phenomena such as global warming and depleting resources becoming agents of change in the way the world perceives energy. In this context, it becomes extremely important for developing countries such as India to plan their energy usage and --promote more sustainable forms of energy. The dominance of conventional energy companies is slowly reducing as renewable energy companies are growing fast in developed countries. However, renewable energy companies in India are currently in the primary stages of their development, and need investors as well as the government to support their growth.

The study aims at identifying and analysing the impact of oil price changes on the share prices of five Indian renewable energy companies. The extent and features of the relationship between the variables would help investors in identifying the degree to which oil prices would affect the share prices of renewable energy companies, and understand the implications of a supply shock or long-term price movements of oil on these share prices. The study also accounts for the impact of oil prices on the broad market, which is represented by the NIFTY 50 index in this study. The study would help understand if the market perceives crude oil and renewable energy as substitutes.

II. LITERATURE REVIEW

One of the most important research conducted in this area was by Sadorsky and Henriques (2008). This paper aims to perform an empirical analysis on the relationship between oil prices and the stock prices of renewable energy companies.. The paper concludes that renewable energy stocks could be compared to technology stocks. However, at the time when the paper was published, the prospects of renewable energy being adopted as a mainstream energy source were perceived to be lesser, although the situation has changed in the recent years. Another similar study in the area uses a CAPM-GARCH multi-factor market model to investigate the relationship between oil prices and alternative energy indices (Schmitz, 2009). The results indicate that alternative energy index returns are sensitive to changes in broad market returns and oil price returns. Specifically, an increase or decrease in the broad market or oil prices will lead to a corresponding increase or decrease in the alternative energy stocks. The paper also reports an increase in the volatility of prices, since it was published during the period of an economic recession. This can be avoided by using a longer data series during a more stable period.

There is another study that offers a broader outlook on the subject (Gormus et al., 2015). Although this study is based on the Henriques and Sadorksy study, it differentiates itself by broadly studying the relationship between the general assets market and the alternate energy stocks. The researchers used the Toda-Yamamoto procedure to analyse the long-term relationship between the variables. The generalized impulse response tests conducted by the researchers showed solar stocks showing a significant response to oil prices.

A study by Huang et al. (2011) offers insights into the attention paid by investors towards oil prices while making investments in alternative energy. This study documents a significant difference in the dynamics of oil prices before and after the Middle East wars of 2003 and 2006. This finding implies that investors in alternative energy are now paying closer attention to oil price shocks when making their investment decisions. The relationships suggest that the crude oil market and the energy sector stock market are interacting more closely in recent years than they did prior to 2006.

III. RESEARCH METHODOLOGY

3.1 Objectives of the Study

The objectives of the study are as follows:

1. To find whether global oil price returns have a long or short-term impact on the share price returns of renewable energy companies in India.
2. To study the behaviour of the share price returns during different extents of change in oil prices.

3.2 Statement of Problem

Crude oil prices experienced a substantial increase in 2018, upsetting the macroeconomic elements of several countries. This also helped draw more focus towards renewable energy sources, whose prices have been continuously dropping in the international market. This study would help understand the relationship between oil prices and renewable energy share prices. This would also provide insight into whether investors believe these companies become more valuable as oil becomes economically unviable.

3.3 Scope of the study

The study considers global oil prices (WTI Crude futures) and 5 renewable energy companies listed on the National Stock Exchange of India. The period of the study extends from 1st January, 2012 till 31st December, 2018. The study focuses solely on the Indian renewables industry and the implications of rising or falling oil prices on it.

3.4 Data and Sources of Data

The variables can be broadly classified into independent and dependent. The sole independent variable in the study are the WTI Crude Oil returns. The closing prices of the West Texas Intermediate Crude oil futures contract from 1st January, 2012 to 31st December, 2018 are taken for this purpose. This future is traded on the New York Mercantile Exchange, and is most traded commodity in the world. The period covers a five-year fall in oil prices due to its rise after 2008 financial crisis, and its eventual rise in 2018, where geopolitical factors and supply constraints led the prices to increase again. This would ensure that the period is volatile and diverse enough to provide a more accurate picture. The logarithmic returns of the closing prices are used.

The independent variables include the share price returns of 5 prominent Indian renewable energy companies. The companies chosen are Indosolar, Websol, Ujaas, Orient Green Power, and Suzlon Energy. These companies have been chosen on the basis of several factors. The first is that these companies have been listed on the NSE before January, 2012. The second is that they earn their revenues solely through renewable energy related activities. This is why despite there being larger companies such as Tata Solar, or NuPower Renewables, they have not been chosen as they do not fit the conditions. Although in previous studies researchers have chosen renewable energy indices rather than individual company share prices, there is no such index in India as of this paper. The indices have been created in developed markets such as the USA.

The logarithmic returns of the companies' closing prices have been used. The close prices were obtained from the National Stock Exchange database. The data has been collected for all the days of the 6 years, excepting stock exchange holidays. The crude oil prices have been adjusted to match the dates where the above stocks were traded. Another independent variable is the NIFTY 50 returns. This variable was chosen to estimate whether the oil prices had any impact on the broad market. As the NIFTY 50 captures the top 50 companies traded on the NSE, this variable would provide an accurate picture of how the market is affected by changes in crude oil prices. This would make it possible to compare the impact between the industry and the market as a whole. It would also make it easier to see to what degree the price changes are affecting the industry specifically after neutralizing its effects on the entire market.

3.5 Statistical Design

The variables have first been tested for descriptive statistics. This includes the mean, standard deviation, kurtosis, skewness, and the Jarque-Bera coefficients. The means show whether the variables provided positive or negative returns during the period. This is essential in understanding the average movement of the data for comparison between the different variables. The standard deviation shows how spread out the data is from the mean. This is an indicator of how volatile the data has been. The Jarque-Bera coefficient shows if the data is normally distributed or not.

The next test conducted is a correlation analysis. Correlation is a good metric for analysing the direction and degree of relationship between two variables. Positive correlation indicates a direct relationship, and negative correlation indicates an inverse one. Correlation is considered to be weak at <0.2, moderate between 0.2 to 0.7, and high above 0.7. A high correlation would indicate that there is a strong relationship between two variables.

The data will also be tested for stationarityThe Augmented Dickey-Fuller test has been used to test for unit root. If the variables are stationary, the null hypothesis that there is a unit root will be rejected. If the variables are not stationary and have a unit root, then it must be corrected. Stationarity is necessary for tests such as cointegration.

The next test conducted on the variables would be the Granger Causality test. Granger Causality helps detect causality between two variables, in order to identify if there is a short-term relationship between two variables. If there is a short-term relationship between crude oil prices and the share price returns, it would mean that the share prices would be susceptible to short term fluctuations in oil prices as well. This would mean that if oil becomes volatile for a short period of time, the share prices will also experience this.

A cointegration test has also been performed on the variables. Cointegration tests help identify if there exists a long-term relationship between two variables. If the variables were cointegrated, they could deviate in the short run, but would eventually exhibit similar paths. Johansen test has been used to test for cointegration. Johansen's test does not require a dependent variable to be chosen and can thus detect multiple cointegrating variables. If crude oil prices and renewable energy stocks were cointegrated, it would mean that they would have a long-term relationship, and that they are tied together.

The final test used is the One-Way ANOVA test. The ANOVA test is usually used for variables that are not normally distributed. Non-parametric tests such as the Kruskal-Wallis tests are to be used for non-normal data. However, some studies argue that normality is not very important for ANOVA tests, especially if the sample size is big (Blanca et al., 2017). Since the sample size in this case is above 1800 observations, the ANOVA test has been performed. Also, the KW test has limitations in terms of understanding the degree of relationship between the variables. The ANOVA is used in this case to group the oil price fluctuations according to the level of change in returns, and study the mean returns of the share prices in each case.

IV. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Table 1: Descriptive Statistics for CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

The study is aimed at finding the impact of crude oil price returns on the stock price returns of 5 Indian renewable energy companies. The NIFTY 50 index returns have also been used to analyse the extent of impact of crude oil price returns on the broad market. The data has been collected for the period of January, 2012 to December, 2018, and includes 1679 observations. The logarithmic returns of the close prices of the variables have been considered for the analysis.
The crude oil returns are represented by CrudeOil_RN and the NIFTY 50 returns by Nifty_RN. The close price returns of each company including Indosolar Ltd., Suzlon Energy Ltd., Ujaas Energy, Websol Energy Systems Ltd., and Orient Green Power Company Ltd. are represented by Indosolar_RN, Suzlon_RN, Ujaas_RN, Websol_RN and OrientGP_RN.
The mean values of the data indicate if the values have a mean positive or negative return over the 6 years. The mean return of crude oil is -0.0488. This means that most of the investors who have invested in oil during this period have borne an average loss. NIFTY 50 returns, on the other hand, has a mean of 0.0507. This shows that the average return of the variable has been positive and the investors have seen gains. The mean returns of Indosolar, Suzlon and Orient Green Power are also negative. These shares have fallen by a significant proportion since January 2012. However, Ujaas and Websol have positive mean returns, which means that the investors would have received a gain on the average. The share prices have also experienced an increase from the initial

Descriptive Statistics								
Variables	Mean	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis	Jarque-Bera	Probability
CrudeOil_RN	-0.0488	11.6213	-9.0703	2.1248	0.2081	5.866429	586.6429	0.0000
Nifty_RN	0.0507	6.0973	-3.7380	0.9210	0.2955	5.2558	380.4119	0.0000
Indosolar_RN	-0.0514	30.9340	-17.6829	4.2268	1.2544	8.5441	2590.6560	0.0000
Suzlon_RN	-0.0741	18.1015	-41.2703	3.5007	-0.2698	16.9670	13667.5900	0.0000
Ujaas_RN	0.0174	32.6456	-24.6133	4.0007	0.9955	9.6139	3337.5280	0.0000
Websol_RN	0.2306	18.2322	-22.3144	4.3187	0.5495	5.1265	400.8376	0.0000
OrientGP_RN	-0.0233	18.2322	-15.1718	3.0434	1.2078	9.6428	3495.2540	0.0000

date. The worst fall in returns was experienced by Suzlon, and the highest increase is of Ujaas. All of the company stock returns have a higher standard deviation of 3-4, showing that the dispersion of returns from the mean is higher. This shows that these shares have been quite volatile in the past 6 years and experience high dispersions from their mean value.
From the histograms, it is visible that some of the variables have longer tails, showing that they are positively or negatively skewed. The descriptive statistics show that the returns of Indosolar and Orient Green Power are positively skewed as both have a value of approximately 1.2. They are followed by Ujaas which has a value of 0.9955. The rest of the variables are approximately symmetric. A kurtosis value of less than 3 indicates a platykurtic distribution and of more than 3 indicates leptokurtic. All the variables in the study are leptokurtic in nature. This shows that the variables are highly volatile and that their probability curves have long tails. The data is also tested for normality using the Jarque-Bera test. Since the values are large, the data is not normal.

4.2 Correlation

Multiple correlation coefficient measures how well a variable can be predicted by using a linear function of a setoff the other variables. It essentially measures the correlation between a variable's values and the best projections that can be calculated from predictive variables linearly. The table indicates how closely each variable is correlated to the other. It can be seen that the value of correlation between CrudeOil_RN and the other dependent variables that is Indosolar_RN, Suzlon_RN, Ujaas_RN, Websol_RN and OrientGP_RN is positive but a weak relation can be seen.

Table 2: Correlation between the variables CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

Correlation							
	CRUDEOIL_RN	NIFTY_RN	INDOSOLAR_RN	SUZLON_RN	UJAAS_RN	WEBSOL_RN	ORIENTGP_RN
CRUDEOIL_RN	1.0000	-0.0140	0.0144	0.0489	0.0375	0.0185	0.0730
NIFTY_RN	-0.0140	1.0000	-0.0169	-0.0009	0.0243	-0.0248	0.0161
INDOSOLAR_RN	0.0144	-0.0169	1.0000	0.1937	0.2662	0.2618	0.2022
SUZLON_RN	0.0489	-0.0009	0.1937	1.0000	0.2489	0.2346	0.2944
UJAAS_RN	0.0375	0.0243	0.2662	0.2489	1.0000	0.2028	0.2105
WEBSOL_RN	0.0185	-0.0248	0.2618	0.2346	0.2028	1.0000	0.1889
ORIENTGP_RN	0.0730	0.0161	0.2022	0.2944	0.2105	0.1889	1.0000

A negative correlation between oil prices and share price returns would mean that an increase in oil prices would have a negative effect on the share prices, and vice versa. But since the coefficients are close to zero, this implies weak association between variables. CrudeOil_RN and Nifty_RN also have a weak negative association. This means that the association between CrudeOil_RN and Indosolar_RN, Suzlon_RN, Ujaas_RN, Websol_RN and OrientGP_RN is more than the association between CrudeOil_RN and Nifty_RN.

High correlation among independent variables is undesirable but some degree of correlation should exist between dependent and independent variable and since the same isn't there, it isn't desirable. This could mean that the companies are less affected by industry factors than they are by company specific factors. If they were significantly affected by industry-wide factors, the correlation would be higher. This also shows that these share prices would be less vulnerable to oil price changes, as they have shown to be more susceptible to company specific factors. Another implication of these results could be that since the renewable energy industry is widely believed to have significant potential, company fundamentals and strategies fall under intense scrutiny, as investors would want to invest in the most competent companies within the industry.

Stationarity (Augmented Dickey-Fuller Test)

Table 3: Augmented Dickey-Fuller Test for CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

Augmented Dickey Fuller Test					
Variables	ADF Statistics	1% Level	5% Level	10% Level	Probability
CrudeOil_RN	-44.2630	-3.4304	-2.8631	-2.5676	0.0000
Nifty_RN	-38.0722	-3.4304	-2.8631	-2.5676	0.0000
Indosolar_RN	-33.9456	-3.4304	-2.8631	-2.5676	0.0000
Suzlon_RN	-38.1475	-3.4304	-2.8631	-2.5676	0.0000
Ujaas_RN	-28.0094	-3.4304	-2.8631	-2.5676	0.0000
Websol_RN	-34.4284	-3.4304	-2.8631	-2.5676	0.0000
OrientGP_RN	-4.4593	-3.4304	-2.8631	-2.5676	0.0000

The Augmented Dickey Fuller Unit root test on CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Ujaas_RN, Websol_RN and OrientGP_RN are shown in Table 3. ADF test is done to check the stationarity of the data. Data that is stationary has the property that the mean, variance and autocorrelation structure do not change over time.

The p-values of all the variables are below 0.05. Therefore, the variables are stationary.

4.3 Granger Causality

Granger Causality is used to investigate the causality between CrudeOil_RN and the independent variables which are Nifty_RN, Indosolar_RN, Suzlon_RN, Ujaas_RN, Websol_RN and OrientGP_RN. It uses empirical sets of data to find patterns of correlation. It is a measure of cause-and-effect relationship between 2 variables. The results of the Granger Causality test are negative for all variables, showing that crude oil does not Granger Cause any dependent variable. This is consistent with past study in the area of the relationship between crude oil prices and the Indian stock market (Sharma, 2017). This is justified, as there are several other macroeconomic, industrial, and company-specific factors that have a more direct impact than oil prices.

The fact that there is no short-run relationship shows that renewable energy investors need not worry about periods of high volatility in oil prices on their shares. This would mean that they have to be more concerned about other factors that affect the industries or the companies

Table 4: Granger Causality

Granger Causality Test			
Hypothesis	Observations	F-Statistic	**Probability**
NIFTY_RN does not Granger cause CRUDEOIL_RN	1677	0.20469	0.8149
CRUDEOIL_RN does not Granger Cause NIFTY_RN		0.39824	0.6716
INDOSOLAR_RN does not Granger cause CRUDEOIL_RN	1677	0.45948	0.6317
CRUDEOIL_RN does not Granger Cause INDOSOLAR_RN		1.56828	0.2087
SUZLON_RN does not Granger cause CRUDEOIL_RN	1677	0.21542	0.8062
CRUDEOIL_RN does not Granger Cause SUZLON_RN		0.95034	0.3868
UJAAS_RN does not Granger cause CRUDEOIL_RN	1677	0.76792	0.4641
CRUDEOIL_RN does not Granger Cause UJAAS_RN		0.34107	0.7111
WEBSOL_RN does not Granger cause CRUDEOIL_RN	1677	0.41803	0.6584
CRUDEOIL_RN does not Granger Cause WEBSOL_RN		1.58845	0.2045
ORIENTGP_RN does not Granger cause CRUDEOIL_RN	1677	0.55659	0.5733
CRUDEOIL_RN does not Granger Cause ORIENTGP_RN		0.01024	0.9898

4.4 Cointegration

Cointegration indicates the long run equilibrium that ties the individual variables by representing a linear combination of the variables. It is essentially a multivariate generalization of the Augmented Dickey Fuller Test wherein the examination of the linear variables for their unit roots is the generalization.

Cointegration is important, especially in time series as overlooking it can lead to spurious regression issue, which occurs if non-stationary series or arbitrarily trending series are regressed on each other.

Table 5: Johansen Cointegration Test for the variables CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

Johansen Cointegration Test				
Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Probability
None	0.2282	2309.3990	125.6154	0.0000
At most 1	0.2065	1875.7560	95.7537	0.0000
At most 2	0.1852	1488.5040	69.8189	0.0000
At most 3	0.1835	1145.5520	47.8561	0.0000
At most 4	0.1628	806.1987	29.7971	0.0000
At most 5	0.1585	508.8405	15.4947	0.0000
At most 6	0.1231	219.9325	3.8415	0.0000

The test assumes no trend in the series with a restricted intercept in the cointegration relation. Table 5 shows the results for testing the number of cointegrating relations. The first column shows the number of cointegrating relations under the null hypothesis, the second column is the ordered eigenvalues, the third column is the test statistic, and the last two columns are the 5% and the 1% critical values. The results indicate 7 cointegrating equations at the 0.05 level.

4.5 One-Way ANOVA

For the purpose of the one-way ANOVA, the crude oil prices were grouped into three classes. The first group (1) includes the days where the returns are greater than 0.5%. This group will extend from 0.5% to the maximum of 11.62%. The second group extends from -1 to -0.5. This group has been chosen to ensure that the number of observations are level for all three groups, and to include a category that captures the mundane fluctuations in the returns. This group is also inclusive of the mean returns, which is -0.48. The third category includes the returns that are below the -1 level. The number of observations for each category are 625, 589 and 466 respectively.

Table 6.1 Grouping for ANOVA

Code	Count of Date	Returns
1	625	>0.5
2	589	(-1) - 0.5
3	466	<-1

Table 6.2 ANOVA for the variables CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

ANOVA						
Variables	Nifty_RN	Indosolar_RN	Suzlon_RN	Ujaas_RN	Websol_RN	OrientGP_RN
Significance	0.906	0.009	0.213	0.038	0.823	0.073

If the p-value is less than 0.05, the alternate hypothesis can be accepted. This shows that it is significant at the 95% level of confidence. The ANOVA test shows that 2 out of 6 variables have a p-value of less than 0.5. This shows that these variables are affected by the price fluctuations in oil.

From the tests, it is evident that variations in the share price returns of Indosolar and Ujaas are related to the returns of crude oil prices. Since the p-values of the other variables are above 0.05, the variances in these returns do not have any relation to the crude oil returns.

Table 6.3 Descriptive Statistics for the variables CrudeOil_RN, Nifty_RN, Indosolar_RN, Suzlon_RN, Websol_RN and OrientGP_RN

Comp.	Nifty_RN			Indosolar_RN			Suzlon_RN			Ujaas_RN			Websol_RN			OrientGP_RN		
Ret. Code	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
N	625	588	466	625	588	466	625	588	466	625	588	466	625	588	466	625	588	466
X	-0.064	-0.042	-0.044	-0.182	0.363	-0.399	0.057	-0.027	-0.310	0.306	-0.027	-0.314	-0.004	0.109	-0.050	0.197	-0.157	-0.151
Std. Dev	0.969	0.828	0.966	3.925	4.690	3.958	3.139	3.805	3.557	3.961	4.140	3.852	4.163	4.069	4.810	3.351	2.775	2.921

The extent of the relation in the variances can be analysed by studying the mean returns of the dependent variables under each group. In the case of NIFTY_RN, the mean returns are negative in all groups. The mean returns are lowest (-0.0636) when in case of group 1, which means that during periods where oil prices rise significantly, the index is adversely affected by it. The returns are relatively higher (-0.0442) in case of group 3, where, the crude oil returns are falling.
The one way ANOVA results are significant for 2 out of 6 variables. The other 4 variables show similar means. The means of all 4 variables are negative in all groups, except for Websol under group 2. However, these are not statistically significant, as their p-value is above 0.05. So, these means cannot be considered to be statistically valid.
In the case of the other two variables, Indosolar and Ujaas, the means are positive under group 1. These results are statically valid as well. This implies that rising oil prices have a positive effect on the share price returns of these companies, which proves the hypothesis to an extent. Therefore, the alternate hypothesis of oil prices impacting renewable energy companies' share price returns can be accepted in 2 cases. This implies that with rising oil prices, the share price returns of these companies also rise. This could be partially due to the perception that these companies are viewed as a substitute for crude oil by the market. For the other companies, the mean is negative in all cases. This could be because a rise in oil prices lead to a rise in the production costs for these companies.

IV. CONCLUSION

The study was conducted during the period of 2012-2018, a turbulent period in the history of oil. This period witnessed the decline of oil prices from one of its highest historical prices, as it struggled to keep up with alternative energy that is becoming cheaper. The period also saw an increase in the prices in 2018. The objective of the study was to observe and study the impact that these oil price changes have on renewable energy stocks. Four tests were performed to analyze the impact, and the following results have been obtained:

• The correlation between all the variables under the study is low. However, although the correlation between the stock returns and crude oil returns is low, it is also seen that the companies have a slightly stronger correlation among themselves. This could be due to the fact that there are industry wide factors that have a stronger impact on these share prices than oil.

• The Granger Causality test results were negative for all the variables. This is consistent with past studies which proved that oil prices do not Granger cause Indian stock prices.

• The cointegration test showed positive results. This implies that the independent and dependent variables have a long-term relationship. This can be further studied using a VECM model.

• The One-Way ANOVA test showed that 2 out of 6 variables are statistically significant. These variables have positive mean returns when oil prices are increasing, which could mean that investors are moving their funds from oil to renewable energy.

It can be concluded that renewable energy companies are not significantly affected by oil price changes, except in two cases. The implication could be that since renewable energy is already expected to be an extremely important industry, oil's power as a substitute diminishes. This means that the performance of the industry would depend upon the performance of the companies. While the rising oil prices would make oil economically unviable, the impact of this phenomenon would not be as significant. Since the study shows that the relationship between crude oil prices and renewable energy shares is very weak, it could mean that oil and renewables can coexist in the economy, each powering different needs.

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