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An Empirical Investigation into the Relationship of Crude Oil Price, Exchange Rate and Sensex

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Abstract

The study investigates long run relationships between oil prices, exchange rates and stock prices in India for the period April 2005 to March 2013 using monthly data. The empirical exercise consists of (1) testing for a unit root in each series (2) testing for the number of co-integrating vectors in the system (3) estimating and testing for the co-integrating relationship in the framework of a vector error correction model (4) testing the direction of causality between the variables using Granger Causality test. The results from the Augmented Dickey - Fuller unit root procedures indicate that all the three variables are first difference stationary. Johansen and Juselius cointegration test suggests that there is at most one co-integrating vector existing among the three variables and the results from Granger causality Wald test suggests that causality runs from Sensex to Crude oil, but not vice-versa.

Keywords: Co-integration, exchange rate, granger causality, oil price, stock price

Crude oil price is often considered as an important factor for understanding the fluctuations in the stock prices. The impact of oil prices on stock market depends on whether the country is an oil exporter or oil importer. In oil exporting countries, a rise in oil prices improves the trade balance, leading to current account surplus. But in the case of an oil importing nation, a rise in the world oil prices negatively affect the trade balance, leading to current account deficit. The theoretical reason for using oil price change as a measure for change in key macroeconomic indicators is that the value of stocks are determined by discounted value of future cash flows (dividends), which in turn are affected by oil shocks.

In the case of oil importing countries, when there is an increase in the oil prices, production costs will increase and this may adversely affect the profitability of firms. This will result in lower cash inflows (dividends) in future, which in turn will affect the value of the stocks. On the demand side, increase in crude oil prices will increase the general price levels, which results in lower disposable income (Anorou, 2007). This will reduce the savings in the economy and reduce the cash inflows in to the stock markets, which will lead to poor performance of stock markets. On the supply side, the central bank will adopt to certain monetary policies like increasing the interest rates to curb inflation. When higher interest rates are offered, bond market will become more attractive than stock markets. Exchange rate also plays a key role in this relationship between crude oil and stock prices (Harri *et.al.* 2009). USD/INR exchange rate influences both sensex and crude oil prices in India. Exchange rate has widely fluctuated in the last decade which in turn has impacted the Indian economy as a whole.

The way in which economy reacts to the fluctuations in the oil prices will be different for oil exporting countries and oil importing countries (Adaramola, 2012). For example, higher oil prices will boost economic growth in oil exporting countries, whereas rise in oil prices will lead to loss of business and consumer confidence in the case of oil importing countries. This may result in significant shifts in the levels and patterns of investment and savings, which will get reflected in the economic indicators. India's oil import has been steadily increasing over the years and it is likely to keep growing in future. Increasing dependence on oil imports and fluctuating foreign exchange rates will have effect on the Indian economy. BSE Sensex is considered as one of the major indicators of Indian economy. The volatility of oil prices and the foreign exchange rates has motivated the researchers to explore the relationship between crude oil price, exchange rate and Sensex. This paper is organised as follows. After the introduction, the review of related literature is discussed, followed by discussion on methodology, results and concluding remarks.

The linkage between the crude oil price and stock market performance has become a significant issue as the later reflects the pulse of the economy. This could be because of the fact that crude oil prices have been showing an exceptional volatility which has led to an increase in uncertainty of the energy sector, the whole economy as well as the financial markets. A large number of studies have stated the relationship between oil prices and stock market performance. Most of the researches have reported significant effects of oil price changes on stock market performance. Chittedi (2012) investigated the long run relationship between oil prices and stock prices for India over a ten year period and reported that volatility of stock prices in India have significant impact on the volatility of oil prices. Auto Regressive Distributed Lag (ARDL) model was used in this study to consider the long run relationship. Ayhan (2011) examined long term relationship between Istanbul stock exchange and international oil price using Johansen Co-integration test and Granger Causality analysis. It was observed that there was a co-integrated relationship between stock index and oil price and there was one way causality relationship from index of the stock exchange to oil price, but oil price was not the causal of the stock exchange index.

There is a large volume of research done to explore the relationship between oil price and stock market returns and they came up with different findings. Sadorsky (1999) applied VAR and GARCH models and reported that oil prices affect the returns of stocks. In his study, interest rate and industrial production output were also included. Anoruo and Mustafa (2007) investigated the relationship between oil price and stock market returns in USA from 1996 – 2006. Co-integration test and Vector Error Correction Model (VECM) were used in this study and they reported that there was a long term relationship (co-integration) between stock market and oil market and there was a one way causality relationship from stock market returns to oil price changes.

Narayanan (2010) investigated the relationship between oil prices and Vietnam's stock prices from 2000 to 2008. Johansen co-integration test used in this study reported that oil prices, stock prices and exchange rates for Vietnam shared a long run relationship. It was also found that both oil prices and exchange rates have a positive and statistically significant effect on Vietnam's stock prices in the long run and not in the short run. Huang *et. al.* (1996) reported findings in favour of causality effects from oil futures prices to stock prices.

Samuel (2010) analysed the impact of oil prices on stock prices of selected major oil producing and consuming countries with exchange rate as an additional determinant. The results revealed that in all countries, variance decomposition and impulse response tests confirm existence of oil prices and exchange rate influences over stock prices. Le and Chang (2011) examined the response of stock markets to oil price volatilities in Japan, Singapore, Korea and Malaysia. Monthly data from 1986 to 2011 was analysed by applying generalised impulse response and variance decomposition analysis. They reported that the reaction of stock markets to oil price shocks varies significantly across markets. The stock market responds positively in Japan, while negatively in Malaysia; the signal in Singapore and South Korea is unclear.

Kiran (2011) studied the long run relationship between oil prices and stock market prices of G7 countries by using Robinson tests for co-integration. Test results indicated that there is evidence of fractional co-integration between oil prices and DAX 30, Dow Jones, FTSE 100 an SP- TSX indices.

Database and Methodology

The study investigates long run relationships between oil prices, exchange rates and stock prices in India for the period April 2005 to March 2013 using monthly data. The oil price data is collected from the website of Ministry of Petroleum, Government of India where as the sensex figures are collected from BSE website and exchange rates (REER) are collected from the Reserve Bank of India website. The empirical exercise consists of (1) testing for a unit root, I(1) in each series, (2) testing for the number of co-integrating vectors in the system, (3) estimating and testing for the co-integrating relationship in the framework of a vector error correction model (VECM), (4) testing the direction of causality between the variables using Granger Causality test.

The tests confirmed non stationarity and the order of integration for all the three series (crude oil price, exchange rate and sensex) by employing the Augmented Dickey – Fuller test (ADF) and the Phillips – Perron (PP) unit root tests which use a null hypothesis of stationarity. The tests were performed for 0 to 12 lags, since monthly data is used. For all the unit root tests, if non stationarity is not rejected, the variable is differenced once and the unit root test is performed again. This is repeated till stationarity is achieved. H0 hypothesis is that series is not stationary and has unit root, alternative hypothesis shows that series is stationary. If the calculated value is bigger than the absolute critical value, then H0 hypothesis is rejected and series is decided to be stationary.

H0: Series is not stationary (there is unit root)

H1: Series is stationary (there is no unit root)

The equation used in ADF test is as follows:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \upsilon_t \qquad (1)$$

The number of difference taken before the series become stationery is then the order of integration, that is I(d). If the series are found to be integrated of the same order, then Johansen Juselius co-integration test (1990) is employed to test for the existence of co-integration vectors among them. Hypothesis examined with Johansen Juselius co-integration test are given below.

H0: There is no cointegration relationship between variables

H1: There is cointegration relationship between variables

The equation used for cointegration test is as follows:

$$\Delta Y_t = \beta_0 + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + u_t \qquad (2)$$

In case of determination of cointegration relationship (cointegration vector) that shows the presence of long term relationship between variables, causality relationships must be analyzed with error correction model (Vector Error Correction Model, VECM). The general vector error correction model with deterministic trend is,

$$\Delta Y_t = \phi + \Pi Y_{t-1} + \alpha t + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \qquad (3)$$

This can be rewritten into the test equation:

$$\Delta Y_t = \phi_1 + \alpha_1 t + \gamma(\beta' Y_{t-1} - \phi_2 - \alpha_2 t) + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \qquad (4)$$

Where, $\phi = \phi_1 - \gamma\phi_2$ and $\alpha = \alpha_1 - \gamma\alpha_2$

Finally to ascertain the direction of relationship between the variables, Granger causality test is used.

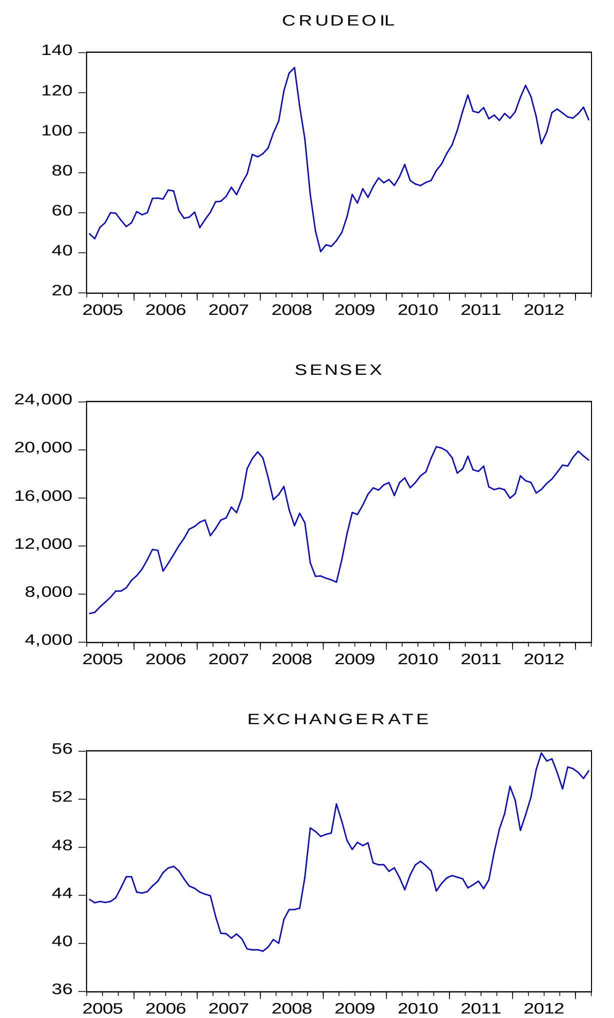

Fig. 1: Graphs showing the trend in crude oil price, sensex and exchange rate (2005 – 13)

Results and Discussion

For the purpose of checking the stationarity of the data, unit root test was used. First the stationarity of all the variables in the level I(0) was checked. Augmented Dickey - Fuller test (ADF) and Philips – Perron test (PP) were performed in terms of three separate models. (1) with constant (2) with constant and trend and (3) without constant and trend. Lag values determined according to

Schwartz Information Criterion (SIC) are applied as lag numbers in the performance of ADF. The results of these tests are given in Tables 1 and 2.

It can be seen that all variables are not stationary in all the three models (constant, constant and trend and without constant and trend) in Augmented Dickey - Fuller test and Philips – Perron test. All the variables have unit roots. If the variables are found non - stationary in their levels, after performing unit root tests, they are made stationary by taking differences. It is found that all variables are not I (0) stationary in their levels and they became stationary when their first differences were taken. Durbin-Watson statistics (DW) for the first difference test are around 2, hence these results are reliable. Out of the three models (with intercept, with intercept and trend and without intercept and trend), the model with intercept and trend is relevant. This conclusion is derived on the basis of theoretical considerations and by looking at the data plotted against time. The variables are showing a growth trend and the variables are equal to their lagged value plus an intercept.

After confirming the stationarity of the variables using ADF and PP tests, Johansen Cointegration test was done. All the variables (oil price, sensex and exchange rate) are integrated of order 1 that is, I (1), which is a prerequisite for performing Johansen Cointegration test. Johansen test determines the existence of a long run equilibrium relation between the variables in the model. The long run equilibrium is determined using Trace Statistics and Maximum Eigen Value. The results of the test are presented in Table 3 and 4.

If there are *k* endogenous variables, with each having one unit root, there can be from zero to *k*-1 linearly independent, cointegrating relations. Conversely, if there is one cointegrating equation in the system, then a single linear combination of the levels of the endogenous series should be added to each equation in the VAR. When multiplied by a coefficient for an equation, the resulting term, is referred to as an error correction term. If there are additional cointegrating equations, each will contribute an additional error correction term involving a different linear combination of the levels of the series. The cointegrating equations may have intercepts and deterministic trends. The asymptotic distribution of the LR test statistic for the reduced rank test does not have the usual chi square distribution and depends on the assumptions made with respect to deterministic trends. The assumption taken here is that series have no deterministic trend and the cointegrating equations have intercepts.

From Table 3, it is found that the calculated value of Trace Statistics is greater than the critical value at 0.05 level of significance at None* (No cointegrating equations). So it can be interpreted that there is at most 1 cointegrating equation or vector existing among the variables and the hypothesis cannot be rejected at one cointegrating equation at 5 per cent level of significance.

Table 1: Unit root tests at level variables

Variable	Augmented Dickey- Fuller test			Phillips-Perron Test		
	With Intercept	With intercept and trend	Without intercept and trend	With Intercept	With intercept and trend	Without intercept and trend
Crude oil Prices	-2.62	-3.41	-0.22	-2.07	-2.75	0.01
Sensex	-2.39	-3.14	0.25	-2.12	-2.48	0.58
Exchange rate	-1.16	-2.17	0.71	-0.81	-1.60	0.84

Critical values for ADF and PP tests for three different models at 5 per cent level of significance are -2.89, -3.46 and -1.94.

Source: Authors' Computation using E – Views

Table 2: Unit root tests at first difference

Variable	Augmented Dickey- Fuller test			Phillips-Perron Test		
	With Intercept	With intercept and trend	Without intercept and trend	With Intercept	With intercept and trend	Without intercept and trend
Crude oil Prices	-5.75	-5.72	-5.75	-5.79	-5.76	-5.79
Sensex	-4.04	-4.05	-3.96	-6.99	-7.00	-6.92
Exchange rate	-7.22	-7.22	-7.19	-7.09	-7.07	-7.02

Critical values for ADF and PP tests for three different models at 5 per cent level of significance are -2.89, -3.46 and -1.94.

Source: Authors' Computation using E – Views

Table 3: Johansen Co-integration Test: Trace Statistics

Hypothesised No. of Cointegrating Equation(s)	Eigen value	Trace Statistics	5 % Critical value	Prob.**
None*	0.3178	48.1538	29.797	0.0002
Atmost 1	0.1261	12.5851	15.4947	0.1309
Atmost 2	0.0005	0.0497	3.8415	0.8236

*denotes rejection of the hypothesis at the 5% level

Trace test indicates 1 cointegrating equation(s) at the 5% level.

Source: Authors' Computation using E - Views

Table 4: Maximum Eigen Statistics

Hypothesised No. of Cointegrating Equation(s)	Eigen value	Max-Eigen Statistic	5 % Critical value	Prob.**
None*	0.3178	35.5687	21.1316	0.0003
Atmost 1	0.1261	12.5354	14.2646	0.0921
Atmost 2	0.0005	0.0497	3.8414	0.8236

*denotes rejection of the hypothesis at the 5% level

Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% level.

Source: Authors' Computation using E - Views

Table 5: Vector Error Correction Model (VECM)

Variable	Coefficient	Std. Error	t-statistic	Prob.
D(Crudeoil(-1))	0.481545	0.10941	4.40134	0.0000
D (Sensex (-1))	-0.000343	0.00084	-0.41044	0.6818
D (Exchange rate (-1))	-0.304360	0.72484	-0.41990	0.6749
R-squared	0.372082	Mean dependent var	0.577419	
Adj. R-squared	0.320371	S.D. dependent var	6.876519	
SE of regression	5.668975	Akaike Info Criteria	25.21013	
Sum squared Resid	2731.668	Schwarz info criteria	25.94540	
Log Likelihood	-289.1345	Durbin-Watson test	2.02	

Source: Authors' computation using E - Views

Table 6: VEC Granger Causality/Block Exogeneity Wald Test

Models	Dependent	Independent	Chi-square	Prob.	Direction
1	Crude oil	Sensex	3.122917	0.2098	No direction
	Sensex	Crude oil	9.267693	0.0097	Unidirectional
2	Crude oil	Exchange rate	0.590359	0.7444	No direction
	Exchange rate	Crude oil	13.15236	0.0014	Unidirectional
3	Sensex	Exchange rate	0.032860	0.9837	No direction
	Exchange rate	Sensex	3.519456	0.1721	No direction

Source: Authors' Computation using E- Views

These results establish the existence of a long-run equilibrium relationship in the model, which is further confirmed by the results of Max-Eigen value test as given in table 4. Therefore, it can be explained that the model has one cointegrating equation.

Vector error correction (VEC) model is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are known to be cointegrated. The VEC specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The VECM model differentiate between the short- and long-run dynamic relationships, and tests for the hypothesis that the coefficients of lagged variables and the error correction terms calculated from the cointegrating regression are zero. If the coefficients in the system are jointly significant, then the system has short run dynamics. The Error correction model shows that the individual coefficients of the explanatory variable (crude oil) are in conformity with theory. This is shown in Table 5. The table shows that crude oil, including its lagged variable is positively related to Sensex. The R-squared shows that crude oil price explains 37% of sensex change. Further, the Durbin-Watson statistics shows that there exist no autocorrelation in the model.

The Wald statistic indicates the short run causal effects between the variables while the t-statistic on the error correction term depicts the long run Granger causal effects. The Granger causality test shows a unidirectional relationship running from sensex to crude oil. In the case of exchange rate and crude oil, unidirectional causality can be seen from exchange rate to crude oil and not vice versa. The volatility of sensex in India has significant impact on the volatility of crude oil prices. Similarly, the exchange rate has significant impact on the crude oil price.

Conclusion

This paper has used cointegration analysis and VECM to examine the long run relationship and the dynamics between crude oil price, Sensex and exchange rate. The study applied Augmented Dickey Fuller unit root procedure to determine the time series properties of the three variables. The Vector Error Correction Model (VECM) and Granger causality Wald test were used to examine the dynamic interactions between the three variables. The results from the ADF unit root procedures indicate that all the three variables are first difference stationary. Johansen and Juselius cointegration test suggests that there is atmost one cointegrating vector existing among the three variables.

The results from Granger causality Wald test suggests that causality runs from Sensex to Crude oil, but not vice versa. The finding that oil prices do not Granger - cause stock market is consistent with the findings of Chittedi (2012) and Maghyereh (2004). This can be explained as the impact of increasing economic activities on the foreign investments and crude oil demand. Normally, in Indian context, a strong link is seen between foreign investments and Sensex movement. When the economy is in good phase, the business activities improve, which motivates foreign investors to invest in Indian markets, thereby improving the stock market index. On the other hand, more the business activities, greater will be the demand for crude oil, which will push the demand and price of crude oil. Between exchange rate and crude oil, exchange rate Granger – cause crude oil, but not vice versa. The results show that both the oil market and stock market are integrated rather than segmented. This finding suggests that the investors cannot benefit by diversifying their holdings in oil and stock market simultaneously.

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