Energy Economics 96 (2021) 105111

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Oil shocks and stock market: Revisiting the dynamics

Anand B. [a], Sunil Paul [b,*]

[a] Sarla Anil Modi School of Economics, Narsee Monjee Institute of Management Studies (NMIMS), Mumbai, India
[b] School of Humanities and Social Sciences, Indian Institute of Technology Goa (IIT), Goa, India

ARTICLE INFO

Article history:
Received 18 June 2020
Received in revised form 1 December 2020
Accepted 7 January 2021
Available online 2 February 2021

Keywords:
Crude oil
Stock returns and volatility
Expected oil demand shocks
Time-varying Structural VAR.

ABSTRACT

The impact of crude oil shocks on the real and financial sector depends on its origin. This study examines the expected demand and supply specific oil shocks on stock market returns and its volatility in the Indian context. Time-Varying Parameter Structural Vector Autoregression-Stochastic Variance (TVP-SVAR-SV) model is used to estimate the models and identify the oil supply shocks, demand specific oil shocks and macro uncertainty shocks. The model is estimated using monthly crude oil price changes, returns of the major oil-producing companies, Policy Uncertainty Index and the stock returns from Jan 2003 to Feb 2020. The impact of oil shocks on stock return volatility is also analysed replacing stock returns with its realised volatility. The impulse response of the Indian stock returns and its volatility from TVP-SVAR-SV model indicate that expected oil demand shocks significantly affect the stock returns and its volatility. However, the results suggest no impact in the case of supply shocks. Similarly, shocks to policy uncertainty leads to negative returns and an increase in its volatility.

1. Introduction

Post-1980s, several economies have embraced liberal economic policies to boost their international trade and economic growth. Such a policy shift resulted in not only deeper integration across global financial markets but also more significant interactions between worldwide financial and commodity markets. Within the commodity markets, crude oil deserves special attention as it is one of the crucial factors of production and a fundamental determinant of economic growth. Thus, after a series of adverse oil price shocks in the 1970s and 1980s, price fluctuations in the international crude oil markets and its aftermath on both the real and financial sector variables caught the attention of researchers, policymakers and financial market participants.

A plethora of empirical and theoretical research probing into the impact of oil prices on economic activity has been added to the related literature ever since the 1970s.[1] However, most of these studies were conducted in the context of industrialised economies and generally established an inverse relationship between oil price fluctuations and economic activity. Theoretically, an adverse oil price shock can affect the economy predominantly through two channels, namely consumption and production channels. In the case of the consumption channel, an oil price rise will exert pressure on the consumer's cost of living, which further exacerbates the economic uncertainties. Such uncertainties will negatively affect the aggregate consumption levels, as consumers are likely to increase their savings and reduce expenditures. Likewise, higher oil prices will adversely affect both production costs as well as the business sector uncertainties, which eventually results in reduced levels of production (Lee and Song, 2011).

In the last couple of decades, an enormous volume of literature has explored various aspects of oil price shocks on the financial sector variables.[2] In particular, studies that investigate the impact on stock market returns have generated immense curiosity among academia and financial practitioners. Theoretically, oil prices can affect stock markets through various channels. For example, an increase in oil prices can cause a reduction in the discount rate via inflationary pressure and lead to an adverse reaction in the stock market (Huang et al., 1996). Similarly, Jones and Kaul (1996) indicate that oil price shocks can negatively affect expected earnings of equities and thus indirectly affect equity prices. Also, rising oil prices can result in higher business operating costs and reduced levels of corporate earnings (Huang et al., 1996; Sadorsky, 1999; Awerbuch and Sauter, 2006; Papapetrou, 2001).

Moreover, the nature of the stock significantly influences the oil-stock dynamics, i.e. whether it represents a consumer or producer of oil and oil-related products. Firms that use oil as a direct or indirect input will be affected by an oil price shock if higher input price does not pass on to the consumers. As a result, both profits and dividends - two crucial factors that influence equity prices- will be negatively affected. Likewise, the impact of oil price fluctuations on equity markets depends on whether the market belongs to an oil-producing country

* Corresponding author.
E-mail address: sunil@iitgoa.ac.in (S. Paul).

[1] See, for example Pierce and Enzler (1974); Gordon (1975); Mork and Hall (1980); Darby (1981); Hamilton (1983); Burbidge and Harrison (1984); Gisser and Goodwin (1986)

[2] See, for example, Bernanke et al. (1997); Gil-Alana (2003); Sadorsky (2011); Shah et al. (2018); Phan et al. (2019); Ji and Fan (2012)

https://doi.org/10.1016/j.eneco.2021.105111
0140-9883/

or non-oil producing country. Generally, significant upward correction of oil prices will exacerbate both risks as well as uncertainty and negatively affect the stock returns of an oil-importing country. Whereas, surging oil prices will positively affect an exporting country's stock market returns provided the government utilises additional oil revenue for increased economic activity through higher public expenditure (Al-Fayoumi, 2009).

1.1. Oil price shocks and stock market returns: A brief review

Interestingly, the empirical evidence on the link between oil and stock market returns appears to be inconclusive and ambiguous in terms of both the sign and size. Generally, the literature suggests a negative relationship between oil prices and stock market returns and various empirical studies confirm this.[3] However, several studies showcase a positive correlation between the two. For instance, Narayan and Narayan (2010) found that oil prices exert a positive and statistically significant impact on Vietnam's stock prices. Similarly, Ono (2011) examined the oil- stock returns relationship for BRIC countries from 1999 to 2009. His results indicate that there exists a positive relationship between real stock returns and some of the oil price indicators for China, India and Russia. The empirical findings of Sadorsky (2001) also point towards a positive and significant relationship between stock prices of Canadian oil and gas companies and crude oil prices. Also, Boyer and Filion (2007) show that the oil and gases prices positively affect stock returns of the energy sector.

Another strand of related literature suggests weak or, even no-correlation between oil price volatility and stock market returns.[4] Such conclusions need further attention as a substantial volume of empirical literature has established a significant relationship between the two, although the direction and magnitude varies. A possible reason for such low association reported by several studies might have emanated from the lack of attention given to the distinct effects of supply and demand shocks embedded in an underlying oil shock. More specifically, oil price fluctuations emerging from supply and demand shocks will impact the stock market differently. For instance, while supply shocks exert a negative and significant impact on stock market returns, demand shocks lead to a significant positive impact. The negative effect associated with supply shocks is quite evident in the case of firms that concentrate on consumer goods, which implies a reduction in consumer spending. On the contrary, the positive relationship originating from oil demand shocks reflect high demand and revenue for the manufacturing firms that use oil as an input for production (Hamilton, 2003).

Various empirical studies previously have suggested the idea that shocks from distinct sources affect the economy in different ways (Kilian, 2008; Cavallo et al., 2012). However, there is a fundamental shortcoming concerning this method; that is to identify a supply shock, there must be an evident disruption in the production of oil, such as a political turmoil or natural calamity. Though this approach seems to be alright, the classification of the shock becomes complex when there is a slow but consistent rise in crude oil prices (Ready, 2018).

As an alternative to this approach, Kilian (2009) decomposes demand and supply shocks by choosing two proxies for oil supply and demand, namely crude oil production and shipping prices. Further, Kilian and Park (2009) extended this approach to study the impact of oil supply and demand shocks on the US stock market. Nevertheless, their study indicates the negligible effect on stock returns by both supply and demand shocks. Similarly, Kilian (2009) explains that only 4% of the contemporaneous variation in oil price changes from 1986 to 2011 was due to the identified demand and supply shocks. Also, the significant portion of oil price changes (77%) can be attributed to precautionary demand shocks and, it may change due to supply-related concerns and expectation of higher demand. Moreover, the shipping prices data used in the model reflects the increases in demand with a lag. In this context, Ready (2018) proposes the asset price index of oil-producing companies as a control variable to distinguish demand and supply shocks. He argues that the stock index of oil-producing companies respond to changes in demand for oil than its supply and a positive demand shock in the oil market will favourably affect the returns of the oil-producing companies.

1.2. Oil price-stock market dynamics: The Indian context

Investigating the oil-stock dynamics in the Indian context deserves attention at least for two reasons. Firstly, emerging economies like India have become the economic powerhouse of the world and they have the potential to deliver further. Secondly, India has deregulated its retail petroleum prices, which will increase the economic uncertainties as and when the international crude oil prices escalate significantly. Such domestic uncertainties will undoubtedly have ramifications on both the real and financial sector. The related literature reveals that the Indian stock market returns are affected by international oil price fluctuations. For instance, Sahu et al. (2014) show that there exists a positive long-run relationship between oil prices and the Indian stock market returns. However, the study also indicates that oil prices do not have a significant causal effect on Indian stock market. Anand et al. (2014) suggest that crude oil price fluctuations significantly affect the volatility of stock market returns. Moreover, the volatility spillover from oil to stock returns appeared to be stronger after the global financial crisis. Ghosh and Kanjilal (2016) by employing the Toda–Yamamoto version of Granger causality tests for the period ranging from January 2003 to July 2011 conclude that international crude oil prices do affect the Indian stock market in phase II (January 2003–June 2007) and Phase III (January 2009–July 2011) with no feedback effect.

At this outset, this study contributes to the existing literature in the Indian context in several ways. The oil prices may respond differently depending upon the nature of shocks. For instance, an increase in oil prices due to an expected rise in oil demand signals better economic prospects. Oil being an essential input for production in many manufacturing industries, it is intuitive to argue that such oil price revisions as positive news in the stock market. The existing empirical literature does not provide sufficient insights about this channel through which oil shocks affect the stock returns and its volatility. The study employs the index of oil-producing companies to capture the impact of expected oil demand shocks.[5] Accordingly, we assume, the innovations in the index of oil-producing companies as oil specific demand shocks in time-varying structural VAR systems. Similarly, India being one of the largest crude oil importers and an emerging economy, the dynamics between the two variables experience significant changes. Hence, the interaction needs to be examined using a time-varying parameter model. Apart from this, the related literature often neglects the impact of domestic macroeconomic uncertainties on stock returns and its volatility. Various studies have highlighted the influence of macroeconomic uncertainties on stock markets returns through channels such as discount rates and expected earnings.[6] Also, Kang and Ratti (2013) reveal that oil price shocks are one of the major contributing factors of

[3] See, for example, for example, Hamilton (2003); Al-Fayoumi (2009); Filis (2010); Miller and Ratti (2009); Basher et al. (2012)

[4] For further reading refer, Chen et al. (1986); Jones and Kaul (1996); Huang et al. (1996); Sadorsky (1999); Kilian and Park (2009)

[5] See Ready (2018) for a similar argument

[6] See for example, Gallo et al. (2016); Kang (2019); Kang and Ratti (2013)

domestic macroeconomic uncertainties. Hence, we attempt to capture the impact of macroeconomic uncertainty using the Policy Uncertainty Index based on Baker et al. (2016).[7]

2. The empirical approach

2.1. The model

Time-varying Parameter Structural Vector Auto Regressions with Stochastic Variance (TVP- SVAR-SV) model is used to examine the effect of shocks from oil to Indian stock returns and its volatility. TVP-SVAR-SV would be more appropriate as it captures the time varying VAR coefficients and the error covariance matrix. The constant parameter structural VAR fails to account the time variations among the relationships which may lead to incorrect inference about the interconnectedness between these variables.[8] Similarly, TVP- SVAR is better compared to a constant parameter VAR based on subsamples or rolling samples as we can avoid arbitrariness in the choice of sample period and the resulting loss of information. Following Primiceri (2005) and Del Negro and Primiceri (2015) we assume that:

$$y_t = B_{0,t} + B_{1,t}y_{t-1} + \ldots + B_{p,t}y_{t-p} + u_t \tag{1}$$

where y_t is a 4×1 vector with returns of Brent Oil prices (op_t), returns of NYSE Arca Oil index (od_t), Economic Policy Uncertainty Index (epi_t) and stock market indicators based on BSE Sensex as its elements. The paper estimates two models with different stock market indicators; one with stock returns(r_t) and another with its realised volatility(v_t). $B_{0,t}$ is a 4×1 vector of time varying constants and $B_{j,t}$ for $j = 1, 2, \ldots p$ are 4×4 matrices of time varying coefficients. Further, we assume that $\beta_t = vec([B_{0,t}, B_{j,t}]^T)$, where $vec(.)$ is the vectorization operator that rearranges the elements of **B** as a vector. The reduced form errors are the heteroscedastic unobservable shocks and it follows a Gaussian process($u_t \sim N(0, \Omega_t)$. The relation between reduced form error from structural errors are given as follows:

$$u_t = A_t^{-1}\Sigma_t\varepsilon_t \tag{2}$$

where A_t is a lower triangular matrix with ones on the main diagonal, Σ_t is a diagonal matrix and $\varepsilon_t \sim N(0, I_n)$. Then the Ω_t can be decomposed as follows:

$$A_t\Omega_t A_t^T = \Sigma_t\Sigma_t^T \tag{3}$$

For simplicity the coefficients of the contemporaneous relations in A_t is assumed to evolve independently. Therefore, each equation can be represented by column vectors $\alpha_{i,t}$ for $i = 1,2,3$ containing the first i elements of the $(i+1)^{th}$ row of A_t. Further, let $\alpha_t = [\alpha_{1,t}^T, \ldots, \alpha_{3,t}^T]$ and σ_t be the vector of diagonal elements of Σ_t. We assume all the time varying coefficients to evolve as a random walk process:

$$\beta_t = \beta_{t-1} + \nu_t \tag{4}$$

$$\alpha_{i,t} = \alpha_{i,t-1} + \zeta_{i,t} \tag{5}$$

$$\log\sigma_t = \log\sigma_{t-1} + \eta_t \tag{6}$$

All the innovations are assumed to follow a joint normal distribution with a variance-covariance matrix as given below:

$$V = Var\left(\begin{bmatrix}\varepsilon_t \\ \nu_t \\ \zeta_t \\ \eta_t\end{bmatrix}\right) = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \tag{7}$$

where $\zeta_t = [\zeta_{1,t}^T, \ldots, \zeta_{4,t}^T]$. The variance-covariance of $\zeta_t(S)$ is assumed to be block diagonal (i.e. three independent blocks S_i for $i = 1,2,3$, as the elements of α_t evolves independent to each other. TVP-VAR- SV model is chosen for the following considerations. The TVP-VAR-SV is capable of capturing the time-varying nature of shocks and is flexible enough to capture the unknown uncertainty that affects both oil and stock market.

2.2. Model specification

The posterior distributions of the time-varying coefficients are estimated using Markov Chain Monte Carlo(MCMC) methods given in (Del Negro and Primiceri, 2015). The study uses 40,000 iterations of the Gibbs sampler after discarding first 10,000 iterations as burn-in. We estimate the TVP-SVAR-SV model with two lags, and the standard convergence statistics were satisfactory. Time-invariant VAR is estimated using the first 40 observations ($\tau = 40$) to calibrate the prior distributions. The specification of prior is as follows:

$$\beta_0 \sim N\left(\hat{\beta}, 4.\hat{V}_\beta\right) \tag{8}$$

$$\alpha_{i0} \sim N\left(\hat{\alpha}_i, 4.\hat{V}_{\alpha i}\right) \tag{9}$$

$$\log\sigma_0 \sim N(\log\hat{\sigma}, I_n) \tag{10}$$

$$Q \sim IW\left(\hat{Q}, \tau\right) \tag{11}$$

$$W \sim IW\left(\hat{W}, d_w\right) \tag{12}$$

$$S_i \sim IW\left(\hat{S}_i, d_{si}\right) \tag{13}$$

where $\widehat{\beta}, \widehat{V}_\beta, \widehat{\alpha}_i, \widehat{V}_{\alpha i}$ and $\log\widehat{\sigma}$ are the point estimates from time invariant VAR and $\widehat{Q} = \tau\left(\lambda_1\widehat{V}_\beta\right), \widehat{W} = d_w(\lambda_2 I_n)$ and $S_i = d_{si}\left(\lambda_3\widehat{V}_\alpha\right)$. We assume $\lambda_1 = 0.0001$, $\lambda_2 = 0.01$ and $\lambda_3 = 0.0001$ and the degrees of freedom for the Inverse Wishart(IW) prior distributions are set as follows: τ for Q, d_w for W (which is equal to the number of rows in I_n) and d_{si} for S_i which is equal to $(i+1)$ for $i = 1, 2, \ldots, n-1$. The values of prior distributions so specified are diffusive and uninformative but not flat.

2.3. Identification of shocks

Although, the identification scheme used in this paper follows the strategy of Ready (2018) to distinguish expected oil demand and supply but it is distinctly different from it. Our paper, following Ready (2018), also uses returns of oil producing companies (NYSE Arca Oil Index) to identify the oil specific demand shocks. It is assumed that the oil producing firms benefit from increases in oil demand and have an innate hedge against shocks to oil supply, hence the shocks to the returns of oil producing companies can be used to identify the expected oil demand shocks. Similarly, the identified shocks are orthogonal to unexpected changes in the VIX index, with supply shocks being defined as oil price changes orthogonal to demand shocks and changes in the VIX. The empirical evidence shows that the supply and demand shocks so identified captured 78% and 21% of total variation in oil prices respectively. The risk shocks captured by VIX index accounted only 1% of the

[7] The index of policy-related economic uncertainty for India is created following Baker et al. (2016). The index is a weighted average of the news coverage related to uncertainties, policy and economy in 7 leading Indian newspapers namely, The Economic Times, the Times of India, the Hindustan Times, the Hindu, the Statesman, the Indian Express, and the Financial Express. The data and details are available at http://www.policyuncertainty.com

[8] Existing literature in the Indian context also highlight the time varying nature of relationship between oil prices and stock market (Ghosh and Kanjilal, 2016; Anand et al., 2014). Differences in correlation between stock returns and oil price changes across various shock episodes is provided in Table A1 in Appendix A.

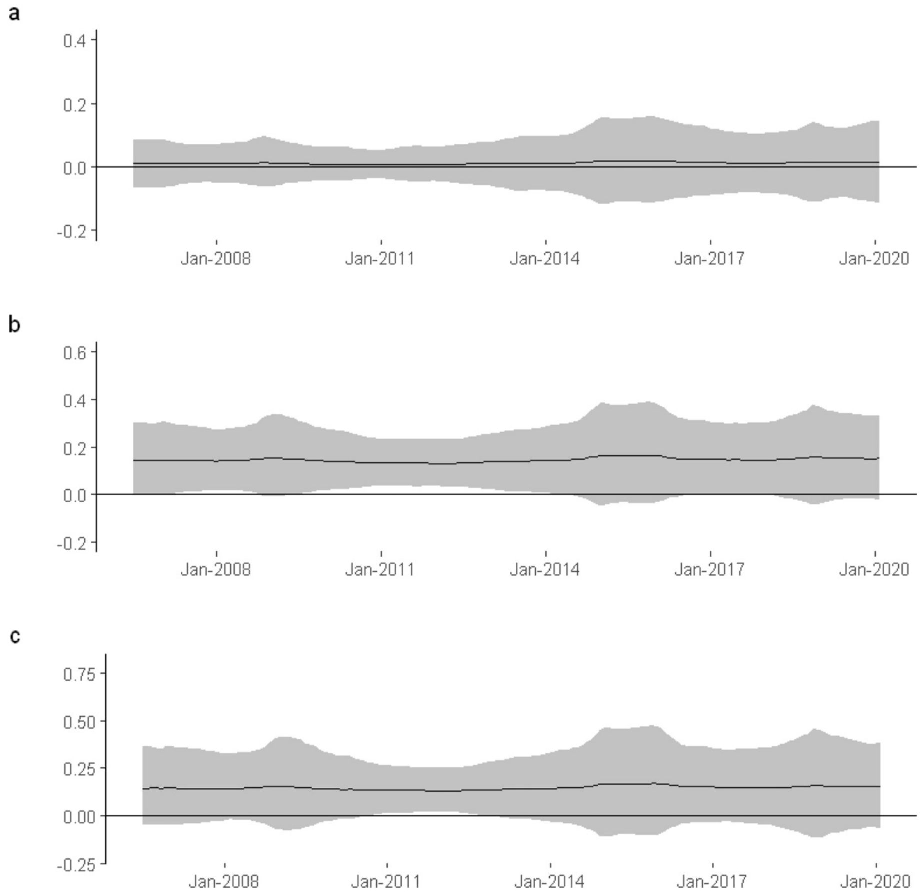

Fig. 1. Accumulated impulse responses of stock returns to one unit increase supply specific oil shocks. Panel a)Simultaneous responses; Panel b)Three months ahead responses; and Panel c) Six months ahead responses. *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as the shaded area around the line.

total variation. This strategy helps to identify the forward looking nature of oil prices compared to the schemes used in other pioneering works such as Kilian (2009). Forward looking demand and supply shocks are far more important than the realised shocks (Fueki et al., 2020; Davig et al., 2015). However, our study differs from Ready (2018) on the treatment of risk shocks and the use of TVP-SVAR-SV model. Economic policy uncertainty (EPU) index is used instead of VIX index as a proxy for changes in risk, as it captures not only the changes in aggregate risk but also the precautionary demand of oil. Empirical evidences suggest that uncertainty index and oil shocks are interconnected and EPU enhances the impact of oil price shocks (Kang and Ratti, 2013; Aloui et al., 2016; Antonakakis et al., 2014).

Coefficient matrix of contemporaneous relations A_t^{-1}, is restricted to be a lower triangle matrix to identify the oil shocks. The relation between reduced form and structural errors with these restrictions are given as follows:$u_t = A_t^{-1}\Sigma_t\varepsilon_t$. The identifying restriction is given above assumes that return of crude oil prices is contemporaneously orthogonal to all other shocks. Similarly, the return of stock index of oil-producing companies is assumed to respond contemporaneously to oil price shocks but not to policy uncertainty and Indian stock returns or its volatility. The policy uncertainty index ordered after the oil market block, and it implies that any shocks in the oil market instantaneously would reflect in the policy uncertainty index following Kang and Ratti (2013). The stock market indicators (returns in model 1 and volatility in model 2) respond to all the shocks contemporaneously. As discussed in the previous section, we assume that the innovations in the return of the index of oil-producing companies as expected oil demand shocks. Hence, the innovations of return on oil prices can be interpreted as oil specific supply shocks as we already controlled for the demand side factors using the return of the index of oil-producing companies, and the macro uncertainty shocks including precautionary oil demand shocks using EPU index.

2.4. Data

The monthly data on the relevant variables are collected over the sample period from 2003:01 to 2020:02. The world Brent crude oil price (US dollars per barrel) is obtained from the International Monetary Fund (IMF). The dollar price of oil was then transformed into Indian currency using average monthly bilateral exchange rates. This study uses the asset prices of oil-producing companies to identify the expected oil demand shocks. Accordingly, returns of NYSE Arca Oil Index is used as a proxy for oil-producing companies. NYSE Arca Oil Index is a price-weighted index of the leading companies involved in the exploration, production, and development of petroleum. Returns of crude oil prices and NYSE Arca Oil index are then constructed. News based policy uncertainty index is collected from the policy uncertainty portal, as mentioned in footnote 7. Monthly returns of BSE Sensex and its realised volatility is taken as Indian stock market indicators. The realised volatility measures of stock returns are constructed using daily returns of BSE Sensex r_i. The monthly realised volatility is constructed as $v_t = \log\left(\sum_{i=1}^{M} r_i^2\right)$.[9] where M is the total number of days in a particular month. The construct of monthly volatility series thus reflects the contributions of daily volatility.

[9] Logarithmic transformation realised volatilities are considered rather than the standard deviation to avoid negativity constraints

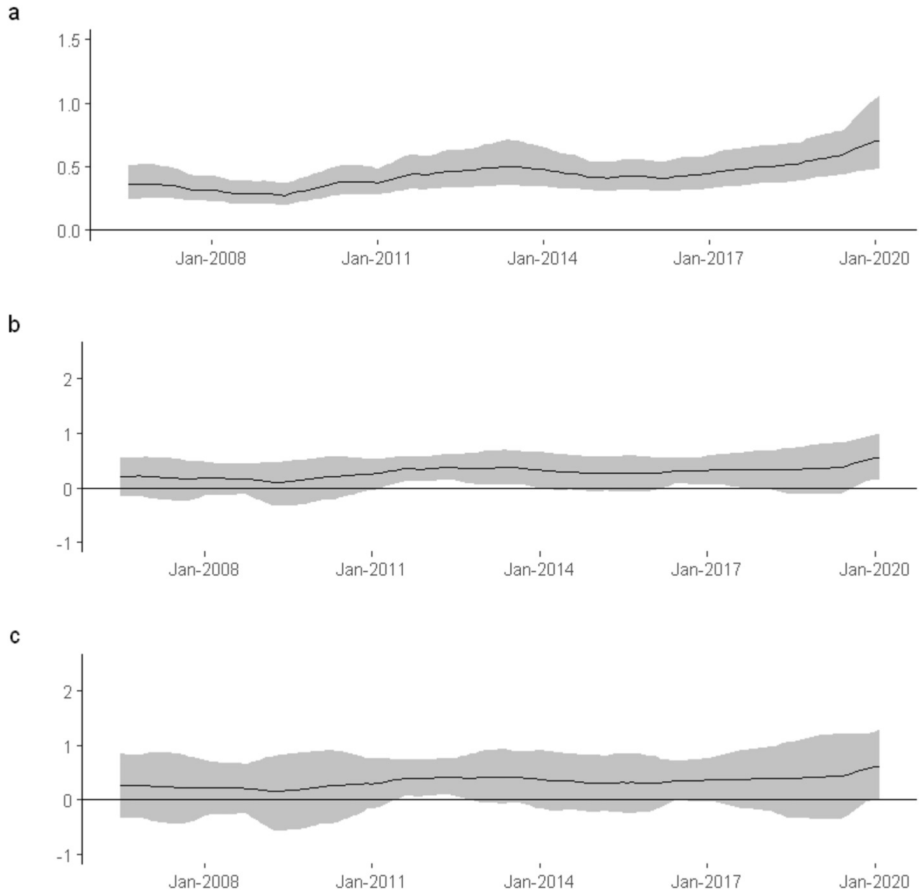

Fig. 2. Accumulated impulse responses of stock returns to one unit increase expected oil demand shocks. Panel a)Simultaneous responses; Panel b) Three months ahead responses; and Panel c) Six months ahead responses.) *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as the shaded area around the line.

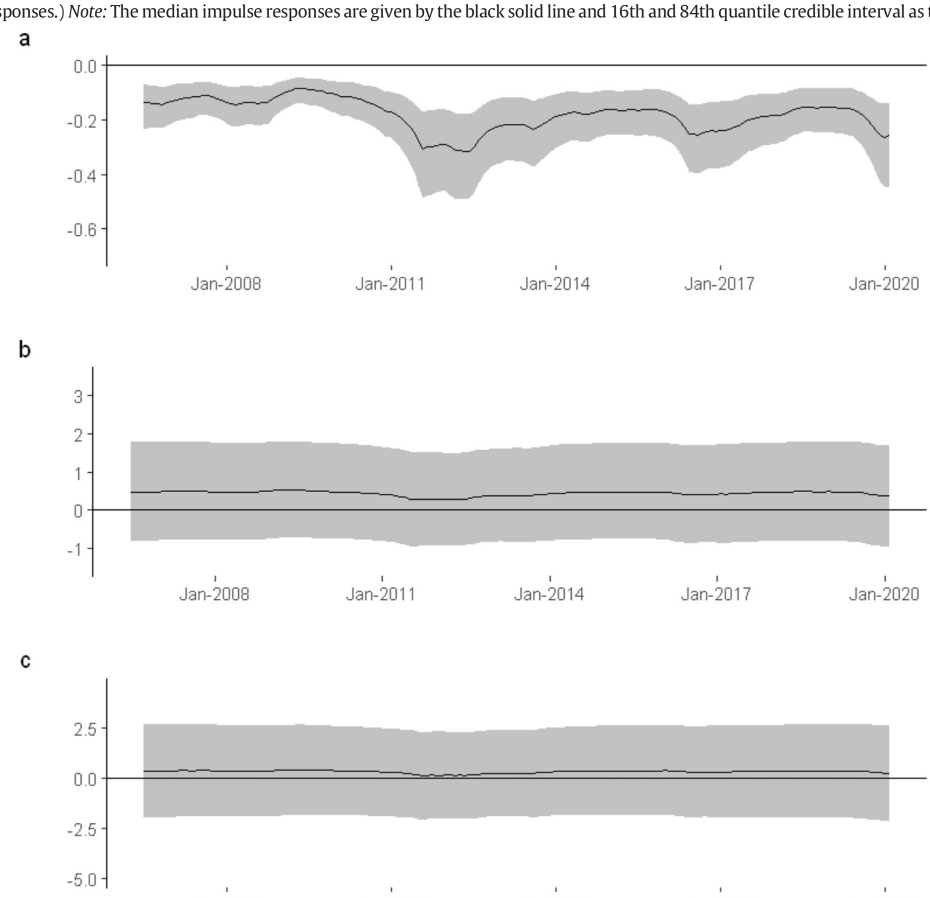

Fig. 3. Accumulated impulse responses of stock returns to one unit increase Indian macro uncertainty shocks. Panel a)Simultaneous responses; Panel b)Three months ahead responses; and Panel c) Six months ahead responses. *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as the shaded area around the line.

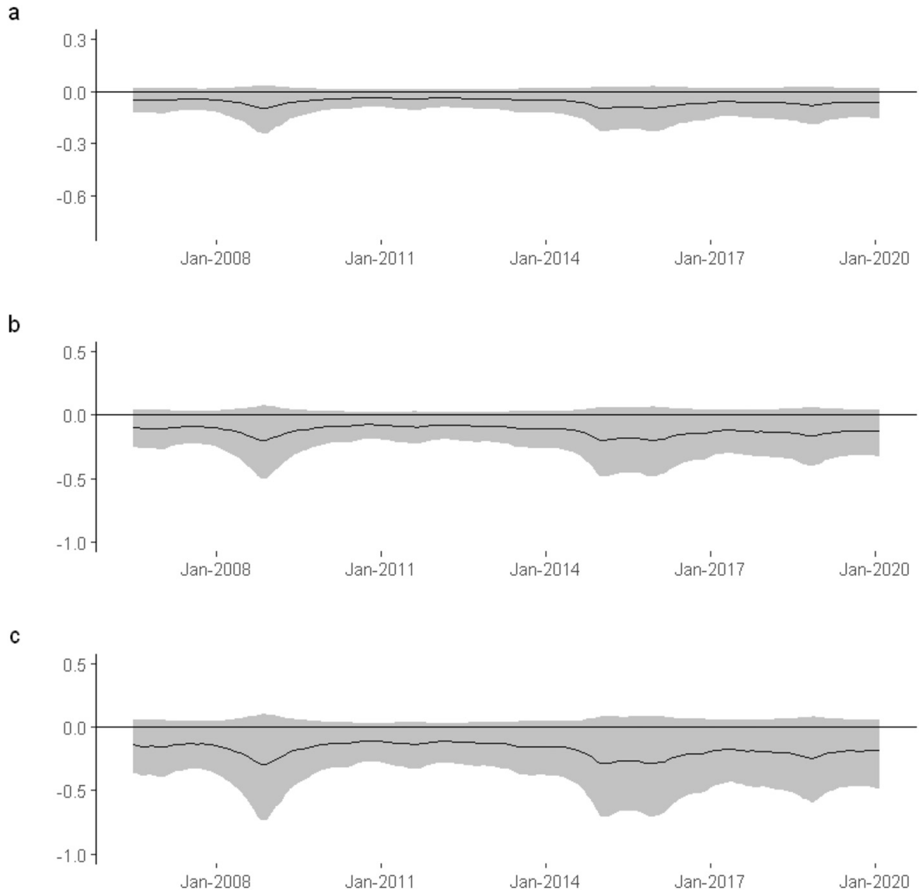

Fig. 4. Accumulated impulse responses of stock return volatility to one unit increase supply specific oil shocks. Panel a)Simultaneous responses; Panel b)Three months ahead responses; and Panel c) Six months ahead responses. *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as thd shaded area around the line.

3. Results and discussion

The impact of oil shocks on stock market is examined using the estimates of models given below:

Model 1: $y_t = (op_t, od_t, epu_t, r_t)$.

Model 2: $y_t = (op_t, od_t, epu_t, v_t)$.

Model 1 examines how different kinds of oil shocks affect stock returns, and model 2, the stock volatility. All the variables are tested for its time-series properties using standard unit roots tests such as Augmented Dicky Fuller(ADF) and Phillps -Perron unit root test. The results indicate that the variables under scrutiny are stationary at levels.

3.1. Oil shocks and stock returns

Figs. 1 to 6 display the accumulated impulse responses of stock returns and volatility. Fig. 1 shows the accumulated response of stock returns to supply specific oil shocks, Fig. 2, responses to expected oil demand shocks, and Fig. 3 captures the responses to the shocks to EPU index. Similarly, Figs. 4 to 6 display the accumulated impulse responses of realised stock volatility to supply specific oil shocks, expected oil demand shocks and Indian policy uncertainty index shocks. Each figure exhibits the contemporaneous, 3 and 6 months ahead accumulated responses in separate panels. The median time-varying simple posterior impulse responses of stock returns and its volatility to these shocks up to 20 months ahead horizons are given in Figs. A.7 and A.12 in Appendix A.[10] These 3D graphs are presented to show the persistence of responses for those shocks which are statistically credible as per the significant intervals given in Figs. 1 to 6.

Fig. 1 shows the posterior accumulated impulse responses of stock returns to shocks in oil prices. The median of impulse responses are given by black solid line and the 16th - 84th quantile credible interval is given by the shaded area in the plots. The simultaneous response of stock returns to supply specific oil shocks are given in Panel (a) and it indicates no significant response in stock returns. Likewise, the 3 and 6 months ahead accumulated impulses in panel b) and c) also suggest no significant response from stock returns due to supply specific oil shocks. The response of stock returns to simultaneous demand specific oil shocks are positive as given in Fig. 2(a). The expected increase in oil demand signals future higher earnings, which impacts the stock returns positively. For instance, crude oil markets experienced higher prices during 2009–11 owing to demand-side factors and the oil demand shocks during this period had a more significant influence on stock returns as evident from the plot. Further, panel b) and c) in Fig. 1 shows the accumulated impulse responses after 3 and 6 months, respectively. The results reveal no significant responses in stock markets returns at these horizons. This implies that the impact of demand shocks on stock returns are transitory. The same is evident in Fig. A.8 in the appendix, which shows the median time-varying impulse response of expected oil demand shocks on stock returns for up to 20 months ahead period. The response of stock returns seemingly oscillates between positive and negative regions, then eventually converges to zero. Fig. 3 shows the response of stock returns to a unit impulse in policy uncertainty index. The contemporaneous shocks to economic policy uncertainty index have a negative and significant impact on stock returns (Fig. 3a). However, the impact is statistically insignificant after 3 (Fig. 3 b) as well as six months (Fig. 3c) as given by the 16th - 84th

[10] Accumulated impulses are plotted in the Figures 1 to 6. The 3D plots in appendix display simple impulse responses of stock returns and volatility for better clarity

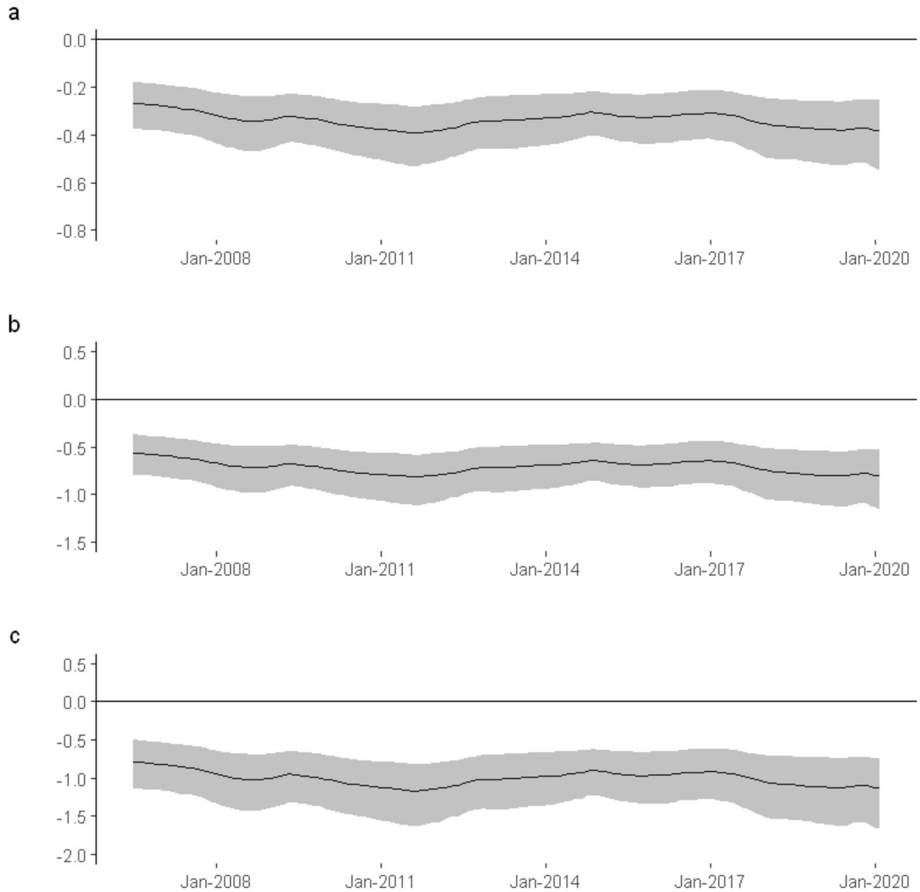

Fig. 5. Accumulated impulse responses of stock volatility to one unit increase expected oil demand shocks. Panel a)Simultaneous responses; Panel b) Three months ahead responses; and Panel c) Six months ahead responses.) *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as thd shaded area around the line.

quantile credible interval in these figures. The impulse response graph shows considerable time variation compared to the impulse responses of supply specific oil shocks and expected oil demand shocks. The Fig. A.9 in appendix summarizes the information of median impulse responses and indicates the transitory nature of shocks on stock returns similar to oil demand shocks discussed earlier.

3.2. Oil shocks and stock volatility

In order to understand the impact of oil shocks on stock volatility the stock returns were replaced with realised stock return volatility and generated the impulse responses. The results of accumulated impulse responses of stock volatility are given in Figs. 4 to 6. The median impulse responses of stock return volatility due to supply specific oil shocks, expected oil demand shocks and policy uncertainty shocks are presented as 3D plots in Figs. A.10 to A.12, appendix (A).

The response of stock return volatility to oil supply shocks are presented in Fig. 4. The contemporaneous responses of stock returns is given in panel (a), the median impulse responses are given by the black solid line with the 16th and 84thquantile credible interval as the shaded areas. As evident from the plots, the oil supply shocks seem to have a statistically insignificant impact on stock return volatility. The panel (b) and (c) gives the three and six months ahead accumulated responses of stock volatility and it shows similar patterns. Fig. (5) captures the accumulated impulse responses of stock return volatility due to expected oil demand shocks. The contemporaneous response of stock return volatility is positive and significant. As discussed earlier, the innovations in the stock index of oil producing companies capture the expected changes in the oil demand and positive shocks indicate better prospects for the global as well as domestic economy. As better prospects are expected in the long-run, the equities of domestic industries which use oil as input will be less volatile. Panel (b) and (c) show the 3 and 6 months ahead accumulated responses of stock return volatility. The shocks seem to have a persistent impact on stock volatility unlike the response of returns. Similar conclusions can be reached by looking into Fig. A.11 in the appendix where the impulse responses converge to zero only after the 9th month as compared to 2nd month for the stock returns. The Fig. 6 shows the response of stock volatility to a unit impulse in policy uncertainty index. The simultaneous shocks to economic policy uncertainty index have a positive and significant impact on volatility (Panel a). The Fig. A.12 in appendix summarizes the information of median impulse responses and indicates the transitory nature of shocks on stocks unlike the expected oil demand shocks. Thus, the expected oil demand shocks are more persistent on stock volatility than the shocks emanating from the domestic economic uncertainty.

4. Summary and conclusions

A large volume of empirical and theoretical research has been conducted to capture the underlying dynamics between oil prices and stock market returns and its volatility. However, the conclusions in this regard remain unclear both in terms of direction as well as magnitude. A possible reason for the absence of a consensus could be the lack of attention given to the distinct effects of supply and demand shocks embedded in an underlying oil shock. Further, it is intuitive to argue that demand-led oil price shock will increase the expected revenue of the industrial sector. As a result, there will be a significant rise in the expected future cash flow which in general will exert a positive impact on the stock market returns. The existing empirical literature in the Indian

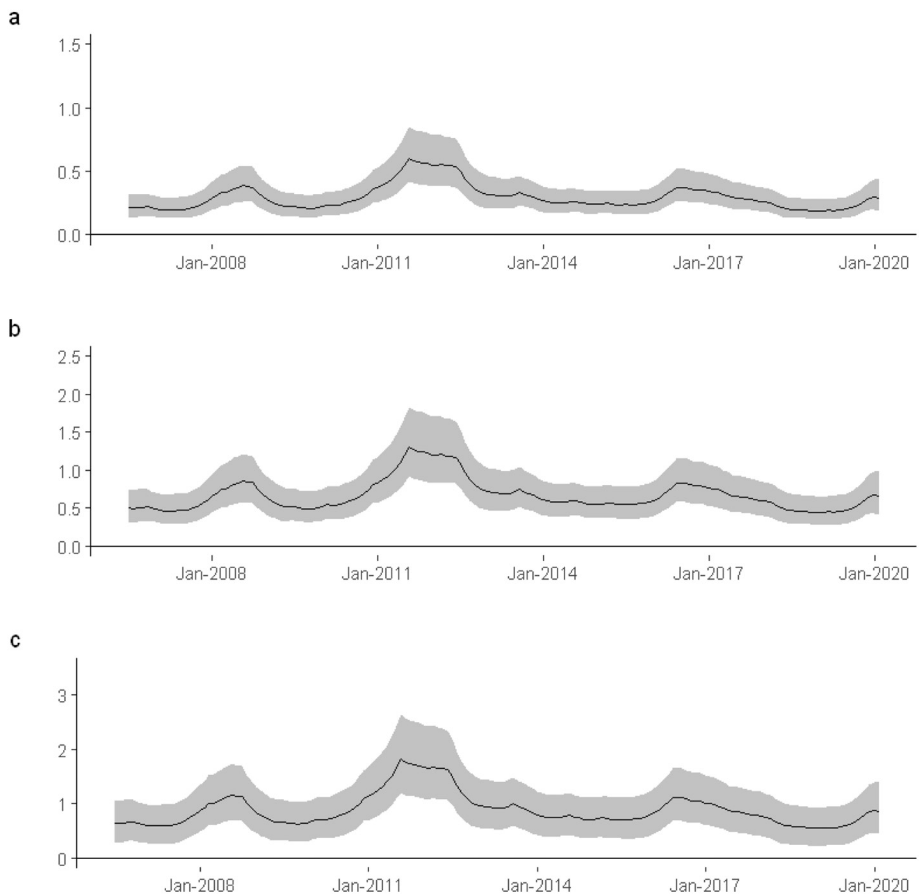

Fig. 6. Accumulated impulse responses of stock return volatility to one unit increase Indian macro uncertainty shocks. Panel a)Simultaneous responses; Panel b) Three months ahead responses; and Panel c) Six months ahead responses. *Note:* The median impulse responses are given by the black solid line and 16th and 84th quantile credible interval as thd shaded area around the line.

context does not provide sufficient insights about this particular channel. In this regard, this study uses the returns of the index of oil-producing companies to capture the impact of expected oil demand shocks. Also, we incorporate the domestic uncertainty index, which is a critical component that might significantly influence the domestic stock returns.

The study estimates two models, one with stock returns and other with stock return volatility, to examine the impact of oil shocks on the stock market. The models are specified as Time-Varying Parameter Vector Autoregressions with Stochastic Volatility (TVP-SVAR-SV) to capture the dynamic interaction between these variables following (Primiceri, 2005; Del Negro and Primiceri, 2015). Samples of posterior distributions are drawn using the Markov Chain Monte Carlo Method (MCMC) with Gibbs sampler algorithm. The impulse response analysis indicates positive and significant impact of expected oil demand shocks on stock returns and decrease in realised volatility. However, the supply specific oil shocks do not significantly affect the stocks returns or its volatility. The expected oil demand shocks have a more persistent impact on the stock volatility than on the returns. The empirical evidence also indicates the transitory nature of these shocks on stock returns and its volatility. Similarly, the shock to policy uncertainty leads to negative stock returns and an increase in stock volatility.The results are in line with recent literature that highlights the increasing importance of oil demand shocks relative to oil supply shocks (see for example, Mokni (2020)). Moreover, as observed by Castro and Jiménez-Rodríguez (2020) many of the recent oil shock episodes are driven by demand factors (Table A.1). Our empirical results highlight the growing importance of expected oil demand shocks which is a transmission channel that has been left mostly unexplored.

Appendix

Table A.1
Oil shock episodes 1999–2018.

Episode	Months	Event	Type	ρ*
Jan 99 to Nov 00	23	OPEC cutbacks	Increase in price	0.24
Dec-01 to Jun-08	79	Asian boom	Increase in price	−0.17
July-08 to Dec-08	6	Global Financial crisis	Decrease in Price	0.31
Jan-09 to Apr-11	28	Global recovery	Increase in price	0.13
Jun-14 to Jan-16	20?	Weak global growth	Decrease in Price	0.12
Mar-16 to Jul-18	29	Global Growth	Increase in price	

* ρ is the correlation coefficient between changes in oil prices and returns on BSE sensex
Source: Based (Castro and Jiménez-Rodríguez, 2020) and author's own calculation.

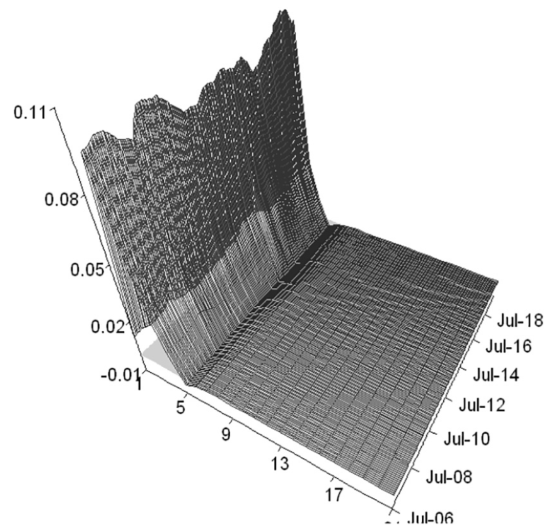

Fig. A.7. Impulse responses (median) of stock returns due to supply specific oil shocks.

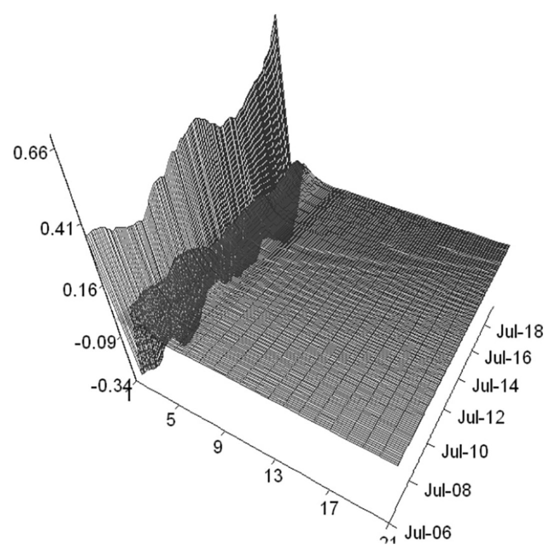

Fig. A.8. Impulse responses (median) of stock returns due to expected oil demand shocks.

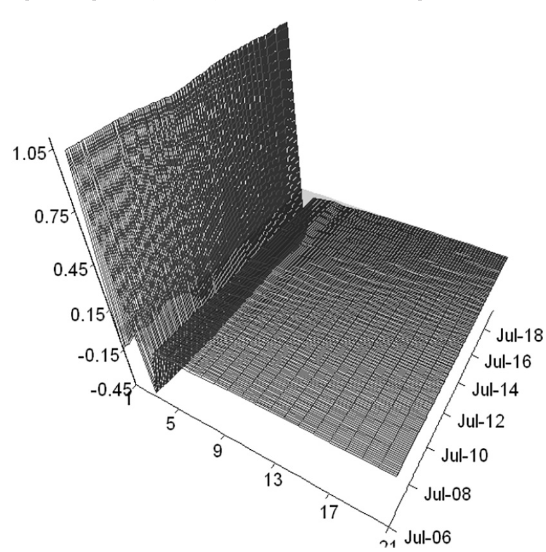

Fig. A.9. Impulse responses (median) of stock returns due to shocks in Indian policy uncertainty.

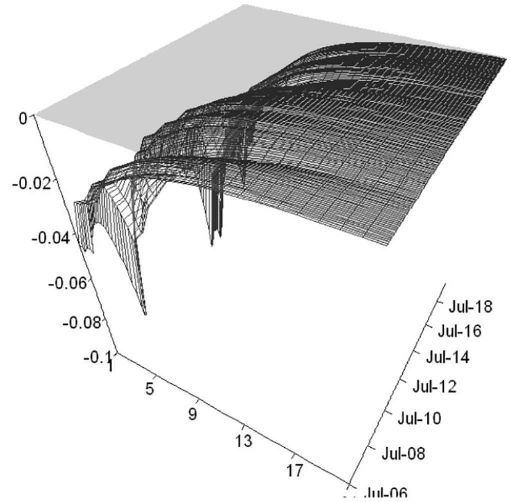

Fig. A.10. Impulse responses (median) of stock volatility due to supply specific oil shocks.

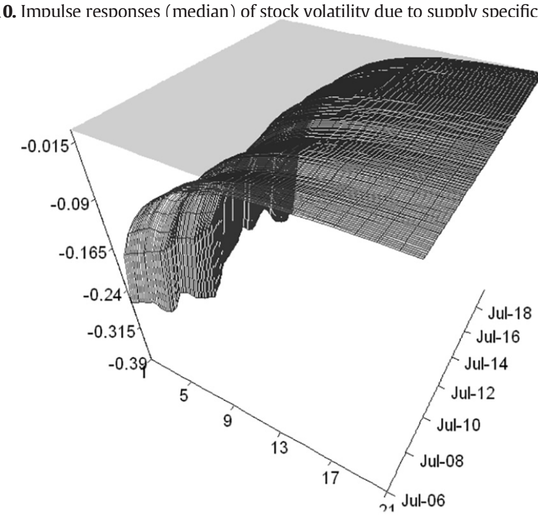

Fig. A.11. Impulse responses (median) of stock volatility due to expected oil demand shocks.

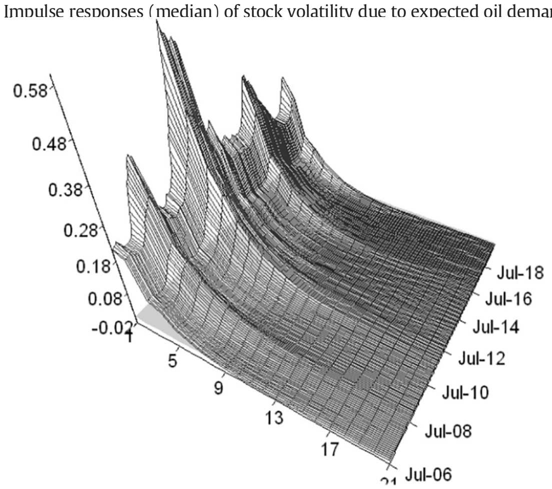

Fig. A.12. Impulse responses (median) of stock volatility due to shocks in Indian policy uncertainty.

References

Al-Fayoumi, N.A., 2009. Oil prices and stock market returns in oil importing countries: the case of Turkey, Tunisia and Jordan. Eur. J. Econ. Finance Adm. Sci. 16 (1), 84–98.

Aloui, R., Gupta, R., Miller, S.M., 2016. Uncertainty and crude oil returns. Energy Econ. 55, 92–100.

Anand, B., Paul, S., Ramachandran, M., 2014. Volatility spillover between oil and stock market returns. Indian Economic Review 49 (1), 37–56.

Antonakakis, N., Chatziantoniou, I., Filis, G., 2014. Dynamic spillovers of oil price shocks and economic policy uncertainty. Energy Econ. 44, 433–447.

Awerbuch, S., Sauter, R., 2006. Exploiting the oil–gdp effect to support renewables deployment. Energy Policy 34 (17), 2805–2819.

Baker, S.R., Bloom, N., Davis, S.J., 2016. Measuring economic policy uncertainty. Q. J. Econ. 131 (4), 1593–1636.

Basher, S.A., Haug, A.A., Sadorsky, P., 2012. Oil prices, exchange rates and emerging stock markets. Energy Econ. 34 (1), 227–240.

Bernanke, B.S., Gertler, M., Watson, M., Sims, C.A., Friedman, B.M., 1997. Systematic monetary policy and the effects of oil price shocks. Brook. Pap. Econ. Act. 1997 (1), 91–157.

Boyer, M.M., Filion, D., 2007. Common and fundamental factors in stock returns of Canadian oil and gas companies. Energy Econ. 29 (3), 428–453.

Burbidge, J., & Harrison, A. (1984). Testing for the effects of oil-price rises using vector autoregressions. *International Economic Review*, (pp. 459–484).

Castro, C., Jiménez-Rodríguez, R., 2020. Dynamic interactions between oil price and exchange rate. PLoS One 15 (8), e0237172.

Cavallo, M.M., Wu, M.T., et al., 2012. Measuring Oil-Price Shocks Using Market-Based Information (International Monetary Fund).
Chen, N.-F., Roll, R., Ross, S.A., 1986. Economic forces and the stock market. J. Bus. 59 (3), 383–403.
Darby, M. R. (1981). The real price of oil and the 1970s world inflation. *NBER Working Paper*, (w0629).
Davig, T., Melek, N.Ç., Nie, J., Smith, A.L., Tuzemen, D., 2015. Evaluating a year of oil price volatility. Federal Reserve Bank of Kansas City, Economic Review 100 (3), 5–30.
Del Negro, M., Primiceri, G.E., 2015. Time varying structural vector autoregressions and monetary policy: a corrigendum. Rev. Econ. Stud. 82 (4), 1342–1345.
Filis, G., 2010. Macro economy, stock market and oil prices: do meaningful relationships exist among their cyclical fluctuations? Energy Econ. 32 (4), 877–886.
Fueki, T., Nakajima, J., Ohyama, S., Tamanyu, Y., 2020. Identifying oil price shocks and their consequences: the role of expectations in the crude oil market. International Finance, 1–24 https://doi.org/10.1111/infi.12384.
Gallo, L.A., Hann, R.N., Li, C., 2016. Aggregate earnings surprises, monetary policy, and stock returns. J. Account. Econ. 62 (1), 103–120.
Ghosh, S., Kanjilal, K., 2016. Co-movement of international crude oil price and indian stock market: evidences from nonlinear cointegration tests. Energy Econ. 53, 111–117.
Gil-Alana, L.A., 2003. Unemployment and real oil prices in Australia: a fractionally cointegrated approach. Appl. Econ. Lett. 10 (4), 201–204. https://doi.org/10.1080/1350485022000041087.
Gisser, M., Goodwin, T.H., 1986. Crude oil and the macroeconomy: tests of some popular notions: note. J. Money Credit Bank. 18 (1), 95–103.
Gordon, R.J., 1975. Alternative responses of policy to external supply shocks. Brook. Pap. Econ. Act. 1975 (1), 183–206.
Hamilton, J.D., 1983. Oil and the macroeconomy since world war ii. J. Polit. Econ. 91 (2), 228–248. https://doi.org/10.1086/261140.
Hamilton, J.D., 2003. What is an oil shock? J. Econ. 113 (2), 363–398.
Huang, R. D., Masulis, R. W., & Stoll, H. R. (1996). Energy shocks and financial markets. J. Futur. Mark., 16(1), 1–27. doi:10.1002/(SICI)1096–9934(199602)16:1<1::AID-FUT1>3.0.C0;2-Q.
Ji, Q., Fan, Y., 2012. How does oil price volatility affect non-energy commodity markets? Appl. Energy 89 (1), 273–280.
Jones, C.M., Kaul, G., 1996. Oil and the stock markets. J. Financ. 51 (2), 463–491. https://doi.org/10.1111/j.1540–6261.1996.tb02691.x.
Kang, W., 2019. The asymmetric responses of aggregate earnings and stock returns to oil shocks and policy uncertainty. Asia-Pacific Journal of Accounting & Economics 1–13.
Kang, W., Ratti, R.A., 2013. Oil shocks, policy uncertainty and stock market return. J. Int. Financ. Mark. Inst. Money 26, 305–318.
Kilian, L., 2008. The economic effects of energy price shocks. J. Econ. Lit. 46 (4), 871–909.
Kilian, L., 2009. Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market. Am. Econ. Rev. 99 (3), 1053–1069.
Kilian, L., Park, C., 2009. The impact of oil price shocks on the us stock market. Int. Econ. Rev. 50 (4), 1267–1287.
Lee, J., Song, J., 2011. Oil and macroeconomy: the case of Korea. Commodity Prices and Markets, East Asia Seminar on Economics. University of Chicago Press, pp. 263–290.
Miller, J.I., Ratti, R.A., 2009. Crude oil and stock markets: stability, instability, and bubbles. Energy Econ. 31 (4), 559–568.
Mokni, K., 2020. Time-varying effect of oil price shocks on the stock market returns: evidence from oil-importing and oil-exporting countries. Energy Rep. 6, 605–619.
Mork, K.A., Hall, R.E., 1980. Energy prices, inflation, and recession, 1974–1975. Energy J. 1 (3).
Narayan, P.K., Narayan, S., 2010. Modelling the impact of oil prices on Vietnam's stock prices. Appl. Energy 87 (1), 356–361.
Ono, S., 2011. Oil price shocks and stock markets in brics. Eur. J. Comp. Econ. 8 (1), 29–45.
Papapetrou, E., 2001. Oil price shocks, stock market, economic activity and employment in Greece. Energy Econ. 23 (5), 511–532.
Phan, D.H.B., Tran, V.T., Nguyen, D.T., 2019. Crude oil price uncertainty and corporate investment: new global evidence. Energy Econ. 77, 54–65.
Pierce, J.L., Enzler, J.J., 1974. The effects of external inflationary shocks. *Brookings Papers on Economic Activity*, *1974*. 1 , pp. 13–61 URL. http://www.jstor.org/stable/2534072.
Primiceri, G.E., 2005. Time varying structural vector autoregressions and monetary policy. Rev. Econ. Stud. 72 (3), 821–852.
Ready, R.C., 2018. Oil prices and the stock market. Review of Finance 22 (1), 155–176.
Sadorsky, P., 1999. Oil price shocks and stock market activity. Energy Econ. 21 (5), 449–469.
Sadorsky, P., 2001. Risk factors in stock returns of Canadian oil and gas companies. Energy Econ. 23 (1), 17–28.
Sadorsky, P., 2011. Financial development and energy consumption in central and eastern european frontier economies. Energy Policy 39 (2), 999–1006.
Sahu, T.N., Bandopadhyay, K., Mondal, D., 2014. An empirical study on the dynamic relationship between oil prices and indian stock market. Manag. Financ. 40, 200–215.
Shah, I.H., Hiles, C., Morley, B., 2018. How do oil prices, macroeconomic factors and policies affect the market for renewable energy? Appl. Energy 215, 87–97.