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RESULTS & DISCUSSION

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RECOMMENDATIONS/SUGGESTIONS

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VOLATILITY TRANSMISSION BETWEEN CRUDE OIL PRICES AND INDIAN EQUITY SECTOR RETURNS

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ABSTRACT

The oil price in the international market has witnessed significant fluctuations in the recent years and such fluctuations tend to have ramifications on various segments of stock market returns. Hence, it is crucial for the policy makers and market participant to identify the spill over between the oil price volatility and volatility of stock returns across various sectors. In this regard, this paper makes an attempt to model such volatility spill over from oil price to various segments of stock market, using a version of bivariate GARCH model. The empirical evidence suggests that there is significant transmission of shocks and volatility between international crude oil prices and stock returns of various sectors.

JEL CLASSIFICATION
C32, G1S, C1

KEYWORDS
Crude oil, Nifty index, Bivariate GARCH, BEKK

1. INTRODUCTION

Imagine the modern economies as the nerve system in a human body then oil is the life blood flowing through those nerves. Last couple of decades had witnessed the surge of oil as one of the important factors of production and a fundamental driver of the world economic activity. As a result a growing body of both empirical and theoretical literature has been evolved in the study of oil and its impacts on various macroeconomic variables. Any upward pressure in oil prices will affect input prices and higher input prices will lead to rise in production costs which will further affect price level and economic growth. Several empirical studies have reported a clear negative correlation between energy prices and aggregate output.

There are various theories in the literature that explain the dynamic relationship between oil prices and stock prices. On theoretical grounds oil price shocks affect stock market returns or prices through their effect on expected earning (Sadorsky,1999).The quantity valuation theory explains the extent to which stock markets are affected by oil prices. Stock price is obtained by simply discounting all expected future cash flows at the investors required rate of returns. Oil shocks influence various economic conditions like inflation, interest rates, production costs, market confidence etc. And corporate cash flows and discount rates reflect these economic conditions (Apergis and Miller, 2009; Park and Ratti, 2008; Arouri et al.2010).Stock prices may react significantly to patterns in oil changes. Equity pricing model is another model which explains oil price-stock price relationship. In an equity pricing model, the price of equity at any point in time is equal to the expected present value of discount future cash flows (Huang et al. 1996; Basher and Sadorsky, 2006).

In the context of transmission of shocks and analysis of variance (volatility) there are mainly two lines of research. One is cointegration analysis to study the co-movements between financial markets over a long period of time; second line of research investigates the time path of variance in various financial variables. To estimate time variant conditional variance, researchers commonly use various ARCH (Auto Regressive Conditional Heteroscedasticity) class models. This paper follows the method used by Farooq and Ewing (2009) which combines the elements of both lines of research mentioned above. Even though there are plenty of literature that investigate the impact of oil price changes on stock markets, most of theses studies concentrate on developed economies, in the case of emerging countries like India, this is still an area that has to be explored further. In this context this paper aims at identifying the volatility spill over between global crude oil prices and returns of various NIFTY indices. In order to capture the relationship between oil and each of these sectors, a bivariate GARCH model is employed. The advantage of this methodology is that it allows us to simultaneously estimate the mean and conditional variance of returns of both oil sector and equity sector. The models are estimated using the daily price data from January 2004 to April 2011, the empirical estimates reveals that there is significant volatility transmission between the oil market and some of the sectors examined. The results are important for financial market participants to make optimal portfolio allocations decisions.

2. REVIEW OF LITERATURE

Major attempts to understand the effects of oil price changes on various economic variables started with the seminal paper Oil and Macroeconomy since World War II (J.D.Hamilton, 1983). Hamilton's findings suggest that oil price fluctuations were one of the significant and responsible factors for every post world war II U.S recession except the recession in 1960.Various researchers have tested Hamilton's basic findings thereafter, using various alternative data sets and methodologies (for instance, Burbridge and Harrison,1984;Gisser and Goodwin,1986;Loungani,1986;Mork,1989).

But very meager attention has been devoted to examine the oil price–financial market dynamics compared to the volume of research done in the field of oil price-macroeconomy relationship. The study by Jones and Kaul (1996) was one of the early notable works investigating the effects of oil price changes on stock markets. Their findings suggest that oil price shocks affect the current and future cash flows which would ultimately affect the stock prices. Hang et al.(1996), Sadorsky(1999),Nanda and Faff (2008),Park and Ratti(2008),Apergis and Miller (2009),Fayyad and Dally (2011),Mallick and Ewing(2009) also provide evidence for significant relationship between oil price stocks and stock returns using various econometric models such as VAR(Vector Auto Regression), Cointegration,VECM (Vector Error Correction Mechanism),ARCH(Auto Regressive Conditional Heteroscedasticity) class models etc.

Even though a considerable amount of literature is available on the energy price-stock market relationship in advanced economies, in the case of emerging stock markets it is comparatively negligible. Some of the noteworthy contributions in this direction are Hammoudah et al. (2004); Basher and Sadorsky (2006); Mohanty et al. (2011); Masih et al. (2011).

The study by Mohanty et al. check the oil price shocks –equity sector returns relationship in GCC(Gulf Cooperation Council) countries using country level and industry level stock returns data, the results suggest that except for Kuwait, all other stock markets are affected by the shocks emanating from the oil market at the country level. And in the case of industries, out of twenty, twelve countries' industry specific returns were significant and showed positive exposure to oil price changes. And their study also reveals that the effects of oil price changes on stock market returns are generally asymmetric in nature both at country level as well as industry level.

Hammoudah et al (2004) investigate the relationship between oil prices and stock prices for five countries in Gulf Cooperation council (GCC).Their study shows that only Saudi Arabia stock market has a bi-directional relationship between oil prices and stock prices among the examined stock markets.

Basher et al. (2011) investigates the dynamic relationship between oil price, exchange rates and emerging stock market by applying a structural VAR model. Their result suggest that positive shocks to oil prices are more likely to depress emerging market stock prices and U.S Dollar exchange rates in the short run.

Masih et al. (1996) Study how important is oil price variations and its volatility on equity market performance. Their empirical investigation using a VEC model reveals that there is a dominance of oil price volatility on real stock returns and firms need to adjust their risk management procedures as the oil price volatility has significant effect on the time horizon of investment.
Basher and Sadorsky (2006) probe the impact of oil price changes on various emerging stock market returns by applying an international multifactor model and find strong evidence for oil price risk impacts stock price returns in emerging markets. Two of the most popular and effective methods developed for modeling volatility of high frequency financial time series data are, ARCH model Engle (1982) and the generalised version by Bollerslave(1986). To estimate the volatility spill over between different markets multivariate models (MGARCH) models have been used widely.
Brooks (2007) used an AP GARCH (Asymmetric Power GARCH) Model to study the emerging stock markets and the results reveals that emerging market behaviour is quite different from developed markets.
Using the BEKK parameterization of MGARCH, Li and Majerowska (2008) investigate the linkage between developed markets and emerging markets. Their result shows that there is significant volume of volatility spill over from the developed markets to the emerging ones.
This paper employs bivariate GARCH models to simultaneously estimate the mean and conditional variance of oil and various NIFTY indices returns. It also employs the BEKK parameterization of the multivariate GARCH model which does not impose the restriction of constant correlation among variables over time. A bivariate GARCH model is used specifically, which would be helpful to study the volatility transmission between oil returns and various NIFTY sector indices. The empirical model adopted in this paper is similar to that of Malik and Ewing (2009) to study the volatility transmission between oil price returns and various stock indices returns.

3. METHODOLOGY

The mean equation for a GARCH return series is given by

$$R_{i,t}=\mu_i+\alpha R_{i,t-1}+\varepsilon_{it} \quad (1)$$

Where $R_{i,t}$ is the return on series i between time t and t-1, a long term drift coefficient is denoted by μ_i. Equation (1) was estimated and in order to test the presence of ARCH effects the residuals were checked, using the test described by Engle (1982).And each of the estimated series exhibited evidence of ARCH effects.
In the next step the BEKK parameterization proposed by Engle and Kroner (1995) which is a variant of the bivariate GARCH model and capable of detecting volatility transmission among different series as well as volatility within each series is employed. To ensure that the covariance matrix is positive semi definite (a requirement to make sure that the estimated variances are non-negative) the model incorporates quadratic forms. The BEKK parameterization for the bivariate GARCH (1,1) model can be written as:

$$H_{t+1}=C'C+B'H_tB+A'\varepsilon_t\varepsilon'_tA \quad (2)$$

Here Ht_{+1} represent the conditional variance matrix and C is a 2×2 lower triangular matrix with three parameters where as B is a 2×2 square matrix which shows, to what extent the current levels of conditional variances are related to past conditional variances. A is 2×2 square matrix that measures the extent to which conditional variances are correlated with past squared errors. And the total numbers of estimated parameters are eleven.
The expanded form of conditional variances for each equation in the bivarte GARCH (1, 1) model is given below:

$$h_{11,t+1}=c_{11}^2+b_{11}^2h_{11,t}+2b_{11}b_{12}h_{12,t}+b_{2,1}^2h_{22,t}+a_{11}^2\varepsilon_{1,t}^2 + 2a_{11}a_{12}\varepsilon_{1,t}\varepsilon_{2,t}+a_{21}^2\varepsilon_{2,t}^2 \quad (3)$$

$$h_{22,t+1}=c_{12}^2+c_{22}^2+b_{1,2}^2h_{11,t}+2b_{12}b_{22}h_{12,t}+ b_{22}^2h_{22,t}+a_{12}^2\varepsilon^2{}_{1,t}+2a_{12}a_{22}\varepsilon_{1,t}\varepsilon_{2,t}+a_{22}^2\varepsilon^2{}_{2,t} \quad (4)$$

Eqs. (3) and (4) tells us how shocks and volatility are transmitted over time and across the two series taken for scrutiny.[1]
The likelihood function given below is maximized assuming normally distributed errors:

$$L(\theta)=-T\ln(2\pi)-\frac{1}{2}\sum_{t=1}^{T}(\ln|H_t|+\varepsilon'_tH^{-1}{}_t\varepsilon_t) \quad (5)$$

Where 'T' is the number of observations and θ is the parameter vector to be estimated. To maximize this non-linear log likelihood function numerical maximization techniques were used. Several iterations were done with the simplex algorithm to obtain the initial conditions, as suggested by Engle and Kroner (1995).In order to obtain the final estimate of the variance-covariance matrix and standard errors the BFGS algorithm was employed.[2]

4. DATA

Equity market data are obtained from S&P CNX NIFTY and its various indices. Daily returns are calculated from January 5, 2004 to November 30, 2011.When a holiday occurs the value on the previous day is taken to calculate the return. Use of daily return in the analysis will be helpful in capturing the volatility spill over more accurately. S&P CNX NIFTY and its various indices namely: S&P CNX Finance, S&P CNX Auto, S&P CNX Energy are specifically examined in the study. These indices are widely used by the market participants to closely follow movements in various sectors like finance, industries, auto, energy, consumer services, health care; technology etc. These indices represent a large cross section of firms and industries in India.
The S&P CNX NIFTY is the headline index on the National Stock Exchange of India Ltd. (NSE).It includes 50 most prominent stocks and a true reflection of the Indian stock market. The S&P CNX NIFTY covers 21 sectors of the Indian economy. It is used for variety of purposes such as benchmarking fund portfolios, index based derivatives and index funds. The CNX Auto index is designed to reflect the behaviour and performance of the automobiles sector which includes manufactures of car, motorcycles, heavy vehicles, auto ancillaries, tyres etc. It comprises of 15 stocks that are listed on the NSE. Energy sector covers companies belonging to Petroleum, gas, and power sub sectors.

[1]The coefficient terms in Eqs. (3) and (4) are non-linear function of the estimated elements from Eqs(2)
[2]Quasi maximum likelihood estimation was used and robust standard errors were estimated by the method developed by Bollerslave and Wooldridge (1999)

The CNX Finance index is designed to reflect the behaviour and performance of the Indian financial market which includes banks, financial institutions, housing finance and other financial service companies .It comprises of 15 stocks that are enlisted with NSE.

West Texas Intermediate (WTI) was taken as the measure of oil price.WTI is a crude oil stream traded on the domestic spot market at the Cushing, Oklahoma Centre. Consistent with earlier research this analysis focuses on returns as the price series were non-stationary at levels. Table (1) provides descriptive statistics for each of the return series. As all the return series were found to be leptokurtic, each of the mean equations should be tested for the existence of ARCH(Auto Regressive Conditional Heteroscedasticity).In each case the mean equations exhibited ARCH effect which appropriates the use of a GARCH (Generalized Autoregressive Conditional Heteroscedasticity).The Ljung-Box statistics indicates autocorrelation in all returns.

5. EMPIRICAL RESULTS

This paper probes in to the relationship between oil shocks and various NIFTY indices. Hence four bivariate GARCH models are estimated each containing the oil returns and returns on corresponding stock market index. Results for each of the variance equations are shown Table (2).The term $h_{11,t}$ describes the conditional variance(volatility) for oil returns at time t and $h_{12,t}$ explains the conditional covariance between oil returns and corresponding sector. The effect of news (an unexpected shock) is represented by the squared error terms ε_1^2 and ε_2^2 originating in the oil market or stock market sector respectively and it can be called as direct effects. The cross values of error terms $\varepsilon_{1,t}$, $\varepsilon_{2,t}$ shall be considered as the impact of indirect effects of shocks transmission and capture the 'news' in the oil market and the corresponding equity market sector in time period t.

The results for the oil-NIFTY model suggests that oil returns volatility is significantly affected by its own news (coefficient on $\varepsilon_{1,t}^2$) and its past volatility (coefficient on $h_{11,t}$).And there is no evidence for direct or indirect effects from equity sector to oil sector, which is very much sensible in logical line of thinking.

The significant coefficients on $\varepsilon_{1,t}^2$ (the news effect) and the past volatility ($h_{11,t}$) reiterate the fact that the NIFTY sector is quite exposed to the shocks emerging from the oil sector. The coefficients on $\varepsilon_{1,t}$,$\varepsilon_{2,t}$ and $h_{12,t}$ which represent cross effects(indirect effects) and its past volatility turned out to be insignificant, suggesting lack of shock transmission through indirect channels.

The oil finance-model reveals that the volatility of oil sector returns are significantly affected by its own shocks and its past volatility. And the insignificant coefficient on $\varepsilon_{1,t}^2$ reveals that there is no evidence that the finance sector is affected by the immediate shocks(news effect) from the oil sector but still we cannot say that this sector is completely insulated from the oil shocks as the coefficient on $h_{11,t}$ (past volatility) is significant. But in the case of cross effects (indirect effects) both $\varepsilon_{1,t}\varepsilon_{2,t}$ and $h_{12,t}$ (representing the news effect and its past volatility respectively) are reported significant and the magnitude is negative in the case of past volatility, suggesting that even though the immediate shocks emanating from the oil sector are not directly affecting the finance sector returns but still the sector is affected through certain indirect channels. And as mentioned above the past volatility term is significant but negative which means once the market participants form expectations regarding the influence of oil price shocks on market returns and the oil price shocks are seemingly persistent, then the investors are more likely to dwindle their volume of speculative investments, which will eventually reduce the over all market volatility.

The oil-energy model tells us that the energy sector returns are significantly affected by its own news and past volatility (the significant coefficients on $\varepsilon_{2,t}^2$ and $h_{22,}$t).And it is also affected by the shocks emerging from the oil sector since both the news effect and past volatility are found significant suggesting the fact that the energy sector is quite exposed to the oil shocks. But there is no evidence reported for any kind of cross effects in this sector, indicating that unlike the finance sector the quantum of speculative investments are quite less in energy sector.

From the oil-auto model, we see that the news effect from the oil sector significantly affect the auto sector returns, but the past volatility term (coefficients on $h_{11,t}$) is insignificant, which reveals that the auto sector is not much vulnerable to the oil shocks in the long run. This result is bit surprising as the auto sector is one such sector where oil is used as a basic input, this result suggests that the investors, by and large do not expect a drastic fall in auto mobile sales in long run, this is true in the case of an emerging country like India. And from the insignificant coefficients on $h_{12,t}$ and $\varepsilon_{1,t}\,\varepsilon_{2,t}$ it is clear that there is no cross (indirect) effects affecting the auto sector returns which shows that there is not much speculative investments are flowing to this sector.

Overall, this paper finds that there is transmission of shocks between oil sector and some of the examined equity sectors. Factors like, efficiency in information exchange and cross market hedging could be the major reasons for this phenomenon. The findings of this paper are novel as no significant studies have conducted to identify the dynamic shock transmission mechanism between crude oil price shocks and response of various Indian equity sectors.

6. CONCLUDING REMARKS

This paper examined the shock transmission between oil prices and S&P CNX NIFTY index and three of its indices namely: finance, energy, and auto. This analysis used daily data from January 5, 2004 to November 30, 2011.The study provides estimates of shocks and volatility transmission between oil returns and returns in various equity sectors.

India, being an emerging economy with very high dependency on crude oil import, volatility in crude oil prices is very crucial. As the retail petroleum prices are more or less under administrative mechanism and highly subsidised, the effects of oil price shocks may not affect the macroeconomic indicators immediately, but the scenario will be completely different in equity sector where any change in various factors like oil price shocks, foreign interest rate changes, foreign monetary policy announcements etc will be immediately reflected in various market indices. In that case it is very crucial to understand and identify the transmission mechanism of shocks and volatility emerging from oil market and its influence on various Indian stock market indices.

Overall, these results can provide useful information for various purposes like asset price model building, risk calculation, and forecasting. And more over it is very crucial for an investor in financial market to have a proper understanding about the volatility transmission mechanism over time and across different sectors to make suitable and optimal portfolio allocations.

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TABLES

TABLE (1)

	Auto	Finance	Energy	Nifty	Oil
Mean	0.000666	0.000653	0.000326	0.000581	0.000564
Median	0.001319	0.001363	0.000841	0.001265	0.0013
Maximum	0.140046	0.178069	0.154433	0.164137	0.164137
Minimum	-0.14004	-0.14413	-0.215993	-0.12846	-0.12846
Std.Dev.	0.017312	0.022421	0.019473	0.025867	0.025908
Skewness	-0.401845	-0.14077	-1.131095	-0.04974	-0.05271
Kurtosis	9.287202	8.92886	18.2821	7.305756	7.289397
Q(4)	29.58	36.592	8.18	4.67	5.017

Notes: The sample contains daily returns from January5, 2004 to November 30; 2011.The total number of observations is 1897.Q (4) is the Ljung-Box statistic for serial correlation for various series.

TABLE (2)

Oil

$h_{11,t+1} = 1.05x10^{-5} + 0.095\, h_{11,t} + 0.1002\, h_{12,t} + 0.005\, h_{22,t} + 0.032\, \varepsilon^2 1,t + -0.006\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.073\, \varepsilon^2{}_{2,t}$

(10.49) (11.01) (.40) (.94) (4.94) (-.147) (.38)

NIFTY

$h_{22,t+1} = 5.83x10^{-6} + 0.027\, h_{11,t} + -0.097\, h_{12,t} + 0.086 h_{22,t} + 0.001\, \varepsilon^2{}_{1,t} + -0.037\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.128\, \varepsilon^2{}_{2,t}$

(.17) (19.91) (-0.014) (64.44) (9.13) (-0.85) (8.80)

Notes: h_{11} denotes the conditional variance for the oil return series and h_{22} is the conditional variance for the NIFTY sector series. Reported directly below the estimated coefficients are the corresponding t -values in parenthesis. The mean equation included a constant term and a lagged term which were significant at conventional levels.

TABLE (3)

Oil

$h_{11,t+1} = 1.05x10^{-5} + 0.095\, h_{11,t} + 0.1002\, h_{12,t} + 0.005\, h_{22,t} + 0.032\, \varepsilon^2 1,t + -0.006\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.073\, \varepsilon^2{}_{2,t}$

(10.49) (11.01) (0.40) (0.94) (4.94) (-0.14) (0.38)

Finance

$h_{22,t+1} = 5.83x10^{-6} + 0.027\, h_{11,t} + -0.097\, h_{12,t} + 0.086 h_{22,t} + 0.001\, \varepsilon^2{}_{1,t} + -0.037\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.128\, \varepsilon^2{}_{2,t}$

(0.17) (19.91) (-0.01) (64.44) (9.13) (-0.85) (8.80)

Notes: h_{11} denotes the conditional variance for the oil return series and h_{22} is the conditional variance for the finance sector series. Reported directly below the estimated coefficients are the corresponding t -values in parenthesis. The mean equation included a constant term and a lagged term which were significant at conventional levels.

TABLE (4)

Oil

$h_{11,t+1} = 1.05x10^{-5} + 0.095\, h_{11,t} + 0.1002\, h_{12,t} + 0.005\, h_{22,t} + 0.032\, \varepsilon^2 1,t + -0.006\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.073\, \varepsilon^2{}_{2,t}$

(10.49) (11.01) (0.40) (0.94) (4.94) (-0.14) (0.38)

Energy

$h_{22,t+1} = 5.83x10^{-6} + 0.027\, h_{11,t} + -0.097\, h_{12,t} + 0.086 h_{22,t} + 0.001\, \varepsilon^2{}_{1,t} + -0.037\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.128\, \varepsilon^2{}_{2,t}$

(0.17) (19.91) (-0.01) (64.44) (9.13) (-0.85) (8.80)

Notes: h_{11} denotes the conditional variance for the oil return series and h_{22} is the conditional variance for the energy sector series. Reported directly below the estimated coefficients are the corresponding t -values in parenthesis. The mean equation included a constant term and a lagged term which were significant at conventional levels.

TABLE (5)

Oil

$h_{11,t+1} = 1.05x10^{-5} + 0.095\, h_{11,t} + 0.1002\, h_{12,t} + 0.005\, h_{22,t} + 0.032\, \varepsilon^2 1,t + -0.006\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.073\, \varepsilon^2{}_{2,t}$

(10.49) (11.01) (0.40) (0.94) (4.94) (-0.14) (0.38)

Auto

$h_{22,t+1} = 5.83x10^{-6} + 0.027\, h_{11,t} + -0.097\, h_{12,t} + 0.086 h_{22,t} + 0.001\, \varepsilon^2{}_{1,t} + -0.037\, \varepsilon_{1,t}\varepsilon_{2,t} + 0.128\, \varepsilon^2{}_{2,t}$

(0.17) (19.91) (-0.01) (64.44) (9.13) (-0.85) (8.80)

Notes: h_{11} denotes the conditional variance for the oil return series and h_{22} is the conditional variance for the auto sector series. Reported directly below the estimated coefficients are the corresponding t -values in parenthesis. The mean equation included a constant term and a lagged term which were significant at conventional levels.

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