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Effects of Crude Oil Prices on Indian Financial Sector

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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 the economy as a whole. Hence, it is crucial for the policy makers to identify the spillover implications of oil price volatility on the stability of various segments of domestic markets. In this regard, this paper makes an attempt to model such volatility spillover from oil price to select variables such as inflation, index of industrial production, exchange rate and stock returns by employing BEKK model - a widely used version of bivariate GARCH model. The empirical evidence suggests that fluctuations in oil prices in the international market seem to have significantly triggered the volatility in the Indian financial and real sectors.

***Keywords**: BEKK Model, Spillover, Bivariate GARCH, Exchange Rate, Financial Stability*

1. Introduction

If the modern economies are the nerve system in a human body then oil is the lifeblood flowing through it. Since 1970_S the entire world has witnessed the surge of oil as one of the crucial factors of production and a fundamental driver of the world economy. During the period 2008-12 international crude oil prices have touched several unprecedented heights. This can be the result of confluence of various aspects such as supply constraints, demand pressure, linkage with financial markets, institutional intervention etc. Oil is universally considered as a crucial strategic resource, hence the market transactions and volatility in crude oil prices may affect both the real sector and the financial sector. In the theoretical framework there are a number of channels through which volatility in oil price can affect the economy. The supply constraints of oil will reduce the basic inputs to production(Sajal Ghosh,2010).Other channels include real balance effect, income transfers, and aggregate demand effect, sector adjustment effect, inflation and monetary policy (Brown and Yucel,2002).

Volatility clustering is the basis of any such volatility spillover effect mechanism and ARCH (Auto Regressive Conditional Heteroscedasticity) type models (Engle, 1982) will be highly useful in testing and measuring the volatility clustering. GARCH model (Generalised Autoregressive Conditional Heteroscedasticity) (Bollerslave, 1986) is based on ARCH model. In this paper we employ the BEKK parameterization of the multivariate models to simultaneously estimate the mean and conditional variance of oil and various sector returns. Our empirical model is similar to that used by Malik and Ewing (2009) to study the volatility transmission mechanism between oil returns and various equity sector returns.

2. Review of Literature

Huge volatility in crude oil prices over the past couple of decades has generated immense curiosity among the researchers to probe into the linkage effects between oil and various aspects like financial markets and macroeconomic indicators. Ever since the path breaking paper 'oil and macroeconomy since world war-II' (Hamilton,1983) was published, quite a lot studies have been conducted to dig deeper in to the dynamic effects of oil price volatility; for example Burbridge and Harrison(1984),Gisser and Goodwin(1986), Federer(1996), Cunado and Garcia(2005), Sadorsky(1999), Papapetrou(2000), Zhang et,al.(2008).But most of these studies were conducted in a framework which would be more suitable for developed countries. The representation of developing and less developed countries in the existing literature is meager compared to their developed counterparts. Lesser dependence on oil and less energy consumption of these countries and lack of reliable data sources are the probable reasons for this phenomenon. However, in recent times developing countries like China, India, Brazil, South Africa etc. are fast growing and experiencing very high demand for energy especially crude oil. Currently china and India are in the list of top five crude oil importing countries in the world. The rapidly growing Indian economy has been experiencing a quantum jump in the crude oil import, from 20.7 million tonnes during 2000-01 to 153.3 million tonnes during 2009-10 (Economic Survey 2011, GOI).Being a net oil importer, India is hugely affected by the undesirable price fluctuations in the international crude oil market. India's petroleum sector was highly regulated and the subsidy allocated for bridging the gap between the actual price and the regulated price used to be borne by the 'oil pool' account until April1, 2002 after that this was completely abolished and it was decided that there would be complete deregulation of petroleum prices. However the deregulation was effective only for some products, all the key products like high speed diesel, petrol, kerosene, liquefied petroleum gas (LPG) remained under Government control (Kumarjit et al., 2012).Due to immense pressure from international crude oil market and mounting under recoveries the Government of India was forced to keep the retail prices of petrol out of the regulatory umbrella with effect from June 25, 2010 (Ministry of petroleum GOI). Because of various socio political reasons, price revisions of petroleum products including petrol (even after the recent deregulation) does not happen in tune with the international crude oil prices changes.

Oil has visibly a significant impact on headline inflation and industrial production. The weight ascribed to mineral oils itself in the Indian WPI basket is 9.36% which is not a negligible one. And the basic input for many of the industrial products is various petroleum products. Hence the burgeoning volatility in crude oil market will certainly have an impact on the importing country, but in Indian case it is not being immediately transmitted to the economy due to the restrictive regulatory framework but it does not mean that the real sector and the financial sector in India is completely insulated from the price fluctuations in the international crude oil markets. There exists a possibility of transmission of volatility and risk from one sector to another. This idea is well studied in the literature using various concepts like volatility spillover effect, risk slipover effect and mean spillover effect. The volatility spillover effect shows that price volatility in various sectors can be mutually affected, i.e., the volume of price volatility in one sector may be affected not only by its own past volatility but the price volatility emerging out of various other sectors from elsewhere, or in other words the volatility information can be transferred among different sectors (Yue-Jun-Zhang et.al., 2008). 'Oil and Macro economy since world war II' (Hamilton, 1983) was one of the novel and significant attempts in the literature to understand the oil-macroeconomy relationship. His findings suggest that oil price fluctuations were one of the major factors for every post world war II U.S recession except the recession in 1960.Later various researchers have tested Hamilton's basic findings employing various alternative data sets and methodologies for instance, Burbridge and Harrison (1984), Gisser and Goodwin (1986), Loungani (1986), Mork(1989). Even though various empirical studies have reiterated the theoretical assumptions that oil price shocks will likely to trigger wage hike and inflation and affect output negatively, it was observed that the intensity was varying across different countries (Burbridge and Harrison, 1984).But in the later years various studies suggest that for many Western and some Asian countries the oil-macroeconomic relationship is missing in the long-run (Cunado and Perez de Gracia, 2003, 2005). In terms of volatility transmission, Malik and Hammoudeh (2007) investigated the volatility transmission mechanism among U.S equity, Gulf Equity and global crude oil markets using multivariate GARCH models. They found that Gulf equity markets gains substantially out of the oil market volatility. And in the case of Saudi Arabia there was evidence for significant volatility spillover from the equity market to oil market. By employing BEKK model, Malik and Ewing (2009) analyzed volatility transmission between oil prices and equity sector returns of five different U.S sector indices and found evidence for transmission of shocks and volatility between some of the examined markets, the findings corroborates the concept of cross-market hedging and sharing of common information between investors. Yue-Jun Zhang et.al. (2008) explores three different spillover effects namely mean spillover, volatility spillover and risk spillover to identify the spillover effect of U.S Dollar exchange rate on oil prices using various econometrics tools like VAR model, ARCH class models etc. They have identified a significant long run relation between the two markets and also sudden changes in the U.S Dollar exchange rates will not cause considerable change in the oil market. Using the BEKK parameterization of multivariate GARCH model, Li and Majerowska (2008) probed in to the linkage between developed markets and emerging markets. Their result shows that there is considerable amount of volatility spill over from the develop markets to the emerging ones. In the Indian context, it was observed that a 20 percentage point hike in oil prices would result in an increased inflation by 1.3 percentage points and a reduction in industrial output by 2.1 percentage points (Bhattacharya and Bhattacharya, 2001).A study conducted by the Federation of India Chambers of Commerce (FICCI, 2005) suggests that if oil prices were double and persistent for two years it would have enhanced inflation by 7.9 percentage points and cut down the GDP growth by 4.9 percentage points. An empirical analysis by Gerogio et al. (2007) establishes that doubling the oil price would result in 5 percentage points increase in consumer price index (CPI) but interestingly India was one of the few countries where there was no evidence found for structural break in the oil price-macroeconomy relationship. K.Mandal et al. (2012) estimate the pass-through impact if prices were fully deregulated and their results reveal that such pricing strategy would have resulted in mounting inflation with undesirable effects on output. Study by Sajal Ghosh (2009) shows that there exists a unidirectional causality between crude oil import and economic growth in the long-run; hence it is less likely that a dip in the Indian crude oil import would affect its economic growth in the long-run. A probe in to the oil price-exchange rate nexus (Sajal Ghosh, 2011) reveals that an increase in the oil price returns results in a depreciation of Indian Rupee vis-à-vis to U.S Dollar, and a positive and negative oil price shocks have similar effects on exchange rate volatility in terms of magnitude.

3. Data and Methodology

This paper uses Indian crude oil basket as a measure of monthly crude oil price returns. Inflation, based on WPI is widely used in India for various policy formulations as it has broad coverage across the country. Hence monthly data on WPI is utilized as a measure of inflation. Due to absence of monthly GDP data, Industrial production has been taken as a proxy for output even though GDP data would have been a better measure for output. These two variables indicate the real sector whereas monthly data of Rupee-Dollar exchange rate returns and stock returns are chosen to capture the dynamism in financial sector. Rupee-Dollar nominal exchange rate is selected as the U.S Dollar is the most prominent international intervention currency and it facilitates quite a large volume of international trade and financial transactions. Equity market data are obtained from S&P CNX NIFTY. 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. Monthly returns are calculated from April, 1993 to April, 2012. Table (1) provides descriptive statistics for each of the return series. As each of the return series were found to be leptokurtic (i.e., they have

the characteristic of fat tails) each of the mean equations had to be tested for the existence of ARCH effect. In each case the mean equations exhibited ARCH effect which appropriates the use of GARCH model. The Ljung-Box statistics indicates autocorrelation in all returns.
For each return series the mean equation is specified as:

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

The return on series i between time $t-1$ and t is denoted by $R_{i,t}$. μ_i is a long term drift coefficient. ε_{it} Stands for the error term for the return on series i at time t . Equation (1) was estimated and the residuals were checked for ARCH effect, using the test described by Engle (1982).And it was observed that each of the estimated series were showing ARCH effects.

Once ARCH effect is found, a variant of bivariate GARCH called BEKK (Engle and Croner, 1995) is employed. This model captures the persistence of volatility transmission among different series as well as within each series and also it ensures that the covariance matrix is positive semi definite.
The BEKK representation for the bivariate GARCH (1, 1) model can be written as:

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

Here H_t represents the conditional variance-covariance matrix and C is a 2×2 lower triangular matrix with three parameters. Matrix B depicts the extent to which the present conditional variances are related to past conditional variances. A is nothing but a 2×2 square matrix of parameters that captures the effects of lagged shocks or events on volatility. In this case the total numbers of estimated parameters are eleven.
The expanded form of conditional variances for each equation in the bivarte GARCH (1, 1) model gives:

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

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

Equations (3) and (4) reveal, how and to what extent shocks and volatility are transmitted over time and across two series.
The following likelihood function is maximized assuming that the errors are normally distributed.

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

Where 'T' is the number of observations and θ is the parameter vector to be estimated. To arrive at the final estimate of the variance –covariance matrix and corresponding standard errors the BFGS (Broyden–Fletcher–Goldfarb–Shanno) algorithm was employed.

4. Empirical results

This paper focuses on the volatility spillover between oil market returns and returns in four different sectors. Results for each sector are reported in Table No 2. $h_{11,t}$ Describes the conditional variance for oil at time t and $h_{12,t}$ represents the covariance between the oil returns and returns of those of the corresponding sector. ε_1^2 and ε_2^2 are squared error terms in each model which capture the 'news' effect, i.e.an unexpected change or shock originating from oil market or various sectors under examination, in another line of thought it can be called as direct effects. The cross values of error terms (i.e. $\varepsilon_{1,t}\,\varepsilon_{2,t}$) shows the indirect effects of shock transmission as it captures the 'news' in the oil market and corresponding equity market sector in the time period t. In the oil-WPI model, the coefficients on both ε_{1t}^2 and $h_{11,t}$ are significant. This suggests that the oil return volatility is affected by its own news and past volatility. But there is no further evidence indicating a volatility spillover from oil sector to WPI as none of the other coefficients turned out to be significant, pointing towards a rather meager role played by the international crude oil price volatility in the domestic inflation. A near restrictive retail pricing of petroleum products and frequent Government interventions could be the reasons, why the signals emerging from crude oil market is not being reflected in the Indian inflation scenario.
The oil - IIIP model captures the volatility spillover between oil sector returns and the returns in IIIP which is nothing but a proxy for the domestic output. Interestingly this is the only sector which showed a reverse spillover effect i.e. the coefficient on $h_{12,t}$ in

the oil equation which measures the indirect shock transmission between the two sectors turned out to be negative and significant. It shows that the output volatility has ramifications on the oil sector returns through indirect channels and the negative sign implies that the past levels of volatility in domestic output reduce the volatility in oil sector returns. This makes sense, if we consider the facts that India is the fourth largest crude oil consumer in the world and recent spikes in the international crude oil market was basically driven by the demand side economics rather than the supply constraints. And high output volatility in a huge oil consuming country like India would definitely pass negative signals to the international crude oil market as it would have ramifications on the demand side. This would will eventually causes reduction in the Indian crude oil basket volatility through indirect channels. And also, from the coefficient on $h_{22,t}$ which is significant and insignificant coefficient on ε_{2t}^{2} it is evident that even though the past volatility emanating from the oil sector gets transmitted to the present output volatility, the immediate effects (news effect) emerging out of the oil price volatility does not have any impact on the domestic output.

The oil-exchange rate model depicts that the oil sector volatility is affected by its own news effect and past volatility. And in the exchange rate equation, apart from its own shocks and past volatility the past conditional variance of oil sector has significant effects on the present conditional variance of the exchange rate sector. But it is found that there is no volatility spillover of news effect from the oil sector to the exchange rate sector, indicating a lesser role played by the day to day oil price fluctuations in the exchange rate determination. The oil-stock model reveals that, out of the four sectors taken for examination this one is most vulnerable to the crude oil price volatility. The significant coefficients on $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ indicate that the immediate shocks from oil sector affects stock sector returns through direct as well as indirect channels. The coefficients on $h_{11,t}$ and $h_{22,t}$ are also turned out to be significant. This indicates that the past conditional variance of oil sector has significant spillover effects on stock sector returns through both channels of transmission. The reason for this phenomenon lies in the highly integrated nature of the domestic stock markets with other stock and commodity markets across the world. And oil, being used as an important input for various manufacturing and power sector industries (which hold high weight in indices like NIFTY) will certainly have considerable amount of impact on the stock sector returns.

5. Concluding Remarks

This paper examined the transmission of shocks and volatility between oil sector returns and returns of four Indian sectors which comprise of both real sector as well as financial sector. Monthly data from 1993 April to 2012 April was used for analytical purpose. Overall, this paper finds that there are significant levels of transmission of shocks and volatility happening between oil sector and both Indian real and financial sectors. Sharing of common information and cross market hedging are some of the reasons for this (Fleming et al., 1989).While some of the earlier studies have documented the shock transmission between oil sector and financial sector in particular and some of the other studies deal with real sector variables individually, the novelty of this study is that it incorporates both sectors under one common framework. And to best of my knowledge no such study has been conducted in the Indian context so far. And the methodology followed by this paper is proved to be adequately specified as the residuals derived out of the bivariate GARCH model is tested for autocorrelation and found that the autocorrelation problem is removed. The recent events in the international crude oil market are very crucial for a country like India as it is one of the biggest crude oil importers in the world. Even though the day to day fluctuation in the crude oil market is not being transmitted to the Indian retail petroleum prices basically because of the Government intervention, it is certain that there will be some implications on various macroeconomic variables. The empirical results provided by this paper will be useful for different policy making bodies and various participants in the financial markets. And for India the implications of crude oil price fluctuations reiterates various aspects like attaining more energy efficiency and becoming more self reliant in oil production and formulating an effective hedging mechanism for the oil marketing companies.

6. References

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	Oil	**WPI**	**IIIP**	**Stock**	**Exchange Rate**
Mean	0.008	0.004	0.005	0.009	0.002
Median	0.020	0.004	0.000	0.015	0.000
Maximum	0.210	0.076	0.139	0.247	0.065
Minimum	-0.326	-0.021	0.150	-0.306	-0.063
Std.dev.	0.082	0.008	0.049	0.076	0.015
Skewness	-0.918	2.715	-0.375	-0.389	0.515
Kurtosis	4.969	23.339	4.218	3.879	6.943
Q	Q(17) 46.369	Q(19) 76.159	Q(4) 69.231	Q(13) 72.566	Q(15) 47.916

Table 1: Descriptive Statistics

Notes: The sample contains monthly returns from April 1993 to April 2012.The number of observations is 228.

Oil and WPI

$$h_{11,t} = 0.01 + 8.77\times10^{-10}h_{11,t} - 3.4\times10^{-11}h_{12,t} + 9.31\times10^{-12}h_{22,t} + 0.3053\varepsilon^2_{1,t} - 0.004\varepsilon_{1,t}\varepsilon_{2,t} + 1.029\varepsilon^2_{2,t}$$

(2.085) (2.011) (-0.002) (0.002) (3.588) (0.134) (0.949)

$$h_{22,t} = 8\times10^{-7} + 3.2\times10^{-13}h_{11,t} - 1.05\times10^{-11}h_{12,t} + 8.36\times10^{-11}h_{22,t} + 1.45\times10^{-5}\varepsilon^2_{2,t} - 0.001\varepsilon_{1,t}\varepsilon_{2,t} + 0.004\varepsilon^2_{2,t}$$

(0.741) (1.010) (-0.002) (1.281) (0.187) (-0.347) (1.416)

Oil and IIIP

$$h_{11,t} = 0.233 + 0.016\,h_{11,t} - 0.026\,h_{12,t} + 0.003\,h_{22,t} + 0.184\varepsilon^2_{1,t} + 0.029\,\varepsilon_{1,t}\varepsilon_{2,t} + 0.011\,\varepsilon^2_{2,t}$$

(0.852) (12.601) (-4.577) (0.359) (2.847) (0.441) (0.401)

$$h_{22,t} = 0.712 + 0.010\,h_{11,t} - 0.015\,h_{12,t} + 0.005\,h_{22,t} + 0.114\varepsilon^2_{1,t} - 0.050\varepsilon_{1,t}\varepsilon_{2,t} + 0.550\varepsilon^2_{2,t}$$

(2.856) (3.907) (-1.045) (5.394) (0.478) (-0.948) (2.241)

Oil and Exchange rate

$$h_{11,t} = 0.004 + 0.031\,h_{11,t} + 0.355\,h_{12,t} + 0.605\,h_{22,t} + 0.156\,\varepsilon_{1,t} + 0.008\,\varepsilon_{1,t}\varepsilon_{2,t} + 2.240\,\varepsilon^2_{2,t}$$

(4.489) (11.995) (0.177) (0.599) (2.149) (0.152) (1.131)

$$h_{22,t} = 1.38\times10^{-7} + 1.02\times10^{-6}1h_{11,t} + 0.621\,h_{12,t} + 0.946\,h_{22,t} + 0.128\varepsilon^2_{1,t} + 0.029\varepsilon_{1,t}\varepsilon_{2,t} + 1.701\varepsilon^2_{2,t}$$

(0.175) (0.118) (0.235) (8.461) (0.764) (-1.526) (6.454)

Oil and stock

$$h_{11,t} = 0.118 + 0.041\,h_{11,t} - 0.173\,h_{12,t} + 0.025\,h_{22,t} + 0.164\,\varepsilon_{1,t} + 0.289\,\varepsilon_{1,t}\varepsilon_{2,t} + 0.098\,\varepsilon^2_{2,t}$$

(0.304) (3.902) (-0.973) (0.347) (2.044) (1.090) (1.278)

$$h_{22,t} = 0.147 + 0.183\,h_{11,t} + 0.358\,h_{12,t} + 0.175\,h_{22,t} + 0.127\varepsilon^2_{1,t} + 0.067\varepsilon_{1,t}\varepsilon_{2,t} + 0.008\varepsilon^2_{2,t}$$

(1.254) (5.895) (6.124) (7.038) (2.234) (3.273) (3.729)

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Table 2: Summary of bivariate GARCH results.

Notes: $h_{11,t}$ denotes conditional variance for oil and $h_{12,t}$ represents the conditional variance for the corresponding sector. Corresponding t-values are reported directly below the estimated coefficients. Results for the mean equation -which includes a constant term and lagged return term – are not reported for the sake of brevity but are available upon request.