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Article

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Do Different Types of Oil Price Shocks Affect the Indian Stock Returns Differently at Firm-level? A Panel Structural Vector Autoregression Approach

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ABSTRACT

In this paper, we investigate the dynamic relationship between different oil price shocks and Indian stock returns at firm level, using variable-structural vector autoregression (VAR) approach for the period 1995:01-2018:12. We use large unbalanced panel of 1768 manufacturing energy-intensive and non-manufacturing energy-intensive firms listed in the national stock exchange. The estimation results depict that stock returns of India deteriorate due to disruptions in oil supply. In response to aggregate demand shock, stock returns and oil price move in opposite direction, whereas for speculative demand shock, oil price and stock returns have similar reactions. We also use Generalized Methods of Moments technique since our model suffers from endogeneity, thanks to the use of panel data. Since not all oil price shocks are alike, policy makers and investors should look into all aspects and sources of oil price shocks that impact stock returns, and make appropriate policy and investment decisions. From impulse response function, the effect is again cyclical as one could witness ups and downs in stock returns. This is because domestic oil price is partially dependent upon the status of subsidiaries and taxes. Also, inflation does not depend just upon oil price shocks and its sources, but it depends on other shocks such as inflation shock as well.

Keywords: Oil Price Shocks, Aggregate Demand Shock, Speculative Demand Shock, Structural Vector Autoregression, Stock Returns
JEL Classifications: C3, C5, G1, Q4

1. INTRODUCTION AND BACKGROUND

April 1, 2019 "*oil prices push higher as supply worries drive gains*" (Economic Times, Energy World).

December 3, 2018 "*Speculation in the commodities market has also contributed to the fall in crude oil.*"

October 9, 2018 "*Sensex, Nifty drop on fresh spurt in oil price, fall in price*" (Economic Times, Market).

February, 2015 "*The price fall has benefited industries that use oil and its derivatives. These include oil, auto, paint, aviation, cosmetic and fast-moving consumer goods* (*FMCG, Business Today*)."

The above headlines from the popular financial press provide evidence that different oil price changes actually impact the stock market. It is quite commonly acknowledged that global oil price changes are impacting the stock market, but unprecedented increase in oil price in recent times is attributed to shortage of oil supply. From the literature review below, one can easily discern that a lot of research has been devoted to study the impact of oil prices on macroeconomic variables such as inflation, exchange rates, etc. in long-term. However, very little attention has been given to study the impact of oil price shocks on aggregate stock market, and stock market reaction to different oil price shocks in energy finance literature. There should be undertaken some study on decomposition of oil price, and the way it impacts oil price and stock returns (Hamilton, 2003 and Kilian, 2009). Moreover, such studies give more relevant insights for policy making and financial risk management by assessing the stock market reaction to different shocks affecting international oil market and commodity market. For example, various assessments of the relationship between oil price shock and stock returns have fetched mixed results. There are some studies which have found negative relationship between oil price shocks and aggregate stock returns (Basher et al., 2011; Chen, 2009), whereas some other studies have found positive relationship between the same (Narayan and Narayan, 2010; Zhu et al., 2011). These jumbled responses could be because these studies failed to decompose oil price shock while examining the relationship between oil price shock and stock returns. Also, as rightly noted by Smyth and Narayan (2018) in their literature survey work, using panel data leads to greater observation and greater degree of freedom. A very few studies have examined the relationship between oil prices and stock returns using firm-level data (Demirer et al., 2015; Gupta, 2016; Narayan and Narayan 2014).

In this paper we analyse the impact of real oil price and decomposition of oil price shock (crude oil supply shock; shock to the global demand for all industrial commodities; and oil specific demand) on Indian stock market. The focus on India is interesting for two reasons: on one hand, from a general economic perspective, India is the sixth largest country in world GDP share, and the third largest in purchasing power parity[1]. On the other hand, from the perspective of dynamics between oil price and stock returns, India, being an oil-importing emerging economy, is exposed to developments in crude oil market. The recent volatility in global oil price affected the Indian economy through a number of channels such as exchange rate depreciation, inflation and financial markets. Fluctuations in oil stock prices are often considered as consequence of change in real oil price. Researchers and investors can find it relevant to potential predictive reason in oil price change. The importance of decomposition of oil price into oil demand and supply shocks for understanding the transmission of oil price shocks has been propagated by Kilian and Park (2009).

By far, the existing literature is mainly concerned with a study of the impact of real oil price on stock returns, but there is no consensus in the literature. While Kling (1985) finds that real oil price increase results in stock market decline, Chen et al. (1986), and Jones and Kaul (1996) find no association between oil price and stock returns. Apergis and Miller (2009) study found that oil price volatility had negative influence on stock returns. Other popular studies which concluded negative relation between real oil price and stock returns are Basher and Sadorsky (2006), Chen (2009), Jones and Kaul (1996). Kumar and Gupta (2014) found that the aggregate stock returns were more sensitive to negative change in oil prices than to positive change in oil prices.

However, several studies have found positive relation between real oil price and stock returns (Zhu et al., 2014; Zhu et al., 2011; Narayan and Narayan, 2010). Sadorsky (2008) concluded that oil price volatility positively affected the United States stock return. Managi and Okimoto (2013) also found positive relationship between oil prices and stock returns.

1 The World Bank, World Development Indicators database, 2017

Based on industry-specific stock prices or index data, Sharif et al. (2005); Ghouri (2006); Boyer and Filion (2007) studied impact of oil price shocks on oil-dependent industries like oil and gas sectors. The study revealed that oil price shock was positively related to transportation sector. Nandha and Faff (2007) concluded that oil price volatility negatively impacted equity returns of all the industries, leaving some industries such as mining, and oil and gas. It was surprising to see that sectors such as banking, health care, and insurance sectors were majorly affected by higher oil prices.

Aggaarwal et al. (2012) found that 71 major transportation firms were negatively influenced by oil price volatility. Similar results were found by Aye et al. (2014) when oil price negatively impacted on South Africa's manufacturing production. While several conventional studies treated oil price shocks as exogeneous, some studies of late (Kilian and Park, 2009; Barsky and Kilian, 2004; Hamilton, 2003) have recognized that oil supply, aggregate demand and oil specfic demand shocks drive oil price change. Also, Kilian and Park (2009) concluded that increase or decrease in real oil price is the result of underlying structural shock which can be in the form of oil supply shock, aggregate demand shock or oil specific demand shock. These structural shocks altogether have different implications on the variable of interest. For example, the work done by Guntner (2011), while studying the impact of oil demand and supply shocks on international stocks of 6 countires, found that world supply did not have significant influence on stock markets of those 6 countries. On the other hand, an increase in global aggregate demand raised oil prices and stock returns. These findings were in line with the study by Bastianin et al. (2016) according to which stock market of G7 did not respond to global supply shocks while demand shocks impacted significantly on the volatility of G7 stock markets. However, the study done by Apergis and Miller (2009) concluded that even though global stock returns did not react to oil market shocks, decomposition of oil shocks played a significant role in explaning changes in stock market.

For a researcher, it is important to recognise the underlying cause of oil price shock: it can be through oil supply shocks, shock in aggregate deamnd for industrial commmodities, or through oil specific demand. Following the present literature, we recognize three types of oil shocks in the oil industry. First, we look into oil supply shocks which reflect unforeseen changes in quantity. The second type is the aggregate demand shock for industrial commodities arising from business cycle fluctuations. The third is the speculative demand which refelects change in oil inventories. Following Kilian and Murphy (2014), we distiniguish our study from previous works by using shock in oil inventory, and by denoting it as specualitve demand and forward-looking behaviour. The reason for using oil inventory shock as proxy for speculative demand shock is that previous studies (Kilian, 2009 and Bastianin et al. 2016) looked only at the impact of demand and supply shocks on economy, ignoring the speculative component of global oil market.

In our study, we assess the impact of different oil price shocks on Indian stock market at firm-level, by using the methodology propogated by Kilian (2009). Extending the previous studies that considered oil price shock proxy for oil specific demand, we use oil inventories in our analysis for measuring speculative demand. While using oil inventories, we treat them as tool to identify the forward-looking component for oil price shocks. The idea of using speculative demand is to separate speculative component from demand and supply shocks of oil. Hence, we will be assessing the impact of speculative demand on oil price and Indian stock returns, along with oil supply and aggregate demand shock at firm level. According to our knowledge, this is the first study to assess the dynamics between different global oil market shocks and Indian stock returns at firm level, using generalized methods of moments (GMM) and structural VAR model.

The paper proceeds as follows: section 2 describes data. Section 3 deals with methodology, section 4 describes empirical results while conclusion and policy implications are provided in section 5.

2. DATA DESCRIPTION

We estimate a 5 variable GMM and panel structural VAR model using monthly panel data for the period 1995:01 to 2018:12. The present study considers the companies listed in National Stock Exchange (NSE) of India. There is a large unbalanced panel of 1768 firms listed in the NSE, in which the data has a natural nested grouping. In other words, individual firms are grouped by industry into 143 diverse sectors. For our study, we only select those firms which are manufacturing energy-intensive and non-manufacturing energy-intensive. The following industries are considered manufacturing energy-intensive: food, pulp and paper, basic chemical refining, iron and steel, non-ferrous metals (primarily aluminum and nonmetallic) minerals (importantly cement). Non-manufacturing energy-intensive firms consist of agriculture, mining, and construction. India's growth in output in manufacturing and non-manufacturing energy-intensity firms together accounted for 9.4% in 2016 (International Energy outlook, 2016). We consider the closing price of stock prices of 1168 energy-intensive firms. The stock returns are obtained from the first difference of natural log of stock prices. We include the price of crude oil based on the Wholesale price index (WPI)[2] number for oil from the Handbook of Statistics of the Reserve Bank of India. Before proceeding for any pre-tests, we bring the data series about oil price under one constant price of 2004-2005, using the splicing method. We use WPI number as proxy for oil price. We use domestic oil price as represntation for real oil price as Indian firms are subjected to shock in domestic oil price. Following Kilian (2009a), the real price of oil is expressed in log-levels. We also obtain the data for the global oil production measure in millions of barrels of oil from U.S Energy Information Adminstration. Following Kilian and Murphy (2012), we extract data for petroleum inventories provided by the EIA[3]. We use OECD countries as proxy for global petroleum inventories. We use E-GARCH in order to measure the shock in inventories, referred to as 'speculative demand'. We use the global Index of Industrial Production (IIP) as proxy for global real economic activity, unlike other studies which have used ocean freights rates of dry cargo Kilian (2009). Kilian`s real index is constructed by giving wieghts to commodities and routes. This constrction could be biased as equal weights are assigned for both commodities and routes. Also symmetric weights are assigned for different shipping prices for commodities such as grain, oilseeds, coal, iron ore etc. However, the consumption and prices change across time.

Based on these limitations, we use the next popular index as a proxy for global real economic activity: global IIP. The index is based on the data from 34 OECD countries.[4] Hence we use global index industrial production as proxy for global real economic activity. The series is deflated using the US Consumer Price Index. Finally, our variable of interest is Indian stock returns at firm level.

3. METHODOLOGY

As our variable of interest is stock returns, we also discuss the asset pricing model in order to adress the determinants of stocks returns. These determinants are used as control variables along with other explanantory variables in estimation. Instead of the traditional asset pricing model Capital Asset Pricing model (CAPM), we use the Fama-French model developed by Fama and French (1993). Later, we observe how Carhart (1997), discussing the momentum effect on the stock market, extended the original three-factor Fama-French model. The reason for using the three factor Fama-French model is that CAPM failed to explain individual security return. The Fama-French model gave a theoretical background for analysing the relationship between stock prices and oil prices. Hence, Fama-French four factors viz. Index returns, SMB, HML and WML, are included in the GMM and Panel Structural Vector Auto-Regressive (P-SVAR) model.

We employ the Fama and French (1993) and the Carhart (1997) four-factor model to specify the stock returns determinants as follows:

$$(R_{it} - RF_t) = C + b_1\left[R_{Mt} - R_{Ft}\right] + b_2 SMB_{mt} + b_3 HML_{mt} + b_4 WML_{mt} + e_{it} \tag{1}$$

Where R_{it} stands for monthly return on stock *i* at time *t*, RF_t is the daily interest rate of government securities at time *t* and R_{Mt} stands for calculated return on the market index at time *t*. Small minus big (SMB_{mt}) imitates the difference between the returns on portfolios of small and big stocks. High minus low (HML_{mt}) imitates the difference between the portfolio of stocks with a high book to the market value of equity and the return on a portfolio of stocks with low book to market values. Winners minus losers (WML_{mt}) imitates the difference between the return on the portfolio of stocks with high momentum and the return on a portfolio of stocks with low momentum. The ε_{it} in regression stands for error term. The time frame from 1st January 1995 to 31st December 2018 has been considered for monthly stock returns and index returns.[5] To obtain SMB and HML, the book

2 Whole sale price index (WPI) in the Indian context is a central measure of inflation. In our study WPI number for oil is being used.

3 EIA includes crude oil as well as unfinished oils, natural gas.

4 Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Mexico, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the united kingdom and the United States.

5 The data about stock prices and Index returns are taken from CMIE prowess database every month. Stock prices are converted into stock returns by

value and market capitalization are extracted for the financial year closing, i.e. 31st March for companies listed on the NSE. The size category is formed based on the market capitalization using certain breakpoints, starting from the bottom 30% termed as small, middle-sized 40% termed as medium (M), and topmost 30% termed as big (B). Following the above notion, SMB is formed by taking the simple average difference between three small stock portfolios and three big stock portfolios. The BE/ME category is formed by dividing the book value per share by the market value per share, and then breakpoint has been formed by denoting the top 30% as high (H), the middle 40% as medium (M), and the bottom 30% as low (L). The HML is obtained by taking the simple average difference between the three high BE/ME and the three low BE/ME companies. Last, the WML is calculated on the momentum of stock returns. We categorize the momentum on breakpoints of the bottom 30% as low momentum (LM), the middle 40% as medium momentum (MM), and the top 30% as high momentum (HM). So, the simple average difference between the three winners and the three losing portfolios has provided the WML. The SMB, HML, and WML are expected to mimic the return difference in portfolios based on size, BE/ME ratio, and momentum, respectively. Considering the anomalies in the standard CAPM, these variables are expected to have explanatory power in the asset pricing model.

3.1. Different Oil Price Shock Modelling

In order to capture oil price shock, previous studies have used the traditional method of modelling shock by taking standard deviation (SD) of the series. This concept was proposed by Ferderer (1996) who modelled oil price shock by taking the SD of the oil price. Unlike other studies, we use exponential-GARCH (E-GARCH) in order to capture the shock. Basically, the methodology used under GARCH and its family (T-GARCH, E-GARCH etc.) is to record shock from the residuals of the error term of the series. E-GARCH is stated in log form for variables, which means the model is free from parameter restrictions, and E-GARCH is specified as follows:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} + \sum_{k=1}^{m} \theta_k \ln(\sigma_{t-k}^2) \quad (2)$$

Where h_t is specified as the conditional volatility of the oil price, and α_0 is the unconditional variance with constant mean. Hence, using E-GARCH methodology, we calculate different types of shocks pertaining to supply, aggregate demand and oil specific demand. Shocks in oil production are denoted as global supply shocks; shock pertaining to real economic activity is denoted as aggregate demand shock; and finally, any shock arising in inventories is represented as speculative demand shock in order to measure the forward-looking behaviour.

3.2. Econometric Analysis

This section describes the econometric estimation and identification of the structural dynamics of the panel data. Before proceeding to the main model, in empirical research, it is inevitable to do some pre-tests so that the data series becomes suitable for further estimation. Regarding micro panel data with large N, correcting the non-stationarity of panel data series is very crucial. The pre-tests are begun by testing the stationarity of variables, using panel unit root tests such as Levin and Lin (LLC, 1992) Im, Pesaran and Shin W-Stat (IPS) and Hadri tests. The null hypotheses of LLC and IPS assume that the panel data series has unit root against the alternative hypothesis of no unit root. What distinguishes LLC from IPS is that the former test assumes common unit root covering all cross-sections whereas the IPS unit root tests allow heterogeneity in the unit root procedure of individual data. The present study uses Levin and Lin (1992), and I'm, Pesaran and Shin W-Stat.

converting the log of the first difference.

Further, we employ the Durbin-Wu-Hausman tests to detect the presence of endogeneity in the explanatory variables. According to the econometric theory, explanatory variables should not correlate with the error term. Durbin-Wu-Hausman test is generally used on OLS to detect for the same reason. In the present study, we estimate the standard model with various sources of oil price shocks, and it is expressed in the following equations:

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 Oilprice + \varepsilon_{it} \quad (3)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 GOP_t + \varepsilon_{it} \quad (4)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 REA_t + \varepsilon_{it} \quad (5)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 Inventories_t + \varepsilon_{it} \quad (6)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 OilSupplyshock + \varepsilon_{it} \quad (7)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 ADS + \varepsilon_{it} \quad (8)$$

$$(R_{it} - RF_t) = C + \beta_1\left[R_{Mt} - R_{Ft}\right] + \beta_2 SMB_{mt} + \beta_3 HML_{mt} + \beta_4 WML_{mt} + \beta_5 WPI_t + \beta_6 SDS + \varepsilon_{it} \quad (9)$$

In equation 4 above, GOP stands for global oil production; in equation 5, REA stands for real economic activity; ADS in equation 8 stands for aggregate demand shock; and SDS in equation 9 stands for speculative demand shock.

To test whether each explanatory variable is endogenous or exogenous, the regression on each explanatory variable is estimated to diagnose residuals from it. In the process, the independent variable has become a dependent variable. The next step is to diagnose whether the coefficients of residuals are significant. The null hypothesis assumes the individual explanatory variables as exogenous in the system. From the test results, all independent variables (oil price, oil production, real activity, oil inventories, oil supply shock, aggregate demand shock and speculative demand shock) and control variables such as SMB, HML, index return are found to be endogenous. To correct endogeneity, we use instrument variables for the lagged dependent variables and other non-exogenous variables. We consider GMM, developed by Arellano and Bond (1991). So, in the standard model, a dependent variable with a lag is treated as one of the independent variables, i.e., stock returns. The lagged values of the dependent variable is treated as an instrument variable so that these internal variables corrects the issue of correlation between the explanatory variables and the error term. The present study follows the two-step estimation because the first difference transformation could lead to loss of the degrees of freedom. On the other hand, in the two-stage least square estimators, from a particular variable, the average of all future variables is subtracted. GMM takes care of data loss, and also provides efficient and consistent estimates. It is suitable when the N (cross-section) dimension is larger than the T (time series) dimension.

The two-step GMM has been specified in equations 10-16:

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt} +\beta_3 HML_{mt}+\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 Oilprice+\varepsilon_{it} \quad (10)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt} +\beta_3 HML_{mt}+\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 GOP_t+\varepsilon_{it} \quad (11)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt} +\beta_3 HML_{mt}+\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 REA_t+\varepsilon_{it} \quad (12)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt}+\beta_3 HML_{mt} +\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 Inventories_t+\varepsilon_{it} \quad (13)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt}+\beta_3 HML_{mt} +\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 OilSupplyshock+\varepsilon_{it} \quad (14)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt} +\beta_3 HML_{mt}+\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 ADS+\varepsilon_{it} \quad (15)$$

$$(R_{it}-RF_t)=C+\beta_1\left[R_{Mt}-R_{Ft}\right]+\beta_2 SMB_{mt} +\beta_3 HML_{mt}+\beta_4 WML_{mt}+\beta_5 WPI_t+\beta_6 SDS+\varepsilon_{it} \quad (16)$$

While estimating the above equations, lagged values of the dependent variable (stock returns) and the independent one are treated as instruments to take care of endogeneity. Regressors with deeper lags are also used as instruments.

3.3. P-SVAR Model

While following Kilian (2009), we represent the transmission of oil price shocks using our reduced-form panel structural VAR model for 24 months lags.

$$AY_{it}=L_{io}+B_1Y_{it-1}+B_2Y_{it-2}+....B_nY_{it-n}+\phi X_t+\mu_{\varepsilon_{it}} \quad (17)$$

In the equation, matrix specifying coterminous relationship among the variables is represented by A. Y_{it} is a (K×1) vector of an endogenous variable such that $Y_{it}=Y_{1t,}Y_{2t,...}Y_{nt}$, L_{io} is a (K×1) that stands for vector of constants constituting firm-specific intercept terms. The matrix of coefficients with lagged endogenous variables (for every i=1….P)ϕ is represented by B_i. Vector of coefficients and external shocks is represented by X_t. Non-zero diagonal elements for direct effects of some shocks are allowed through μ. ε_t represents vector of uncorrelated error terms. ε_t is categorised into two sections of which the first section consists of shocks related to sources of oil price shocks, while the second section captures the variable of interest- Indian stock returns. Hence, following Kilian and Murphy (2012) methodology, error term (ε_t) in the first section consists of shocks production of oil (oil supply shock). A shock in real activity (aggregate demand shock) seizes unforeseen changes in the global industrial production. Any shock to the oil inventories arising from speculative behaviour regarding oil demand and supply flow (speculative demand shock) is employed to record innovations in oil inventories. In order to capture all structural shocks, we also consider residual shock in the first section of error term. In the second section, innovations to stock returns are captured.

Equation (17) can also be written as:

$$Y_{it}=Z_i+A(P)Y_{it}+H(P)X_t+\nu_{it} \quad (18)$$

Where specifications for Y_{it} and X_t are given as:

$$Y_{it}=(Stockreturns, Indexreturns, SMB, HML, WML) \quad (18.1)$$

$$X_t=\text{Source of oil price shocks} \quad (18.2)$$

Endogenous variables in the study are specified in equation (18.1). X_t in equation (18.2) represents vector of the innovations (shock). Equation (18.1) describes the vector of Firms' endogenous variables used in the study; equation (18.2) describes the vector of the exogenous variable that reflects shocks. Z_i stands for a vector of constants representing firm intercept terms. A(P) and H(P) specify the matrices of polynomial lags, which capture the relationship between the endogenous variables and their lags. $\nu_t=I^{-1}\mu_{\varepsilon_{it}}$ is a vector of the error term. Following Amisano and Giannini (1997) method we impose 35 restrictions[6] on the A and G matrices collectively (where n is the number of variables). As P-SVAR imposes 5 zero on A, the system is over-identified. We estimate 15 free parameters in A matrix, and 5 in the G matrix.

Based on economic theory, we impose restrictions, and discuss how each variable is placed for identification purpose. We assume that the real price of oil is explained by the current and future supply and demand conditions. Any disturbance in oil production and supply will lead to increase in the price of oil, which causes global real activity to slow down. Any disruptions in oil production will lead to shock in inventories. That is why our model also assumes that any shock in oil supply will lead to disturbance in inventories. Oil price also depends upon the global business cycle, and so, any unanticipated movement in real economic activity (aggregate demand shock) may lead to increase or decrease in oil price, depending upon whether aggregate demand shock is positive or negative. Positive shock will increase oil price, and in turn, will lead to increase in oil production. Since oil is storable, the price of oil may depend on the future inventories. Any speculation regarding oil demand or supply will

6 Based on calculation: 2n2-n(n+1)/2 (where n is the number of variables).

impact the current volume of inventories, and successively, the current oil price. These developments will dampen real economic activity, and increase oil production. The domestic oil price does not depend just on international oil price and other sources of oil price; it also depends upon the tax. That's why these effects are indirect, and have little influence on oil price. Finally, our model assumes that all the sources of oil price shocks affect the stock returns. So, the focus of this study is to assess the impact of the sources of oil price shock on Indian stock returns at firm level.

The restrictions imposed on five endogenous variables are reported in Equation 19. All the dependent variables are placed in first row left hand side of the matrix, where REA stands for real economic activity. The first column of the matrix notation consists of shocks in oil price, oil supply, real economic activity and inventories respectively, whereas OPS stands for Oil Price Shocks, oil supply shock, aggregate demand shock and speculative demand shock. Real oil price and stock returns are determined by these above-mentioned shocks. All NAs depict the variables to be estimated. For example, oil price can be determined by its own shock, oil supply shock, aggregate demand shock and speculative demand shock, whereas only oil supply is determined by its own shock. Real economic activity is determined by oil price shock, oil supply shock and speculative demand shock, and by its own shock. And finally, stock returns is determined by oil price shock, oil supply shock aggregate demand shock and speculative demand shock.

$$\begin{bmatrix} & OPS & OSS & A.D.S & S.D.S \\ \text{Oilprice} & NA & NA & NA & NA \\ \text{Oilsupply} & 0 & NA & 0 & 0 \\ REA & NA & NA & NA & NA \\ Inventories & 0 & NA & 0 & NA \\ stockreturns & NA & NA & NA & NA \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (19)$$

4. EMPIRICAL RESULTS AND DISCUSSION

The results of panel unit root tests, GMM estimation and P-SVAR are discussed in this section. Table 1 shows the results of panel unit root tests, except for oil price-change and oil price shock. The rest of the variables are stationary in nature. The first difference between oil price-change and oil price shock is obtained to bring stationarity.

Tables 2 and 3 represent the results obtained from GMM estimation. We use deeper lags for dependent variable (stock returns) in order to prevent endogenity. Stock returns is negatively influenced by its own two lags. Further, market return positively influences the stock returns, which confirms the asset pricing model. Similarly, coefficients of HML and WML are positively related to stock returns, and are statistically significant, whereas SMB shows negative relationship with stock returns. Real oil price has positive and statistically significant relation with stock returns. Similarly, global real economic activity also shows positive influence, and is highly significant. This means that strong global economic activity stimulates stock returns as any increase in global oil production and higher oil inventories decreases real oil price and boosts stock returns. Hence, oil production and oil inventories are positively related to stock returns. In order to explore the relationship between the various sources of oil price shocks and stock returns, we estimate basic model using oil price shock, oil supply shock, aggregate demand shock and speculative demand shock. These results are presented in Table 3. Despite introducing these shocks, the sign and size of the coefficients of Fama-French factors do not change, and remain statistically significant. Results are similar to of the results presented in Table 2. There is positive and statistically significant relation between oil price shocks and their sources to stock returns. It can be interpreted that any shock in supply and demand side of oil boosts Indian stock returns.

The estimation results of the panel structural VAR model are presented in Table 4. Results present responses of the real oil price, world oil production, global real economic activity, crude oil inventories and Indian stock returns to shock in oil price and

Table 1: Panel unit root tests

Method	Unit root with common process				Unit with individual unit root process			
Variable name	Levin, Lin and Chu t				Im, Pesaran and Shin W-stat			
	Level		First difference		Level		First difference	
	Statistics	P-values	Statistics	P-values	Statistics	P-values	Statistics	P-values
Stock returns	−667.693	0.000	-	-	514.297	0.000	-	-
Oil price-change	25.463	1.000	557.805	0.000	17.160	1.000	−413.345	0.000
Oil price shock	26.678	1.000	674.762	0.00	28.658	1.000	−487.493	0.000
Real economic activity	−679.612	0.000	-	-	−491.232	0.000	-	-
Aggregate demand shock	−399.381	0.000	-	-	−262.468	0.000	-	-
Oil production	−23.9012	0.000	-	-	27.4860	1.000	−1417.32	0.000
Oil supply-shock	−77.8816	0.000	-	-	−4.83980	0.000	-	-
Oil inventories	−81.2175	0.0000			−74.5954	0.0000		
Speculative demand shock	−80.6910	0.0000			−73.6129	0.0000		
Index returns	−759.593	0.000	-	-	−519.376	0.000	-	-
SMB	760.519	0.000	-	-	−615.108	0.000	-	-
HML	619.031	0.000	-	-	−466.500	0.000	-	-
WML	148.975	0.000	-	-	−113.21	0.000	-	-

Table 1 exhibits panel unit root tests of Levin, Lin and Chu t and Im, Pesaran and shin W-stat on dependent (stock returns) and independent variables (different oil price shocks and Fama-French factors)

Table 2: Effect of real oil price, real economic activity, oil production and inventories on stock returns generalized methods of moments

Variable	Coefficient	Standard error	t-statistics	P-values
Stock returns (-1)	−0.008486	9.35E-06	−907.5719	0.0000
Stock returns (-2)	−0.085442	3.95E-06	−21627.68	0.0000
Stock returns (-3)	0.075407	8.21E-06	9189.050	0.0000
Real oil price	4.97E-05	4.63E-08	1075.154	0.0000
Oil production	0.000116	7.07E-08	1637.325	0.0000
Real economic activity	3.22E-06	1.33E-09	2409.164	0.0000
Oil inventories	0.156570	5.97E-05	2623.643	0.0000
Index returns	0.046483	1.92E-05	−2417.592	0.0000
SMB	−0.000550	1.98E-07	−2778.412	0.0000
HML	0.001132	3.83E-07	2956.140	0.0000
WML	0.000674	4.05E-07	1663.350	0.0000
Test order	m-Statistic	rho	SE (rho)	Probability
AR (1)	−27.394305	−1650.656172	60.255451	0.0000
AR (2)	6.859029	19.328825	2.818012	0.2043

Instrument validity is tested using Sargan test J statistics which has a null hypothesis of 'test of over identifying restrictions are valid'. It returns the value of 27.36 and a probability value of 0.55

Table 3: Effect of oil price-shock, aggregate demand shock and aggregate supply shock on stock returns generalized methods of moments

Variable	Coefficient	Standard error	t-statistics	P-values
Stock returns (-1)	−0.009	4.14E-06	−2293.341	0.0000
Stock returns (-2)	−0.085	3.93E-06	−21714.26	0.0000
Stock returns (-3)	0.074	3.80E-06	19637.60	0.0000
Oil Price shock	0.003	2.56E-06	1279.348	0.0000
Oil Supply shock	0.020	8.42E-06	2466.285	0.0000
Aggregate Demand Shock	0.002	7.70E-07	3459.368	0.0000
Speculative Demand Shock	0.808	0.000130	6197.610	0.0000
Index returns	0.045	4.14E-06	−11033.32	0.0000
SMB	−0.0006	1.42E-07	−4553.574	0.0000
HML	0.001	1.51E-07	9090.485	0.0000
WML	0.0009	2.65E-07	3672.319	0.0000
Test order	m-Statistic	rho	SE (rho)	Probability
AR (1)	−27.361	−1637.183	59.835	0.000
AR (2)	1.380	3.759	2.722	0.167

Instrument validity is tested using Sargan test J statistics which has a null hypothesis of 'test of over identifying restrictions are valid'. It returns the value of 40.36 and a probability value of 0.40. Tables 1-2 exhibits the estimation results of Generalised Methods of Moments; we treat dependent with lags as independent variable along with other regressors. The values of coefficient are in scientific form. The last two rows exhibit the post estimation results of Arellano-Bond serial correlation test.

Table 4: Estimated matrix with impact of sources of oil price shock on oil price, real activity, inventories and stock returns (P-SVAR)

	Estimated A_0 matrix			
	Oil price shock	Oil supply shock	Aggregate demand shock	Speculative demand shock
Oil price	0.417***	−0.009***	−0.157***	−0.072***
Oil supply	-	0.971	-	-
Real economic activity	0.257***	0.768***	330.73***	−36.477***
Oil inventories	-	−0.004***	-	0.014
Stock returns	0.045***	−0.018***	0.002	−0.011***

Table 4 exhibits Panel SVAR, ***indicates significance at 1% level, **at 5% level and *at 10% level. P-SVAR: Panel structural vector auto-regressive

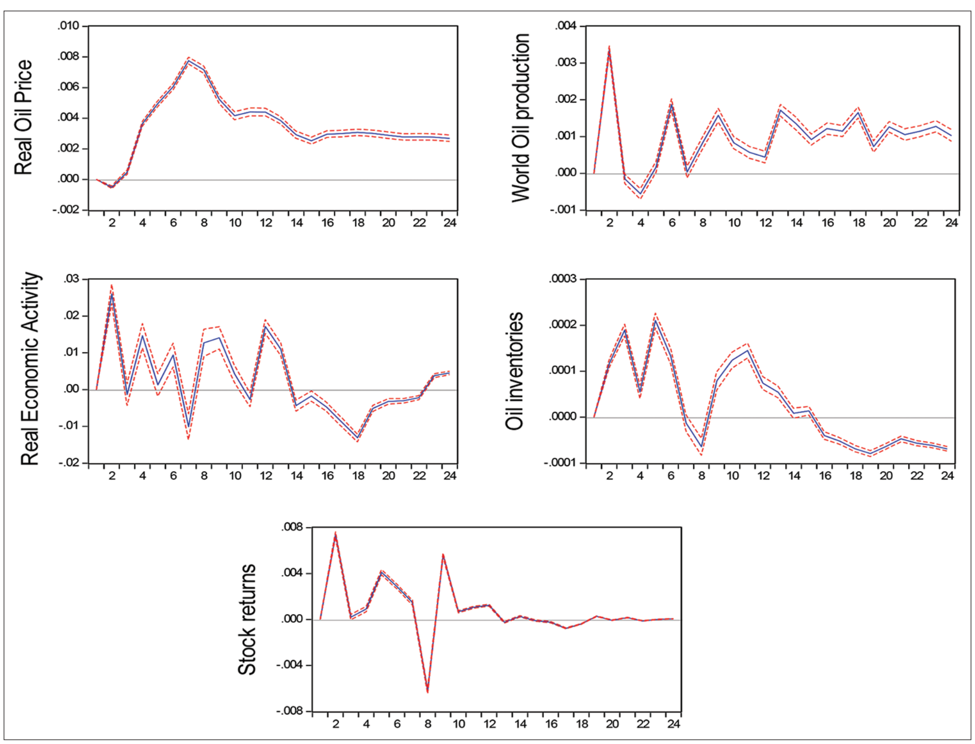
its sources. On the basis of discussion in section 3.4, the blanks in the table reveal that particular variable is not estimated as there is no economic relation. The first row of Table 4 shows the response of oil price to oil price shock and its sources. There is positive influence of oil price shock on real crude oil price. The sign of coefficient associated with the oil price shock is in line with economic theory. In other words, the shock due to increase in oil price may not have contemporaneous impact on oil price, but has positive impact on oil price after some lag. Oil supply shock has negative - and statistically significant - influence on oil price shocks. This is on expected lines as shock due to increase in oil supply results in decrease in oil price, and the other way round. Any shock due to increase in real economic activity will increase oil price. However, our results show that aggregate demand shock is negatively associated with oil price, which is contrary to expected lines. But as domestic oil price partially depends on international oil price, there is no direct link between global real activity and domestic oil price. In comparison, the coefficients associated with speculative demand shock have negative and statistically significant influence on oil price, and this goes well with economic theory. In other words, any shock due to increase in oil inventories will result in decrease in oil price. The second row measures the impact of sources of oil price shock on that of oil supply. The supply side of oil is not affected by the above-mentioned shocks. Oil supply can be influenced by some other shocks such as political events and cartels, which our model does not consider.

The third row measures the impact of different sources of oil price shocks on global real economic activity. Oil price shock has positive effect on global economic activity: the shock due to oil price increase will boost oil production, and in turn, will strengthen global economic activity. Hence, the results obtained are on expected lines. Similarly shock on the supply side of oil has positive - and statistically significant - impact on real economic activity, which means that higher supply of oil will boost the production of energy-intensive industries, and in turn, improve economic performance globally. Looking from the inflation channel perspective, increase in the supply of oil will lead to decrease in the crude oil price; this will cut down the production cost of majority of industries, and inflation will be brought down, boosting stock market. As stock market is considered to be the barometer of economic performance, wellness of stock market also indicates a strong economy. Real economic activity is positively – and statistically - affected by its own shock. Our model assumes that any shock in real economic activity will not have contemporaneous effect on global real economic activity, but will have influence with lag. On the other hand, speculative demand shock has negative effect on real economic activities. That means any shock inventories will have negative influence on real economic activity.

The fourth row shows how oil inventories respond to shock endogenous variables. In our estimation we keep the first and the third rows blank, as we assume that oil price shock and aggregate demand shock do not affect the inventories. The coefficients associated with oil supply shock are statistically significant, and are not surprising, as oil supply shock has negative influence on inventories. Thus, it can be interpreted that increase in current oil supply will deplete the current oil inventories. Since oil is storable, depletion in oil inventories will influence the real oil price. Also, any speculation about future oil demand and supply will also influence the current oil inventories, and as a consequence, this will impact the real oil price, and will ultimately affect the stock returns. Next, oil inventories are positively affected by their own shock.

The last row of the table measures the response of our interest variable (Indian stock returns) to the sources of oil price shocks. Stock return is positively - and statistically significantly - affected by oil price shocks. On the other hand, stock return responds negatively to oil supply shock. To put it in another way, responding disruption in oil supply, oil suppliers (producers) will exhaust oil inventories to make up for the loss in production. An increase in the oil price, emerging from the disruption in oil supply shock, cause a decline in the Indian stock returns at firm level. These results are similar to those of the study done by Kilian and Park (2009): the study concluded that US stock returns reacted similarly to oil supply shock. Similarly, Likewise, a study done by Ghorbel and Younes (2009) concluded that a negative oil supply shock has negative impact on stock returns of some of the

Figure 1: Oil price shock



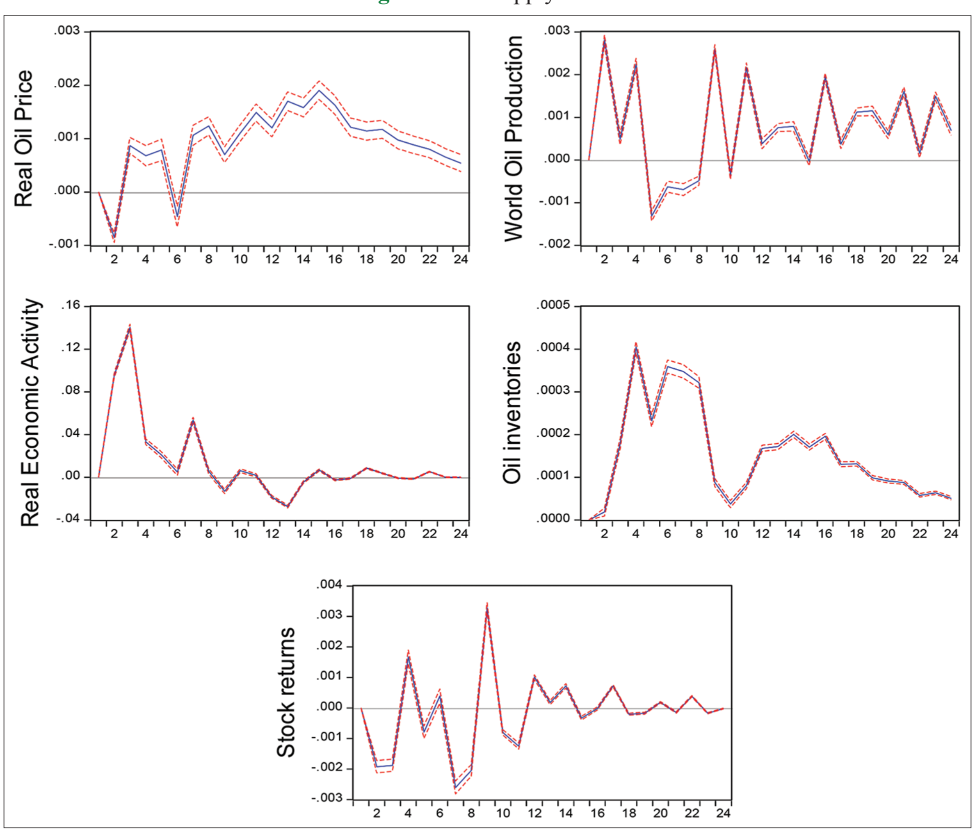
X Axis: Time (monthly), Y Axis: Mean responses. Response to non factorized one standard deviation (SD) innovations ± 2 S.E. *Dynamic responses of stock returns, real economic activity, world oil production, oil inventories and oil price-change to oil price shocks. The solid line gives the mean responses to a one standard deviation shock, while the dotted lines indicate ± 2 standard deviations of the responses. The impulse response function are statistically significant as interval bounds are jointly above or below the zero line importing countries. On the other hand, the results of our study are in contrast with the study done by Akhtam (2004), which suggested that for short-run, oil price shocks have no significant impact on stock returns in emerging markets. The response of Indian stock returns towards shock in aggregate demand is positive, but statistically, not significant. However, the positive association of stock returns with global demand shock is similar to that with the results obtained by Kilian and Park (2009) for US stock returns.

Speculative demand shock has negative - and statistically significant - impact on stock returns. This means that speculative demand shock will lead to higher oil prices. The effect will be inflationary in India, will result in decreased household wealth. These findings are similar to the findings of Guntner (2011), which concluded that stock returns are negatively impacted by a speculative demand shock.

Figures 1-4 show the responses of real oil price, oil production, real economic activity, oil inventories and stock returns to one-SD with four structural shocks. Figure 1 shows that the response to oil price shock results in a decline in real oil price by 0.05% at the 2nd month; however, from the 3rd month, the response becomes positive (0.05%). At the end, (24th month) it reports 0.27% increase. Shock in oil price results in increase in oil production by 0.34% in the 1st month. As expected, positive shock in oil price triggers higher production, and is statistically significant; as a result, oil production consistently increases till the end. Similarly, oil price shock leads to increase in real activity by 2.60%, which is consistent with the theory. So shock due to increase in oil price leads to increase in production, and boosts economic performance. It also causes temporary reduction of real economic activity, which is statistically significant. The effect of unanticipated increase/decrease in oil price on oil inventories is quite cyclical and significant. It begins with positive but marginal effect until the 18th month, and then begins to decline. The effect of oil price shock on stock returns is again cyclical and significant: there is increase in stock returns till the 9th month, and there is a dip at the 10th month. The effect vanishes at the end.

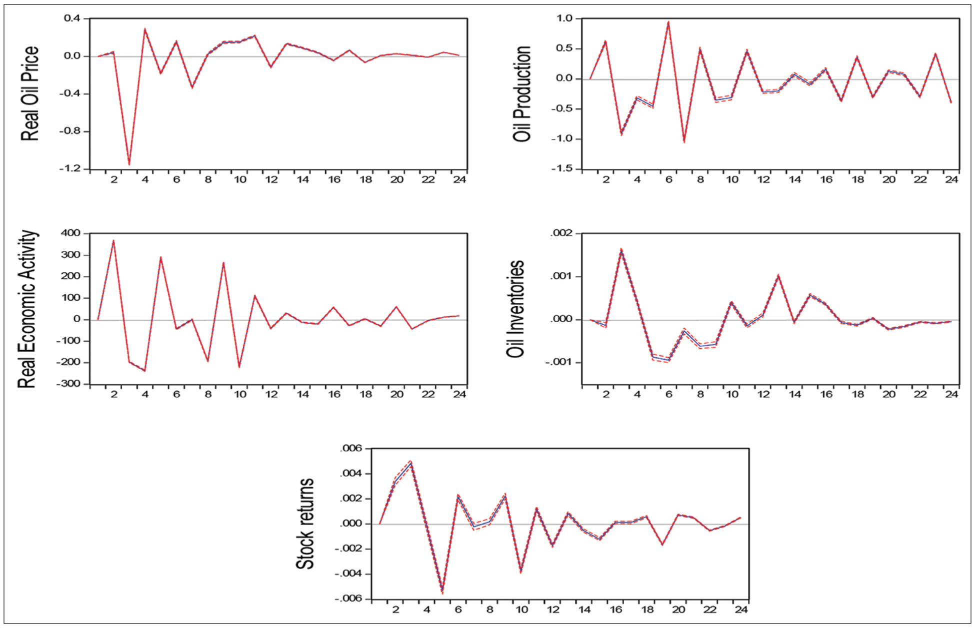
Figure 2 shows the responses to oil supply shock. An unexpected oil supply disruption causes a decline in real oil price by −1.17% at the 1st month. This result is consistent with the view that shock due to dip in oil supply will trigger off an increase in the crude oil price. However, the pattern does not remain the same: from the 3rd month on, there is increase in oil price, and that continues to be persistent and statistically significant till the end. Surprisingly, the response of world oil production to oil supply disruption is positive for the first 5 months. Then the world oil production continues to decrease till the 9th month, and thereafter it recovers. These figures are contrary to the results of the studies done by Kilian (2009) and Gupta and Modise (2013). This could also

Figure 2: Oil supply shock



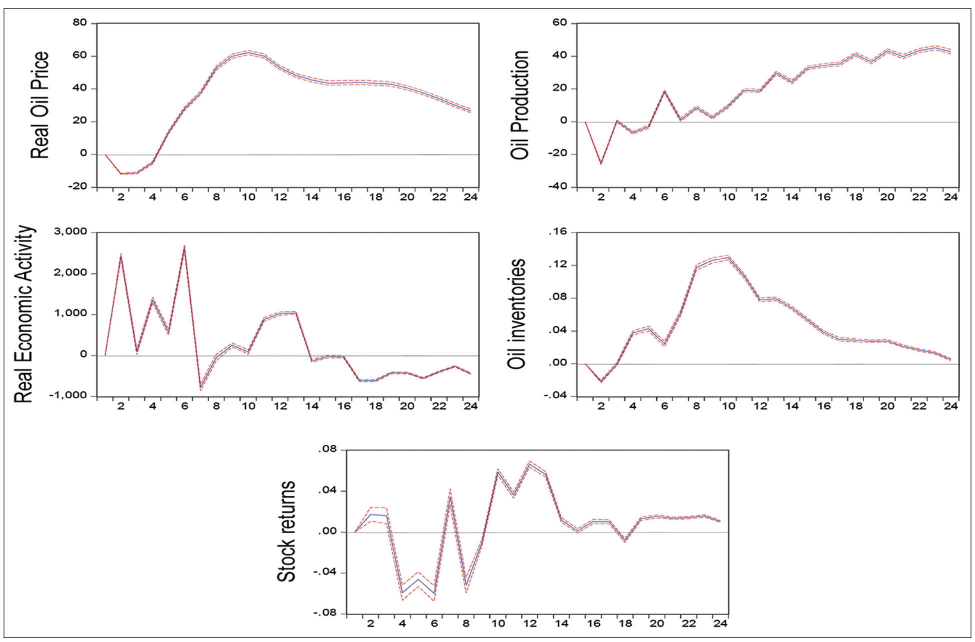
X Axis: Time (monthly), Y Axis: Mean responses. Response to non factorized one standard deviation (SD) innovations ± 2 S.E. *Dynamic responses of stock returns, real economic activity, world oil production, oil inventories and oil price-change to oil supply shocks. The solid line gives the mean responses to a one standard deviation shock, while the dotted lines indicate ± 2 standard deviations of the responses. The impulse response function are statistically significant as interval bounds are jointly above or below the zero line

Figure 3: Global demand shock



X Axis: Time (monthly), Y Axis: Mean responses. Response to non factorized one standard deviation (SD) innovations ± 2 S.E. *Dynamic responses of stock returns, real economic activity, world oil production, oil inventories and oil price-change to global demand shocks. The solid line gives the mean responses to a one standard deviation shock, while the dotted lines indicate ± 2 standard deviations of the responses. The impulse response function are statistically significant as interval bounds are jointly above or below the zero line

Figure 4: Speculative demand shock



X Axis: Time (monthly), Y Axis: Mean responses. Response to non factorized one standard deviation (SD) innovations ± 2 S.E. *Dynamic responses of stock returns, real economic activity, world oil production, oil inventories and oil price-change to speculative demand shock. The solid line gives the mean responses to a one standard deviation shock, while the dotted lines indicate ± 2 standard deviations of the responses. The impulse response function are statistically significant as interval bounds are jointly above or below the zero line

mean that our study period - especially 2013-2018 witnessed higher oil supply, higher oil production and eventually decrease in international oil price. Oil supply shock also has positive and significant effect on real economic activity and oil inventories. Strong economic performance from unanticipated oil supply shock has positive and significant impact on Indian stock returns. Strong economy leaves potential consumers with more wealth and income, resulting in increase in stock returns. The response of stock returns to oil supply shock in our study has more or less followed cyclical pattern, where the 2nd and the 3rd months show negative response, and then, there is increase in stock returns, and so on.

Figure 3 shows that an unanticipated hike in demand for oil, caused by an enhanced global economic performance, will result in increase in oil prices for most of the months. Aggregate demand shock caused short and significant swings in real oil price as there was decline in real oil price in the 3rd, 5th, 12th months, and so on. Unexpected improvement in economic performance also led to increase in production for the 2nd month, and thereafter, witnessed some decline in the 3rd, 5th, 7th, 12th months, and so on. It is not surprising that decline in real oil price in whichever month also witnessed decline in oil production, which is consistent with the view that international oil price contractions lead to decrease in world oil production. The effect of an unanticipated aggregate demand expansion on global real economic activity is volatile as the response keeps changing in every 2 months. It begins with positive real economic activity, but later shows negative response. This also indicates that unanticipated increase in real economic activity temporarily offsets oil production, which in turn affects the real economic activity with some delay. The unanticipated increase in aggregate demand results in lower inventories from 5th to 9th month, and then gradually recovers marginally in between. This is because increased global aggregate demand results in higher demand, leads to slightly higher oil production, and also depletes the inventories. However, the impact is not persistent till the end, as oil inventory accumulation takes place to sustain future demand for oil. The global demand shock has a volatile impact on Indian stock market: it neither has a positive impact which is persistent nor a negative impact throughout the horizon, although the effect is statistically significant. This result is not in line with the studies done by Kilian and Park (2009) for the US economy. Study done by Gupta and Modise (2013) chose South African stock returns as variable of interest. Our results are not in line with of the results obtained from the study done on South Africa. South Africa is an exporting country boosting its own economic performance; and this results in greater income pouring into the economy and households, which then transforms into higher stock returns. India is primarily an importing economy, and so, any turmoil in global economy is going to affect the wealth of the economy in a negative way. Hence, the findings of these two studies are contrary.

Bleak speculative demand shock results in decrease in real oil price for the first 4 months (Figure 4) and then in a recovery of it to a larger extent. The impact of speculative demand shock on real oil price is persistent after the 4th month. This is rational enough as speculation about oil demand and supply will increase the oil demand and oil price in period t + 1 period. The impact of shock in speculative demand on oil production is negative for the first 5 months, and then registers positive response. The reaction of global real activity to speculative demand shock is cyclical. That means, speculation about current flow of demand and supply will lead to uncertainty in the economy. Going by positive speculation about future demand for oil would also result in higher oil prices at t, while global real activity is volatile. As expected, speculative demand shock has positive impact on inventories, except for the first 2 months. This is in line with the findings of Kilian and Murphy (2012). Although the impact of speculative demand shock is positive for the first 4 months, it dips down drastically, and continues to do so till the 9th month. Overall, the effect is again cyclical as one could witness ups and downs in stock returns. This is because domestic oil price is partially dependent upon the status of subsidiaries and taxes. Also, inflation does not depend just upon oil price shocks and its sources, but it depends on other shocks such as inflation shock as well.

5. CONCLUSION

We extend the existing literature that examines the relationship between the stock returns at firm level and different oil market shocks by working on Kilian (2009) methodology by disaggregating the effects of oil market shocks at disaggregated level by using firm-level stock returns of India. We distinguish oil shocks between flow demand, flow supply and speculative demand shocks. In order to assess the impact of these shocks on response variables, we employ structural VAR model using monthly data from 1995:01 to 2018:12. We also use GMM technique since our model suffers from endogeneity, thanks to the use of panel data.

The results show that stock returns at firm-level respond differently to various oil shocks. Oil price shock has positive impact on stock returns. This is due to the fact that the decline in oil price, witnessed over the later years of our study period, might have triggered higher stock returns. This is in line with Akhtam (2004), in whose study results, short-run oil price shocks have no negative impact on stock returns. There is negative relationship between oil supply shock and stock returns, so any disruptions in supply of oil makes oil price uncertain, which, in turn, has negative impact on stock returns. Also, an expected higher aggregate demand shock has positive impact on stock returns. Our results are in line with certain literature which suggests that there is a positive relation between aggregate demand and stock returns. Our results convey that policy makers and investors should look into the sources of oil price shocks before implementing policies or making investment decisions. For example, oil prices are driven by structural demand and supply shocks that may have direct effects on stock returns.

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