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Article

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Relationship between Crude Oil Prices and Stock Market: Evidence from India

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ABSTRACT

This paper estimates the linear interdependencies between international crude oil prices and stock market indices of India using weekly data spanning from January 2010 to January 2017 in a vector autoregressive (VAR) framework. The time series used for the analysis are crude oil futures prices, nifty index, and BSE energy index. Augmented Dickey-Fuller and Philips-Perron unit root tests reveal that all the time series are non-stationary at level and stationary at first difference. Cointegration test reveals the absence of cointegrating factor i.e., absence of long run relationship. VAR model captures all the time series as endogenous variables and independent variables are studied at two lags. Result shows that the Energy Index is very well explained by the lagged values of crude oil futures prices, nifty index, and BSE energy Index. impulse response function reveals that crude oil prices are affected negatively when one standard deviation shocks are given to stock indices.

Keywords: Crude Oil, BSE Energy Index, Nifty, Vector Autoregression
JEL Classifications: Q42, Q43

1. INTRODUCTION

Crude oil is gaining its important as a lifeline to the world's economy in general and to some of the nation's economy in specific. Crude oil is the most actively traded commodity in the world. The Indian oil and gas sector is one of the six core industries in India and plays a huge role in global economy. As a developing country, it is committed to excel its economy in the upcoming years. Increased oil prices have definite impact on world economy through employment, rising inflation, decrease in dollar value all of which combine to economic slowdown. Any massive increase or decrease in crude oil has its impact on the condition of stock markets throughout the world. India is one of the biggest importers of crude oil in the world; ranks 3rd behind U.S and China for import of crude oil. Oil accounts for about 30% of India's total energy consumption. The country's total oil consumption is about 2.2 million barrels per day. India imports about 70% of its total oil consumption and it makes no exports. This accounts for one third of its total imports. While falling crude oil, price is negative for oil-producing countries, India, being a net importer, stands to benefit significantly. India's macro-economic fundamentals such as inflation, fiscal deficit and current account deficit (CAD) have improved meaningfully over the last couple of years, a large part of which can be attributed to falling crude oil prices. The Indian oil and gas sector is one of the six core industries in India and has very significant forward linkages with the entire economy. The Indian oil and gas sector is of strategic importance and plays a predominantly pivotal role in influencing decisions in all other spheres of the economy. Fall in crude oil prices, therefore, helps the country save on import bill, thereby narrowing its CAD. Price of crude oil is influenced by many factors like socio and political events, status of financial markets. From medium to long run it is influenced by the fundamentals of demand and supply. There is an emphasized need for wider and more intensive exploration for new finds, more efficient and effective recovery, a more rational and optimally balanced global price regime- as against the rather

wide upward fluctuations of recent times, and a spirit of equitable common benefit in global energy cooperation.

Decline in crude oil prices helps the government manage its finances better as it translates into lower subsidies on petroleum products (LPG and kerosene), thereby resulting in lower fiscal deficit. This, in turn, helps the government to remain committed to fiscal consolidation roadmap without compromising on economic growth. The fall in global oil prices may be beneficial to India, but it also has its downsides. Directly, it affects the exporters of petroleum producers in the country. India is the sixth largest exporter of petroleum products in the world. This helps it earn $60 billion annually. Any fall in oil prices negatively impacts exports. At a time when India is running a trade deficit - high imports and low exports, any fall in exports is bad news. Moreover, a lot of India's trade partners and buyers of its exports are net oil exporters. A fall in oil price may impact their economy, and hamper demand for Indian products. This would indirectly affect India and its companies. In the recent study, Ghosh and Kanjilal (2016) studied the impact of oil shocks on the Indian economy and concluded that the inflation and foreign exchange reserves are greatly impacted by oil price shocks.

Global oil fluctuations affect the economy of the nations in a positive and negative manner depending whether the country is net importer or exporter of crude oil. India being a developing economy imports the 70% of its crude oil requirements. For an investor and policy maker, it is imperative to understand the relationship between crude oil prices and stock market. The present study attempts to understand the relationship between international crude oil prices and Indian stock market. Ghosh and Kanjilal (2016) studied the most volatile phase in the history of oil price shocks better known by subprime crisis and concluded that international oil price variability has impact on Indian stock market.

The rest of the paper is organized as follows. Section 2 gives an overview of existing literature. Section 3 provides data description and estimation methodologies. Section 4 analyses the empirical results. Finally, Section 5 has conclusions.

2. LITERATURE REVIEW

As per Hamilton (1983), crude oil price shocks played a major role in the US stock returns after World War II. Since then a number of researchers started establishing the relationship between oil price shocks and macroeconomic variables (Jones and Kaul, 1996; Huang et al., 1996; Aydogan and Berk, 2015; Cüppers and Smeets, 2015; Bass, 2017; Ulusoy and Ozdurak, 2018; Ojikutu et al., 2017). Jones and Kaul (1996) used quarterly data from 1947 to 1991 to test whether the international oil price shocks have an impact on the current and future real cash flows of the US and Canadian markets. Using the cash flow dividend valuation model they find that oil international oil price shocks significantly impact US and Canadian real cash flows. Huang et al. (1996) established the relationship between daily oil future returns and daily US stock returns using data spanning from 1979 to 1990. Using the vector auto regression approach, they found that oil future returns have some impact on the individual oil company returns but don't have any significant impact on the market indices like S&P 500. Sadorsky (1999) used monthly data to study the impact of oil price shocks on US stock returns. Using the vector autoregressive (VAR) approach, a significant was found to have on the real stock returns due to changes and volatility in the oil prices. Positive oil price shocks affected more than negative shocks. Ciner (2001) studied oil prices and stock markets by testing for nonlinear linkages, in addition to linear linkages. The data used for the research comprised of daily closing prices of oil futures contract traded on the New York Mercantile Exchange (NYMEX) and the S&P 500 stock index. For testing the linearity and nonlinearity Granger Causality test was employed. The study arrived at two main findings- (1) a nonlinear feedback relation between oil and the stock market. (2) The linkage between oil prices and the stock index movements is stronger in the 1990s.

Park and Ratti (2008) studied the impact of oil price shocks and oil price volatility on the real stock returns for US and 13 European countries. The data taken for the study was from 1986:1 to 2005:12. A multivariate VAR analysis and an error variance decomposition analysis was conducted to establish relationship between oil price shocks and real stock returns and between oil price shocks and interest rates. A statistically significant impact was found to have on the real stock returns on a short term ranging to consecutively maximum 2 months. Norway, an oil exporter positively reacted to the increase in oil prices by generating a positive real stock returns. Contrary to the Norway, for other European countries in the study except (Norway, Finland, and the U.K.) and the US, the scenario was not remarkable as their real stock returns depressed with the impact of oil price shocks at the 5% level in the same month and/or within 1 month. Also, oil price shocks have significantly impacted the interest rates in the US and in Austria, Belgium, Finland, France, Germany, Greece, and Netherlands. However, it was found that the variability in the interest rates contributed more to the real stock returns than oil prices in Denmark, Italy, Norway, and Sweden. While for Spain, the impact was same due to interest rate and oil price variability.

Arouri et al. (2011) studied the returns and volatility transmission between oil prices and stock markets in the Gulf Cooperation Council (GCC) countries over a period of 2005-2010. The empirical methodology applied to detect the volatility spillovers between the markets was Multivariate Econometric technique, VAR moving average - generalized autoregressive conditional heteroskedasticity (VAR-GARCH). The outcome of the study found to have a significant volatility spillovers between oil and stock markets in three out of six GCC countries with the volatility transmission being more apparent from oil to stock markets.

Basher et al. (2012) studied the relationship between i) oil prices and emerging stock markets and ii) oil prices and exchange rates. VAR approach was used to establish the relationship. The outcome of the research is that positive oil price shocks tend to lower emerging markets' stock prices and US dollar exchange rates in the short term. Also, the study establishes that the positive oil production shock depresses the oil prices while positive economic activity increases oil prices.

Bharn and Nikolova (2010) examined the dynamic correlation between stock market and oil prices in Russia using bivariate

EGARCH Model. They reported that when the incidences like 9/11 terrorist attack, Iraq war 2003, and civil war in Iraq war 2006 happened they caused a negative correlation between the oil prices and Russian stock market.

Cong et al. (2008) investigates the interactive relationships between oil price shocks and Chinese stock market using multivariate vector auto-regression. They reported that crude oil price shocks do not show statistically significant impact on the real stock returns of most Chinese stock market indices, except for manufacturing index and some oil companies. Some "important" oil price shocks depress oil company stock prices. Increase in oil volatility may increase the speculations in mining index and petrochemicals index, which raise their stock returns.

Farzanegan and Markwardt (2009) found that the Iranian economy to be highly vulnerable to oil price fluctuations. They analyzes the dynamic relationship between oil price shocks and major macroeconomic variables in Iran by applying a VAR approach. The study points out the asymmetric effects of oil price shocks; for instance, positive as well as negative oil price shocks significantly increase inflation. They find a strong positive relationship between positive oil price changes and industrial output growth. Unexpectedly, they could only identify a marginal impact of oil price fluctuations on real government expenditures. Furthermore, they also observed that the "Dutch Disease" syndrome through significant real effective exchange rate appreciation.

El-Sharif et al. (2005) investigated the relationship between the price of crude oil and equity values in the oil and gas sector using data relating to the United Kingdom, the largest oil producer in the European Union. The evidence indicates that the relationship was always positive, often highly significant and reflects the direct impact of volatility in the price of crude oil on share values within the sector.

3. DATA AND METHODOLOGY

The stock market performance of the energy companies is measured using BSE Energy Index. This index consists of 28 companies that are in the energy sector and are directly affected by the price of the crude oil. Details about the individual companies can be obtained from BSE website (http://www.bseindia.com/sensexview/IndicesWatch_weight.aspx?iname=ENERGY&index_Code=90). The overall performance of the Indian stock market is measured using S&P CNX nifty index. Nifty is free float market capitalisation weighted index covering top 50 companies from 22 sectors of the Indian economy. Crude oil futures data has been used to find the relationship between the three time series.

The present analysis is based on weekly data of three time series namely crude oil futures price, nifty 50 index, and BSE energy index. The time series spans from January 2010 to January 2017 for a total of 370 weekly observations.

Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) Unit root tests are used to find the stationarity in the time series. ADF follows the autoregressive model. The ADF test equations are given as below:

$$\Delta S_t = c_1 + \alpha_2 t + \beta S_{t-1} + \delta \sum_{i=1}^{k} \Delta S_{t-i} \quad (1)$$

$$\Delta S_t = c_1 + \beta S_{t-1} + \delta \sum_{i=1}^{k} \Delta S_{t-i} + \varepsilon_t \quad (2)$$

$$\Delta S_t = \beta S_{t-1} + \delta \sum_{i=1}^{k} \Delta S_{t-i} + \varepsilon_t \quad (3)$$

Where S_t is the time series value at time t, c_1 is constant term, $\alpha_2 t$ denotes trend, k represents the number of lagged terms, and ε_t is residual. The problem of serial correlation in ADF test is solved by the non-parametric PP Unit root test.

The present research uses Johansen's cointegration test to measure the cointegration vectors among the time series. Johansen's cointegration test equations are given as below:

$$S_t = \alpha_1 + A_1 S_{t-1} + \ldots + A_k S_{t-k} + \varepsilon \quad (4)$$

$$\Delta S_t = \alpha_1 + \prod S_{t-1} + \sum_{i-1}^{k-1} \Gamma_i \Delta S_{t-1} + \epsilon_t \quad (5)$$

Where,

$$\Pi = \sum_{i=1}^{k} A_i - I \text{ and } \Gamma_i = -\sum_{j=i+1}^{k} A_j$$

The value of $\prod=0$ shows that no cointegrating vectors are present among the time series. The presence of zero cointegrating vectors shows that long run relationship does not exist in the time series and VAR modelling may be followed. If the cointegrating vectors are present in the time series vector error correction modeling approach should be followed.

We have used the VAR methodology to find the relationship between the three time series. The three VAR equations used in the research paper are given below:

CRUDE_OIL = C(1)*CRUDE_OIL(-1)+C(2)*CRUDE_OIL(-2)
+C(3)*NIFTY(-1)+C(4)*NIFTY(-2)
+C(5)*ENERGY_INDEX(-1)
+C(6)*ENERGY_INDEX(-2)+C(7)

NIFTY = C(8)*CRUDE_OIL(-1)+C(9)*CRUDE_OIL(-2)
+C(10)*NIFTY(-1)+C(11)*NIFTY(-2)
+C(12)*ENERGY_INDEX(-1)
+C(13)*ENERGY_INDEX(-2)+C(14)

ENERGY_INDEX = C(15)*CRUDE_OIL(-1)+C(16)*CRUDE_OIL(-2)+C(17)*NIFTY(-1)
+C(18)*NIFTY(-2)+C(19)*ENERGY_INDEX(-1)+C(20)*ENERGY_INDEX(-2)+C(21)

We have used the VAR methodology to find the relationship between the three time series. The descriptive statistics of individual time series, unit root tests, cointegration tests, and VAR results has been described in the next section.

4. RESULTS

A time series plot of oil prices, nifty, and energy index is shown in Figure 1. For the ease of comparison each time series is set to 100 on January 1, 2010. The graph shows that the time series seems to move together till may 2014. After May 2014 the nifty and crude oil prices moved in the opposite direction. The energy index seems to be stable in the time period studied. Looking at the graph it becomes necessary to study the time series properties and understand the long-run relationship between the time series.

Table 1 shows the summary statistics for weekly returns. The annual average returns are calculated by multiplying the average weekly returns by a factor of 52. The returns show that crude oil has given negative returns followed by energy index and nifty. The highest amount of volatility has been observed in crude oil followed by energy index and nifty. Crude oil prices are negatively skewed whereas stock prices are positively skewed. The normality of the time series is calculated using the Jarque-Bera test. The distribution is normal is rejected for crude oil and nifty. The highest correlation is observed between crude oil and energy index followed by crude oil and Nifty and least correlation is observed between nifty and energy index.

Table 1: Statistics for weekly returns

	Crude_oil	Nifty	Energy_index
Mean	−0.015	0.083	0.039
Median	0.001	0.001	−0.001
Maximum	0.135	0.072	0.114
Minimum	−0.147	−0.068	−0.118
SD	0.042	0.023	0.028
Skewness	−0.176	0.107	0.094
Kurtosis	1.124	−0.012	1.511
Jarque-Bera	20.251	33.980	0.711
Probability	0.000	0.000	0.701
Correlation			
Nifty	0.269722304	1	
Energy_index	0.049074177	0.168034626	1

SD: Standard deviation

Table 2 shows the results for ADF and PP unit root tests. The results of the stationarity tests at the level data do not show any stationarity. Having found that the next step was to calculate the first difference of the time series and check for the stationarity in the time series. Result shows that the first difference of all the time series appears to be stationary. The results indicate that all the time series are stationary in first difference meaning that they are integrated of order 1 i.e. I(1).

The next step is to check for the cointegration relationship among the various time series. If the time series are cointegrated i.e. a long run relationship is observed between the time series then it is possible to predict one time series using the other. We performed Johansen cointegration test to find the cointegration among the various time series. The results are shown in Table 3.

The null hypothesis for the presence of cointegrating vectors has been refuted in both the Trace test and the maximum Eigen value test. Based on the results obtained from Johansen cointegration test we can infer that the long run relationship does not exist between the crude oil, nifty, and energy index as the possibility of presence of even a single cointegrating vector is refuted. The vector error

Table 2: Unit root tests

Variables	Level data	Probability	Stationary status	First difference data	Probability	Stationary status
ADF test						
Crude_oil	−1.032	0.743	Non-stationary	−18.124	0.000*	Stationary
Nifty	−0.768	0.826	Non-stationary	−18.688	0.000*	Stationary
Energy_index	−2.015	0.280	Non-stationary	−21.419	0.000*	Stationary
PP test						
Crude_oIL	−1.083	0.724	Non-stationary	−18.124	0.000*	Stationary
Nifty	−0.625	0.862	Non-stationary	−18.858	0.000*	Stationary
Energy_index	−1.940	0.314	Non-stationary	−21.433	0.000*	Stationary

*Significant at 1%

Figure 1: Crude oil, nifty and energy index

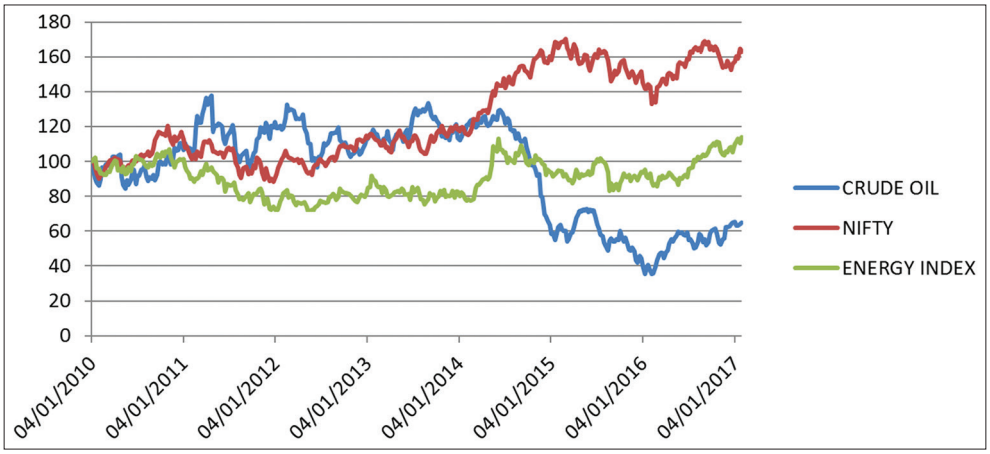


Table 3: Johansen cointegration test results

Trace test				Maximum Eigen value test			
Null	Alternative	Lambda- Tra	Critical value	Null	Alternative	Lambda- Max	Critical value
r≤0	r>0	22.05	29.80	r≤0	r=1	13.18	21.13
r≤1	r>1	8.87	15.49	r≤1	r=2	7.85	14.26
r≤2	r>2	1.01	3.84	r≤2	r=3	1.01	3.84

correction model cannot be applied as the time series are not cointegrated. Therefore, VAR modelling is used to understand the relationship between crude oil, nifty, and energy index.

Table 4 presents the results of the VAR model. The columns represent the dependent variables and the rows represent the independent variables. The independent variables have been taken for two lags to understand how the past values of independent variables explain the dependent variables. The results reveal that the constant values are significant (P-values significant) for all the independent variables when Energy index is the dependent variable. It means that the Energy index is explained by the past values of crude oil, Nifty and Energy Index. Crude oil and Nifty are explained by the first lag values of Crude oil and Nifty respectively. Table 5 shows that the VAR model fit. Adjusted R squared values for all the equations appears to be more than 95%.

Impulse response functions provide further details about the relationship between crude oil prices, nifty, and energy index. The impulse response functions describe the effect of one variable on other in future if a shock of one standard deviation (SD) is given to a variable. We have studied impulse response functions for all the variables (Figure 2) for 12 periods i.e. 12 weeks in future. The impulse response function shows that the impact of one SD of crude oil price reduces the crude oil price in future. The impact of one SD of crude oil on crude oil prices is much more than the effect on nifty and energy Index. The most dramatic effect has been observed on the impact of one SD of nifty on crude oil prices which is significantly affected in the negative direction. Similar responses are also observed for the effect of Energy index on crude oil. One interesting observation between the impulse response function between the stock indices is that one SD shock to energy index affects the nifty significantly in the negative direction. This shows the importance of companies comprising the energy index in the nifty. The negative impact of one SD of energy index on nifty is also observed. Impulse analysis for 12 periods in futures reveals that the most significant negative impact is observed on crude oil prices when one SD shock is received by nifty.

Table 4: VAR model results

	Dependent variables		
	Crude_oil	Nifty	Energy_index
Crude_oil(-1)	1.0258	1.1162	1.9495
Standard error	0.0543	2.6938	1.0139
t statistics	18.8925	0.4144	1.9228
P	0.0000*	0.6787	0.0548***
Crude_oil(-2)	−0.0559	−1.2695	−2.0572
Standard error	0.0536	2.6597	1.0011
t statistics	−1.0433	−0.4773	−2.0550
P	0.2970	0.6332	0.0401**
Nifty(-1)	0.0002	1.0071	0.2815
Standard error	0.0011	0.0550	0.0207
t statistics	0.1997	18.3024	13.5940
P	0.8417	0.0000*	0.0000*
Nifty(-2)	−0.0008	−0.0102	−0.2775
Standard error	0.0011	0.0559	0.0210
t statistics	−0.6742	−0.1820	−13.1994
P	0.5003	0.8556	0.0000*
Energy_index(-1)	−0.0019	0.0824	0.7738
Standard error	0.0023	0.1125	0.0423
t statistics	−0.8297	0.7327	18.2746
P	0.4069	0.4639	0.0000*
Energy_index(-2)	0.0017	−0.1136	0.1948
Standard error	0.0023	0.1121	0.0422
t statistics	0.7721	−1.0134	4.6177
P	0.4402	0.3111	0.0000*
C	6.1736	118.2282	58.0851
Standard error	2.1050	104.4406	39.3103
t statistics	2.9328	1.1320	1.4776
P	0.0034*	0.2579	0.1398

* Significant at 1%, **significant at 5%, ***significant at10%. VAR: Vector autoregressive

Table 5: VAR model fit

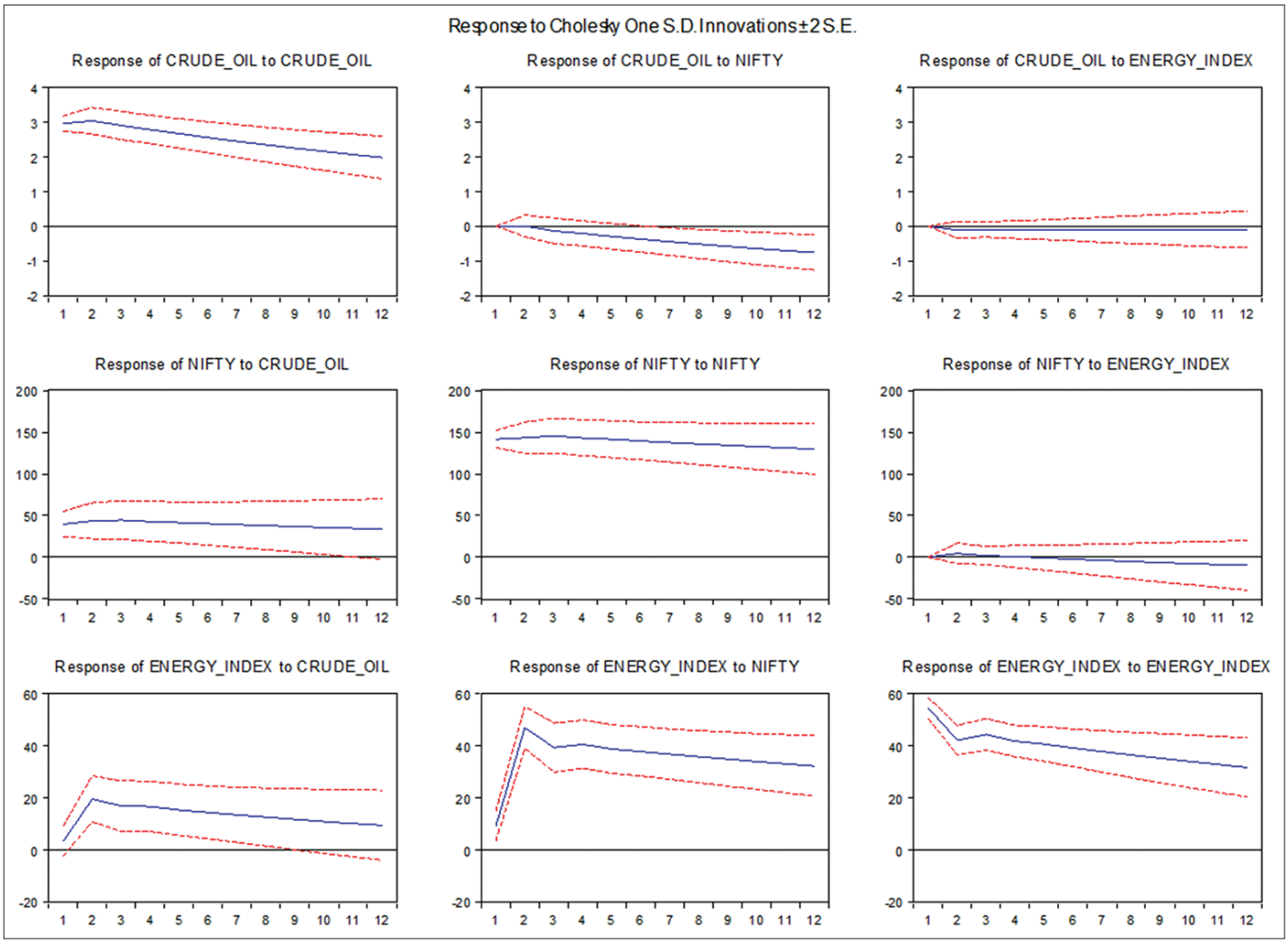
	Crude_oil	Nifty	Energy_index
R^2	0.984	0.988	0.960
Adj. R^2	0.983	0.988	0.959
Sum sq. resids	3178.841	7825070.917	1108569.516
S.E. equation	2.967	147.228	55.415
F-statistic	3633.972	4876.177	1437.466
Log likelihood	−918.908	−2355.685	−1996.101
Akaike AIC	5.032	12.841	10.886
Schwarz SC	5.106	12.915	10.961
Mean dependent	78.451	6581.253	2475.981
S.D. dependent	23.061	1322.622	274.204
Durbin-Watson stat	1.998	1.994	2.092

VAR: Vector autoregressive, SD: Standard deviation

5. CONCLUSIONS

The present study analyzed the relationship between crude oil future prices, nifty and BSE Energy Index. The unit root analysis reveals that crude oil future prices, nifty and BSE Energy Index are stationary at first difference i.e., all the time series are integrated of order one. The cointegration test reveal that crude oil future prices, Nifty and BSE Energy Index are not cointegrated i.e., long run relationship between the time series is absent and any of the time series cannot be used to predict the other time series. As the time series are not cointegrated we proceeded ahead with the VAR modelling wherein crude oil future prices, Nifty and BSE Energy Index are used as dependent variables and lag two difference is used as independent variables.

Figure 2: Impulse response functions



The VAR model reveals that the energy index is explained by al the independent variables. This is a very interesting observation revealed from VAR model that when all the time series are not cointegrated (i.e., a long run association is not observed), energy index is explained by all the lag values of independent variables. Impulse response function 12 weeks in futures reveals that crude oil prices are affected negatively when one SD shocks are given to stock indices. The effect of shock on Nifty increases with time but the effect of Energy index on crude oil remains the same from week 2 to week 12. In comparison to nifty, energy index was affected much by the crude oil shocks and the effects seems to increase with time.

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