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Article

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Investigating the Nexus between Crude Oil Price and Stock Prices of Oil Exploration Companies

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ABSTRACT

In emerging economies, examining the linkage between different markets has become crucial. We have examined the linkage between crude oil and Indian oil exploration companies' equity prices. The augmented Dickey-Fuller method is used to test the stationarity of the series. The Granger causality test, Vector autoregression (VAR) and correlation methodologies are used to examine the causality between the markets. The p-values of Granger causality tests are <0.05, which confirms that the crude oil price causes the price movements of Indian oil exploration equities. The VAR (2) model confirmed that the prices of HOCE, OIL and ONGC follow the first and second lag, Reliance and PETRONET equities follow the first lag of International crude price. The impulse response function shows a positive response of Indian oil exploration equity returns for the positive shocks of crude oil return. The findings of this study may help the traders and investors in the equity market, energy equity investors.

Keywords: Energy Equity, Causality, Oil Price, Vector Auto Regression, Impulse Response Function
JEL Classifications: G21; G30

1. INTRODUCTION

The nexus between the oil market and other financial markets have become many academicians' interests in recent decades. Numerous studies have found the relationship between the oil market and other financial markets. Changes in oil prices lead to fluctuations in economies; the oil shocks affect multiple countries' economies (Atif et al., 2022; Meher et al., 2020; Blanchard and Gali, 2007). Kumar et al. (2021) found the impact of dynamic crude oil prices on the price of natural rubber in India. Amin (2015) found the nexus between the oil price and electricity policy changes in Bangladesh. Alamgir and Amin (2021) found a positive relationship between oil price and Asian stock market indices. Kumar et al. (2021) examined the relationship between crude oil price and Indian tyre equity prices; the multivariate GARCH models revealed a negative relationship between the oil and tyre equity prices.

India is the third-largest oil consumer globally, after USA and China. The amount of crude oil extracted in India is insufficient to meet the domestic demand. Hence, a massive volume of crude is imported from foreign countries. According to IEA (India Energy Outlook 2021), the primary energy demand is expected to double to 1,123 million tonnes because of the expected growth in GDP to USD 8.6 trillion by 2040. India has low conventional energy resources than its required energy needs, driven by a vast population and a rapidly increasing economy. As an alternative, India can harness the enormous potential of solar energy as it receives sunshine most of the year. It also has vast potential in the hydropower sector, which is being explored across states in the

northeast. However, an expensive amount of capital investment is the hurdle to the growth of such alternative sources. For oil exploration, the government has planned to invest US$2.86 in upstream oil and gas production (Alamgir and Amin, 2021). These strong fundamentals ensure good growth and a future for India's oil exploration sector. However, the global oil market is not stable. Using the Granger causality test and Vector Auto Regression (VAR) model, we examine the relation between oil prices and Indian oil exploration companies' stock prices.

2. LITERATURE REVIEW

Many studies revealed that the Indian stock market and stock prices react to different issues (Meher et al., 2021; Kumar et al., 2020; Hawaldar, 2016; Iqbal, 2014). Earning announcements (Iqbal and Mallikarjunappa, 2009; Iqbal et al., 2007), risk and return (Iqbal 2015; 2011) and oil prices (Atif et al., 2022) affects stock prices significantly. Long et al. (2021) have used the VAR methodology to examine the relationship between money supply, inflation and output in Vietnam and China. VAR model is applied to analyse the relationship between the crude oil market and pandemic Covid-19 (Shaikh, 2021). To understand the spillover across equity markets between China and Southeast Asian countries, Hung (2019) applied VAR and BEKK models. Kilian and Zhou (2020) have applied the VAR model to understand the oil price shocks in the demand and supply of oil in the market. To examine the volatility transmission between crude oil, gasoline, heat oil and carbon emissions, Bunnag (2015) has used VAR and VECM models. To examine the nexus between crude palm price, soybean oil price and crude oil price, Songsiengchai et al. (2018) have used VAR and Granger causality test.

The nexus between crude oil price volatility and stock indices movement in India and China was examined using wavelet analysis (Mishra and Debasish, 2022). Researchers found the relation between global crude oil price and equity market both in Indian and Chinese economies. Barbaglia et al. (2020) stated that the volatility spillover exists between the energy, equity, and bioenergy markets. The study's interaction between oil and currency exchange markets was evident (Butt et al., 2020). An unconditional causal relationship was found between oil price and exchange rates in Malaysia by (Butt et al., 2020). Volatility and correlation spillover was evident from the oil market to the Indian industrial sectors (Kumar and Maheswaran, 2013). A couple of times in the past, the business dailies in India have reported that depreciated oil prices are taking the tyre sector stocks up (Shyam, 2019). A study by Bagchi (2017) found asymmetric volatility responses for negative and positive innovations, and a further negative relationship was observed between returns and volatility of crude oil and Sensex. A study by Dutta (2018) revealed a long-term correlation between the stock market and oil market volatilities.

Further, Granger causality found a short-term lead-lag relationship between the USA's oil and stock markets. The Causal Relationship between Crude Oil Price, Exchange Rate and Rice Price study (Adam et al., 2018) revealed only a short-term relationship between the selected variables. Oil price volatility in the context of Covid-19 was studied by Bourghelle et al. (2021). The study revealed that the pandemic has negatively impacted the whole economy. The COVID 19 pandemic reduced global demand for crude oil, increased uncertainty, and triggered a severe economic recession in most developed and emerging countries (Meher et al., 2020). This led to a supply shock as the pandemic resulted in an oil trade war between the major oil-producing nations (Saudi Arabia and Russia). These shocks led to extremely high levels of oil price volatility. The empirical study of Fuentes and Herrera (2020) stated that the crude oil, gold market, green energy stocks and S and P 500 indices show a unidirectional relationship. Empirical studies by Saeed et al. (2020), Liu and Hamori (2020), and Yu-Ling Hsiao et al. (2019) also found some evidence of a linkage between energy stock prices and the oil market. Many causal studies have used the Granger causality test, VAR and VECM models to summarise this section. Numerous studies from various economies have found nexus between crude oil and the equity market. Studies have appeared from the Indian perspective concerning causality between crude oil prices and Sensex, crude oil prices and tyre equities, crude oil prices, and currency exchange rates. However, a specific study regarding the nexus between oil prices and oil exploration companies' stock prices has not appeared. This work aims to address the topic. Those few questions left unanswered necessitated the following research agenda worthwhile. This work aims to add to the exciting literature segment on the linkage between the crude oil market and equity market in India by examining the causal relationship of crude oil prices with Indian oil exploration companies' equities.

3. METHODOLOGY

This empirical study analyses the nexus between the oil market and Indian oil exploration companies' stock prices. Based on market capitalisation top five oil exploring companies are selected they are Reliance Industries (RELIANCE), Oil and Natural Gas Corporation (ONGC), Petronet LNG (PETRONET), Oil India (OIL) and Hindustan Oil Exploration Company (HOEC). From the official website of Yahoo finance, the daily closing price data of crude oil and Indian oil exploring companies' equities are gathered for the period from March 10, 2010 to December 31, 2021. After adjusting the missing values in the oil and equity price series using the V-Look up the function of the Microsoft excel package, we could finalise 2443 daily observations for each price series.

We have applied Pearson correlation, Granger causality test, and VAR model to examine the causal relationship between the Indian oil exploration equities with crude oil prices. The general equation of Pearson's correlation model is presented in equation 3.1. Augmented Dicky-Fuller (ADF) tests are performed to check the stationarity of the series. If the price series are not stationary, log-returns of the series are taken to make such series stationary.

$$r = \frac{n\left(\sum(COP)(OEE\right) - (\sum COP)(\sum OEE)}{\sqrt{[n\sum COP^2 - (\sum COP)^2][n\sum OEE^2 - (\sum OEE)^2]}} \quad (3.1)$$

Profillidis and Botzoris (2019) opined that a causal test could only examine the causal relationship between two variables. The general equation of the causality test of Granger (1969) is

presented in equation 3.2. In equation 3.1, the variable *COP* is the crude oil price, *OEE* is the price of Indian oil exploration equities determinant and commodity price, and *r* is the correlation coefficient.

$$y_t = \alpha + \beta_1 \times y_{t-1} + \beta_2 \times y_{t-2} + \ldots + \beta_p \times y_{p-2} + \varepsilon_t \quad (3.2)$$

Equation 3.2 resembles the Autoregressive process, where y_t is the price of Indian oil exploration equity, α is the intercept, ε_t is the error term, and β_1, β_2, β_3 are the slope parameters of the Auto $r_{(p)}$ process. Equation 3.2 is augmented by introducing the lag values of crude oil price (x_t) and the resulting equation presented below.

$$y_t = \alpha + \beta_1 \times y_{t-1} + \beta_2 \times y_{t-2} + \ldots + \beta_p \times y_{p-2} + \varnothing_1 \times x_{t-1} + \ldots + \varnothing_n \times x_{n-1} + \varepsilon_t \quad (3.3)$$

In equation 3.3, *x* is the price of crude oil in the international market, and *n* is the lag length for which the past values of crude oil prices are statistically significant. The general equation of the bivariate VAR (1) model is presented in equation 3.4.

$$OEE_t = \beta_{OEE0} + \beta_{OEE1} OEE_{t-1} + \ldots + \beta_{OEEk} OEE_{t-k} + \propto_{OEEk} COP_{t-1} + \ldots + \alpha_{OEEk} COP_{t-k} + u_{OEEt} \quad (3.4)$$

$$COP_t = \beta_{COP0} + \beta_{COP1} COP_{t-1} + \ldots + \beta_{COPk} COP_{t-k} + \propto_{COPk} OEE_{t-1} + \ldots + \alpha_{OEEk} OEE_{t-k} + u_{OEEt} \quad (3.5)$$

Where (OEE) in equation (3.3) is the equity price of oil exploration companies, dependent on its past values, past values of crude oil price, and (u_{OEEt}) is the white noise error term. Similarly, the COP in equation (3.2) is the crude oil price, which functions its past values and past values of oil exploration equity prices (OEE) and u_{COPt} is the white noise error term. The term "t" in the above two equations is the time index. This study accommodates the above seven endogenous variables in the model: six selected oil exploring companies' equity price series and crude oil spot price series.

4. DATA ANALYSIS AND DISCUSSION

The price line chart of crude oil prices and Indian oil exploration companies' equities are shown in Figure 1. The equity price series of PETRONET and RELIANCE shows an upward trend during the study period. The crude spot series shows a mixed trend, and the equity price series of OIL, ONGC and HOEC resemble the price series of the crude spot. We have witnessed crude oil trading with a negative value in the New York mercantile exchange (NYMEX) due to the Oil crisis during the COVID pandemic. This is evident from a sharp fall in crude spot prices and all selected stock prices of oil exploration companies during the beginning of 2020.

The descriptive statistics of crude oil spot and Indian oil exploration companies' stock prices are presented in Table 1. In panel b of Table 1, the mean return of all the series is equal to zero, the standard deviations of those series are greater than zero. This indicates that the returns on crude and Indian oil exploration equities were highly volatile during the study period. The minimum price of crude during the study was US$ 10.01; this was reported during the COVID pandemic in 2020. Most economies were in lockdown at the beginning of 2020, resulting in an increased crude inventory in the international market. This resulted in crude trading with negative values too in the futures market of the NYMEX platform. This is evident from an extremely high value of Kurtosis (63.74) for crude returns compared to the Kurtosis of Indian exploration equity returns. Negative skewness for the return series of crude, OIL and ONGC indicate a longer left tail that is the extreme losses during the study period. The positive skewness reported in Table 1 is evidence of good profits for the equities of HOEC, PETRONET and RELIANCE during the study period. The Jarque-Bera test statistics imply that the series is not normally distributed.

The test for stationarity of the series is done using ADF methodology; the unit root test results are presented in Table 2. The P values for the unit root tests for the price series are greater than 0.05, and the absolute value of the t-statistic of ADF is less than the critical values at 1%, 5% and 10%. These statistical values confirm that the price series of crude and oil exploration equities are not stationary. The logged returns of crude prices and select stock prices of Indian oil exploration companies are computed using the log function $r_{ji,t} = \ln(\frac{P_{ij,t}}{P_{ij,t-1}})$.

Where, $P_{ij,t}$ and $P_{ij,t-1}$ are the closing prices of crude oil and Indian oil exploration equity returns for day's *t* and *yesterday t-1,* respectively.

The probability values of the ADF test for the returned series of crude price and Indian oil exploration equities are <0.05, the absolute values of the t-statistic of ADF tests are greater than the t-statistic for 1%, 5% and 10% critical values. This confirms that the return series of crude price and Indian oil exploration equities are stationary. The return series are plotted in Figure 2, in which the log-returns are reverting to zero, and the series is not showing an upward or downward trend.

The correlation analysis and Granger causality test analysis are presented in Table 3. The OIL and ONGC company's stock prices positively correlate with a crude price; the correlation coefficients are 0.67 and 0.57, respectively. The equity prices of PETRONET and Reliance are negatively, and the price of HOEC equity is moderately positively correlated with crude price. The second half of Table 3 presents the Granger causality test results; the null hypothesis is that the crude price does not Granger cause the oil exploration equities in India. The probability values of the Granger causality test for both return and price series of all oil exploration equities are less than or equal to 0.05. The probability values of all the correlation coefficient estimations are <0.05; the same is not presented in the Table. Hence, with a 95% confidence level, we can confirm that the price of crude oil in the international market will cause the prices of Indian oil exploration equities.

This empirical study examines the nexus between crude price and Indian oil exploration equities. With a default lag length of 2, the VAR model was estimated. Post estimation, the function lag length criteria are used to identify the optimal lag length for the

Figure 1: Price series of crude oil spot and Indian oil exploring companies' equities. Source: Authors processing

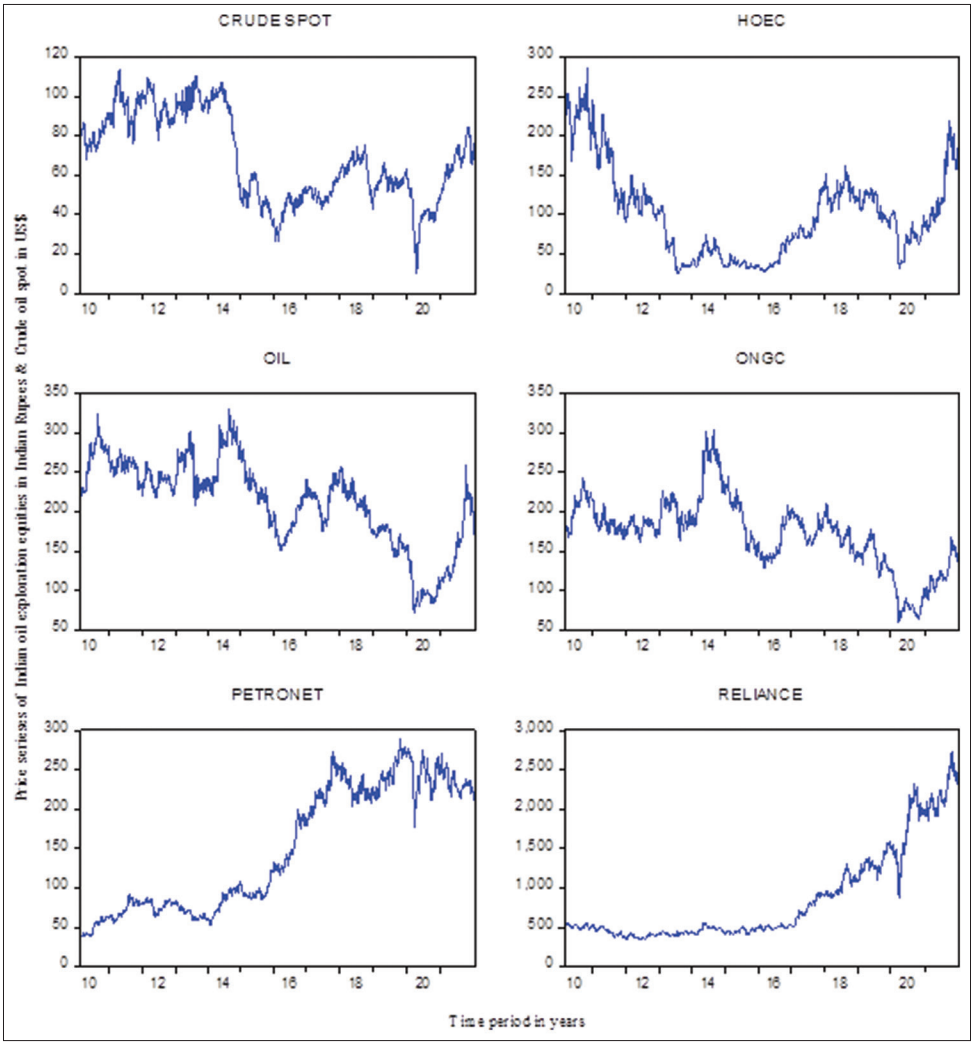

Table 1: Descriptive statistics of crude oil and Indian oil exploration company equities

Statistic	CRUDE	HOEC	OIL	ONGC	PETRONET	RELIANCE
Panel a: price series						
Mean	69.01	100.38	212.81	171.44	149.53	862.36
Maximum	113.93	286.40	330.60	303.43	288.25	2731.85
Minimum	10.01	24.40	70.35	60.00	38.03	334.88
SD	22.27	57.10	54.83	44.69	78.82	601.36
Skewness	0.12	0.84	−0.60	−0.15	0.16	1.31
Kurtosis	1.85	3.12	2.77	3.38	1.32	3.53
Jarque−Bera	139.39	290.68	152.29	24.40	297.41	730.83
Observations	2443.00	2443.00	2443.00	2443.00	2443.00	2443.00
Panel b: return series						
Mean	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.32	0.23	0.15	0.13	0.10	0.14
Minimum	−0.60	−0.26	−0.13	−0.17	−0.09	−0.13
SD	0.03	0.04	0.02	0.02	0.02	0.02
Skewness	−2.31	0.10	−0.07	−0.05	0.31	0.37
Kurtosis	63.74	7.29	7.74	8.90	4.97	7.60
Jarque-Bera	377535.60	1878.39	2285.73	3548.70	432.64	2207.60
Observations	2442.00	2442.00	2442.00	2442.00	2442.00	2442.00

Source: Authors' computations

VAR model. Based on Akaike information criteria (AIC), Schwarz criteria (SC) and Hanna Quinn (HQ) information criteria, the optimal lag for the model is identified as 2. Hence, this VAR (2) model estimated 78 coefficients with six endogenous variables, of which 19 coefficients were statistically significant with a 95% confidence level. Only the coefficients on this objective are presented in Table 4. Other significant coefficients are presented as VAR equations in 4.1–4.5.

Figure 2: Return series of crude oil spot and Indian oil exploring companies' equities. Source: Authors processing

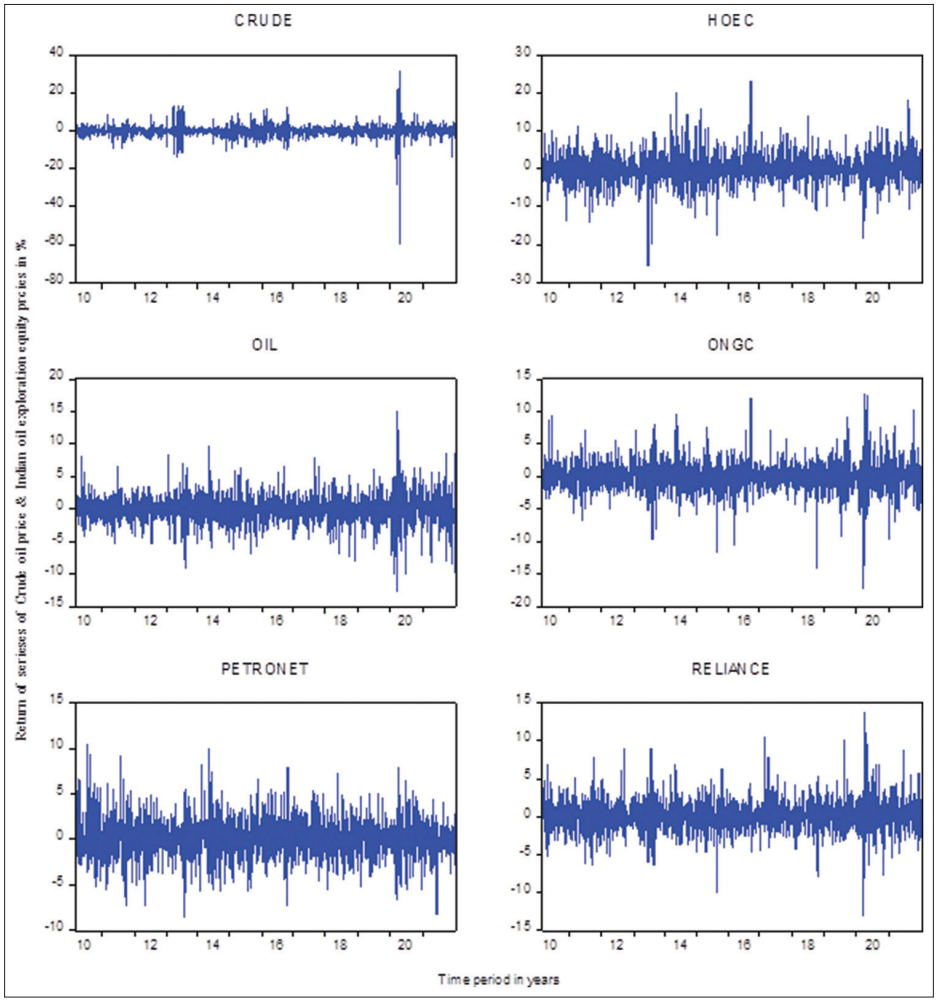

Table 2: Unit root test results of crude oil and Indian oil exploration company equities

Price series				Price series			
Variable	**Critical value**	**t-Statistic**	**Probability**	**Variable**	**Critical value**	**t-Statistic**	**Probability**
Crude	ADF test	−1.65	0.46	Crude	ADF test	−40.11	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	
HOEC	ADF test	−2.42	0.14	HOEC	ADF test	−47.02	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	
OIL	ADF test	−1.93	0.32	OIL	ADF test	−37.07	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	
ONGC	ADF test	−1.79	0.39	ONGC	ADF test	−38.17	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	
PETRONET	ADF test	−1.32	0.62	PETRONET	ADF test	−52.05	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	
RELIANCE	ADF test	0.93	1.00	RELIANCE	ADF test	−21.26	0.00
	1% level	−3.43			1% level	−3.43	
	5% level	−2.86			5% level	−2.86	
	10% level	−2.57			10% level	−2.57	

Source: Authors' computations

$$OIL = 0.05 \times CRUDE(-1) + 0.03 \times HOEC(-1) + 0.03 \times CRUDE(-2) - 0.06 \times OIL(-1) - 0.09 \times OIL(-2) + 0.07 + ONGC(-1) + 0.05 \times RELIANCE(-1) \quad (4.1)$$

$$HOEC = 0.12 \times CRUDE(-1) + 0.04 \times HOEC(-1) + 0.07 \times CRUDE(-2) \quad (4.2)$$

$$ONGC = 0.09 \times CRUDE(-1) + 0.08 \times CRUDE(-2) + 0.06 \times OIL(-1) - 0.08 \times ONGC(-1) \quad (4.3)$$

$$PETRONET = 0.03 \times CRUDE(-1) - 0.08 \times PETRONET(-1) - 0.06 \times PETRONET(-2) \quad (4.4)$$

$$RELIANCE = 0.06 \times CRUDE(-1) \quad (4.5)$$

Table 4 proves that the international price of crude oil causes the price movements of Indian oil exploration equities. There are three values presented in each cell: coefficient, standard error, and t-statistic. The coefficients presented in bold letters are the statistically significant coefficients with a 95% confidence level. The regression coefficients for the equities of HOEC, OIL and ONGC are statistically significant for the first and second lag of crude return. This confirms that the crude prices of the previous 2 days will cause today's prices of HOEC, OIL and ONGC. The equity price of HOEC depends on its previous lag as well. The oil price will be influenced by the past 2 days' crude oil price, its price past 2 days, and the first lag of HOEC, ONGC and Reliance equity prices. The regression coefficients of ONGC confirm that the first lag of OIL and its price will cause its price movements in addition to the crude oil price. The coefficients of PETRONET

Figure 3: Impulse response of Indian oil exploration equity returns to the crude oil return. Source: Authors processing

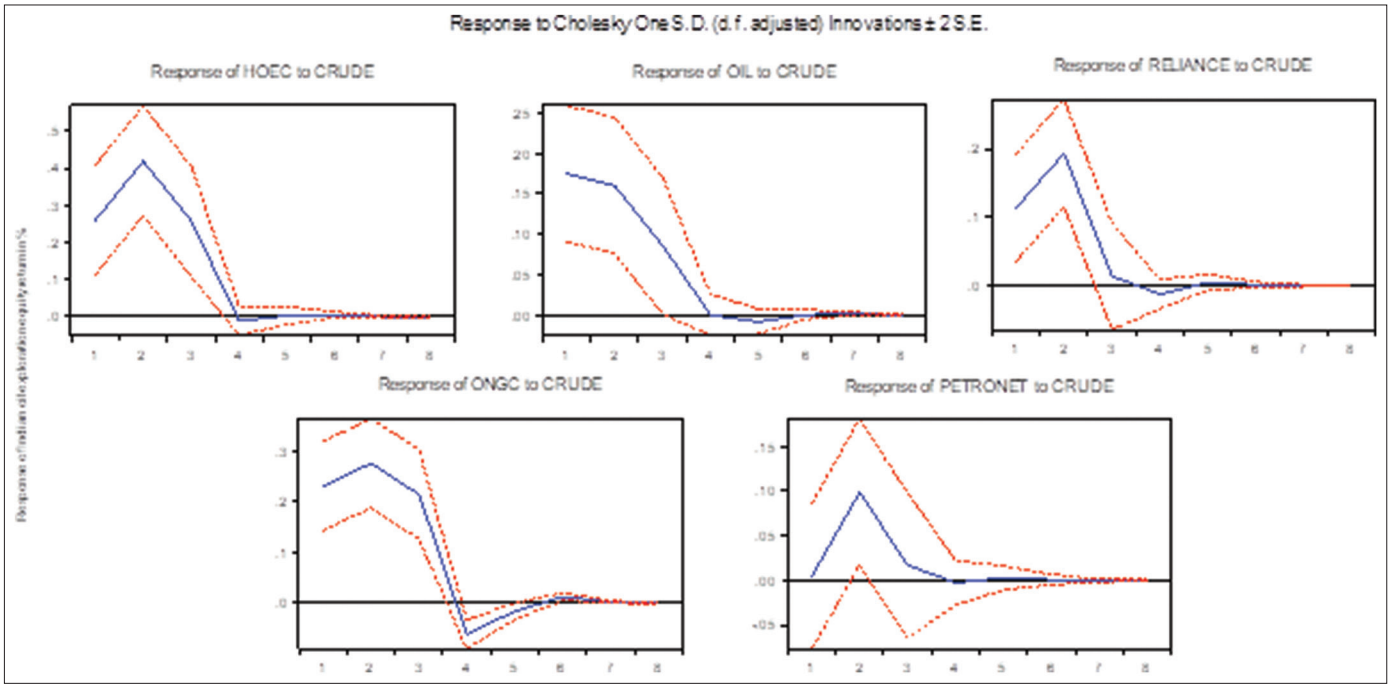

Table 3: Results of correlation analysis and Granger causality tests

Correlation of crude oil with Indian oil exploration equities			CRUDE does not Granger Cause oil exploration equity price	
Variable	**Price series**	**Return series**	**Price series**	**Return series**
HOEC	0.34	0.056	0.00	0.00
OIL	0.67	0.072	0.02	0.00
ONGC	0.56	0.080	0.00	0.00
PETRONET	−0.63	−0.004	0.05	0.05
RELIANCE	−0.36	0.046	0.01	0.00

Source: Authors' computations

Table 4: VAR estimates

Lag	CRUDE	HOEC	OIL	ONGC	PETRONET	RELIANCE
CRUDE (−1)	−0.116	0.117	0.045	0.086	0.027	0.058
	−0.020	−0.023	−0.013	−0.014	−0.013	−0.012
	(−5.725)	(5.120)	(3.485)	(6.292)	(2.107)	(4.836)
CRUDE (−2)	−0.088	0.073	0.025	0.081	0.005	0.011
	−0.021	−0.023	−0.013	−0.014	−0.013	−0.012
	(−4.282)	(3.158)	(1.937)	(5.869)	(0.379)	(0.909)

Source: Authors' estimation

and Reliance confirm that the first lag of crude oil price will cause the price and return of these equities.

The impulse response of Indian oil exploration equity returns for crude oil return shocks is plotted in Figure 3. A positive crude return shock would increase oil exploration equity returns in India, and we found that a positive crude oil disturbance would increase India's oil exploration equity prices. The red and blue lines in Figure 3 are 95% confidence interval and response to shock, respectively.

5. CONCLUSION

Examining the linkage between commodities markets with other economies' markets has become the interest of many researchers today. The stock markets have become more volatile in recent decades. Numerous studies have evidenced the positive or negative impact of macros like oil price, interest rate, inflation rate and currency exchange rates on the financial markets. In such markets, examining and understanding the influence of such macros on the market of a particular sector is essential. This study has examined the nexus between international crude prices and Indian oil exploration equity prices. The VAR (2) model found that the past 2 days' price of crude oil would influence the price of HOEC, OIL and ONGC equities. The correlation coefficients and the Granger causality test statistics confirmed the linkage between oil price and oil exploration equities.

Further, the previous day's price of crude would influence the price of PETRONET and Reliance. These findings are supported by the impulse response of Indian oil exploration equity returns to the positive international crude oil returns shock. Further, using multivariate volatility models, one can examine the portfolio hedging feasibility of crude oil futures to oil exploration equity portfolios. These causal studies help investors and analysts decide on their buy, sell, or hold decisions in the equity markets.

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