Articles

Revisiting the relationship between oil price and macro economy: Evidence from India

Rajesh H. Acharya[*] and *Anver C. Sadath*[**]

Abstract

In this paper we revisit the research question of how Indian economy reacted to the changes in the historical oil price. Data on aggregate variables such as real GDP, WPI, interest rate and money supply since 1996 to 2017 are used to estimate Auto-Regressive Distributed Lag (ARDL) model and Structural Vector Auto-Regressive model (SVAR). Empirical results clearly show that oil price is negatively related to real GDP and at the same time, its effect on general inflation is not clear probably due to the massive subsidization of energy resources during the period of study and consequent cushioning of the inflationary effect of oil price shock. Results also show that in the short run, macroeconomic aggregates are mostly influenced by real factors than monetary factors. Result implies that policy makers must create adequate safeguards to ensure that ordinary citizens are not hurt from oil shock as India's reliance on oil import is expected to increase in the future and also promote efficient use of energy resources.

Keywords: oil price shock, uncertainty effect, reallocation effect, irreversible investment.

JEL classification: Q41, Q43, C32, E22.

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[*] Assistant Professor, School of Management. National Institute of Technology Karnataka, Surathkal. Karnataka, India. E-mail: rajeshacharyah@gmail.com. Phone: +917259394898.
[**] Assistant Professor, Department of Economics. Central University of Kerala. Kasaragod, Kerala, India. E-mail: anver.omanoor@gmail.com. Phone: +918547879230.

1. Introduction and background

Energy resources like oil occupy a crucial position in the modern economics as they are extensively used in the provisions of goods and services. That is why volatility in their prices has been a major concern for modern economies especially since World War II. According to the theory of irreversible investment of Bernake (1983) and Pindyck (1991), contrary to the propositions of perfect frictionless market models, firms and consumers may tend to delay the execution of their investment as well as purchasing decisions in the face of uncertainties like energy price uncertainty as these expenditures would be irreversible or sunk costs once incurred. Therefore, firms and consumers may prefer to wait until markets stabilize implying that uncertainties like energy price uncertainty will hamper current investment and household expenditure. Further, as argued by various authors (see, for e.g., Hamilton, 2008; Edelstein and Kilian, 2007, 2009; Lee, et al., 2011 and Acharya and Sadath, 2016) increase in the marginal cost as a result of increase in energy price will force firms and households to cut investment and purchases. In addition to these direct effects of energy price shock, there is an indirect effect namely reallocation effect (see, for e.g., Hamilton, 1988; Davis and Haltiwanger, 2001 and Basky and Kilian, 2004; Edelstein and Kilian, 2009). According to reallocation effect, reallocation of displaced factor inputs owing to energy price shock will be difficult in the presence of frictions in the market for inputs and this will lead to overall increase in the inefficiency and decrease in the economic activities.

Results from existing literature on the relationship between oil price and macro economy are mixed. Hamilton (1983, 1985, and 1996) argued that oil price shocks are caused by exogenous developments like military conflict in the Middle East, OPEC embargo, etc. and most of the oil price shocks during 1948-72 are negatively correlated with macroeconomic performance of United States. Similar views were echoed by Burbidge and Harrison (1984), Gisser and Goodwin (1986), Mork (1989), Hooker (1996), Rotemberg and Woodford (1996), Blinder and Rudd (2008), Oladosu (2009), Berk and Yetkiner (2014) and Timilsina (2015). However, according to authors like, Darby (1982), Bohi (1990) and Bernanke, et.al (1997), US recessions were caused by wrong monetary policy prescriptions adopted by Federal Reserve in the event of oil price shocks. But this monetary explanation of recession was subsequently refuted by Hamilton (2003, 2004, and 2008) who reiterated his original thesis that economic performance of US economy was negatively correlated with changes in oil price since World War II. Of late, when recession hit US economy in 2009-08, Hamilton (2009a, 2009b) along with authors like Ramey and Vine (2011) again argued that recession was caused by oil price shock of 2007-08. However, Hamilton admitted that rise in oil price in 2007-08 was primarily caused, unlike previous episodes of price hike, by inelastic global demand especially from emerging countries like India and China[1].

Another significant view established by pioneers like Hamilton (1983) is that as far as US economy is concerned, oil price was exogenously determined especially

[1] See, for example, Dahl (1993), Cooper (2003) and Hughes et al. (2008) for details of price elasticity of oil demand who too reported evidences of low price elasticity of demand.

until 1973 as the intervention of regulatory agencies such as Texas Rail Road Commission (TRC) used to filter out endogenous and domestic influences on oil price changes. However, this view was subsequently challenged in the literature (see, for example, Barsky and Kilian, 2001, 2004; Edelstein and Kilian, 2007; Kilian, 2008a, 2008b; Kilian and Vigfusson, 2011, 2013; Tiwari, 2013; Cunado et al., 2015; Li et al., 2015, Baumeister and Kilian, 2016a and Baumeister and Kilian, 2016b). According to these studies, oil price surge experienced by US especially after 1980 was primarily caused by factors like expansionary monetary policy and strong pressure from demand side of the market. And, instead of attributing pivotal role to oil price shocks in causing US recessions, they argued that it was developments in the domestic economy like Tax reform Act (1986) that led to recession.

On the demand side, strong global demand shock involves not only demand for energy intensive industrial goods but also increase in precautionary demand for oil on the expectations of future supply disruptions implying that oil price increase has become endogenous to US economy. Positive effects of such increased demand for industrial goods outweigh the negative effect of higher energy price and hence, according to Kilian (2008b) for example, US economy did not experience recession despite increase in the oil price in 2003. In other words, whether oil price shock leads to recession or not depends upon the source of the shock such as crude oil supply shock, precautionary demand shock owing to anticipated future supply disruptions and global demand shock for industrial goods (Kilian, 2009 and Kilian and Hicks, 2013). In the similar vein, Blanchard and Gali (2007), Nordhaus (2007), Lee and Song (2009), Blanchard and Riggi (2009) and Cunado et al. (2015) also found declining impact of oil price on economy as a result of change in the structure of economy and consequent change in propagation mechanism of oil shock along with accommodative monetary and exchange rate policies.

Another important revelation of the existing studies from developing economies is that impact of oil price shock depends upon whether the country is a net oil importer or exporter. For example, Du et al. (2010), Qianqian (2011), Ahmed and Wadud (2011), Schubert and Turnovsky (2011),Wang and Zhang (2014), Cross and Nguyen (2017), Kim et al. (2017) show negative effect of oil price shock on oil importing emerging economies like China and Malaysia. At the same time, for example, Mork et al. (1994), Farzanegan and Markwardt (2009) and Nusair (2016) show positive relationship between oil price shocks in oil exporting countries implying that oil exporting economies experience boom or recession as oil price surges or falls respectively. Mork et al. (1994) have specifically pointed out that the magnitude and direction of effects of oil price shock would depend upon whether the country is a net oil importer or exporter and therefore, the relationship between oil price and GDP will vary from country to country for the same reason.

Finally, extant literature argues that macroeconomic effect of oil price changes is asymmetric implying that while price rise pushes the economy into recession; price fall did not result in the economic boom (Mork, 1989; Mork et al., 1994; Hooker, 1996; Hamilton, 1996 and 2003, Farzanegan and Markwardt, 2009; Du et al., 2010; Yeh et al., 2012; Wang and Zhang , 2014 and Nusair, 2016). For example, US economy did not witness any substantial spurt in the growth despite decrease in the oil price in 1986 whereas the economy was negatively affected whenever oil prices were increased before 1986 (Kilian, 2008a). According to this literature, rigidities in the prices of inputs and outputs, uncertainty effect, reallocation effect in the form of factor inputs failing to get absorbed in new employments after having displaced by oil price uncertainties, magnitude of interaction between price and income elasticity of demand for petroleum products are some of the major factors responsible for the macroeconomic asymmetric effect of oil price changes.

However, the notion of asymmetric effect of oil price change has been refuted by influential studies (see, Edelstein and Kilian, 2007; Kilian, 2008c; Edelstein and Kilian, 2009; Kilian and Vigfusson, 2011 and 2013; Herrera et al., 2011, Kilian and Hicks, 2013, and Baumeister and Kilian, 2016b). According to them evidences of asymmetry is spurious as the insights from theories of uncertainties and reallocations effects were prima facie imposed on the statistical models used in such studies to examine the nature of relationship between economic activities and oil price changes.

For example, according to authors like Edlestein and Kilian (2009), evidences for reallocation effect and uncertainty effects are missing in U.S data and their estimates show that purchasing power and real consumption have responded symmetrically to increases and decreases in oil prices since 1970s (see Edelstein and Kilian, 2009). Moreover, in addition to supply shocks, demand shocks also have played decisive role in causing oil price shocks in U.S since 1970s. For example, oil price decline of 1986 did not cause economic boom in U.S, despite increase in purchasing power and growth in real consumption, because of sharp decline in non-residential fixed investment expenditure in response to the tax reform act that coincided with oil price decline in 1986[2]. Thus, beneficial effect of oil price decline was fizzled out by negative effects of decline in investment. Consistent with the view of Edelstein and Kilian (2009), evidences from developing economies also show that nature and extent of the effect of oil price shocks on macro economy primarily depend on the source of the shock as to whether the shock is supply or demand driven (see, for e.g., Cunado et al., 2015; Li et al., 2015 and Cross and Nguyen, 2017)

Overall, previous literature shows how oil price shock affects an economy depends on, first, whether shock is exogenous or endogenous to the economy, second, policy response of the economy to the shock, third, propagation mechanism of shock to the economy and finally, whether the country is a net oil importer or exporter. Given these insights, there is immense relevance for revisiting the relationship between oil price and macro economy in Indian context due to the following reasons. First, there can be difference or similarities in the response of economies to energy price shock with profound economic implications, as found out by Kilian (2008c) among G7 countries. Second, US, for example, became more concerned about energy price shocks in the 1970s as its energy supply peaked in early 1970s and thereby increased its dependence on imported oil from Middle East with obvious supply side risks which culminated in the deregulation of market for crude oil (Baumesister and

[2] 1986 tax reform act done away with investment tax credit and eliminated real estate tax shelters.

Kilian, 2016a). If so, there exists a case for a study on the response of Indian economy to energy price shocks as India meets about 75% of its total energy requirements with fossil fuels mostly imported. According to IEO (2015) India is the third largest importer of oil after U.S and China, and India's reliance on Middle East for energy resources is expected to increase from 57% in 2014 to 63% in 2040 with likely increase in its energy vulnerability.

According to Energy Statistics (2017)[3] India has an estimated reserves of coal of 308.80 billion tons (BT) and 621.10 million tons (MT) of crude oil. The production of coal in India increased from 430.83 MTs during 2006-07during 2006-07to 639.23 MTs during 2015-16 with a compound annual growth rate (CAGR) of 4.02%. Since the average quality of Indian coal is not very high, import of high quality coal is also increasing. For example, it increased from 43.08 MTs during 2006-07 to 199.88 MTs during 2015-16.

Likewise, India is heavily dependent on foreign countries for crude oil and as a result while import of crude oil increased 111.50 MTs during 2006-07 to 202.85 MTs during 2015-16, import of petroleum products has increased from 17.76 MT to 28.30 MT during the same period.

As far the consumption of energy resources in India are concerned, while estimated total consumption of raw coal by industry has increased from 462.35 MT during 2006-07 to 832.46 MT during 2015-16 (with a CAGR of 6.06%), estimated consumption of crude oil has a steady increased from 146.55 to 232.87 MMT during the same period (with CAGR of 4.74%). In 2015-16, for example, High speed diesel oil accounted for 40.42% of total consumption of all types of petroleum products, followed by Petrol (11.83%), LPG (10.63%), Petroleum Coke (10.45%) and Naphtha (7.19%). Sector-wise consumption of different petroleum products reveals that Reseller/Retail contributes 53% in the total consumption followed by Domestic sector with contribution 20%.

Therefore, in this paper we attempt to revisit the analysis of relationship between oil price and macro economy in Indian context with updated data and methodology. This study would help to unravel the similarities and differences in the way in which Indian economy responded to oil price changes and thereby would constitute a valuable addition to the existing literature.

The present paper is organized as follows. Following the introduction and background in the section 1, data and research method used are outlined in section 2 and 3 respectively. Section 4 provides empirical results followed by conclusion in section 5.

2. Data

To test the macroeconomic impact of oil price changes, we use several macroeconomic variables. First, as a measure of output, we use real Gross Domestic Product (GDP). Further, we take real rate of return of central government security with 10

[3] Energy Statistics (2017), Central Statistical Office, Ministry of Statistics and Program Implementation, Government of India, www.mospi.gov.in.

years maturity as proxy for the interest rate in the economy and broad money supply (M3) for liquidity in the system. Finally, we use WPI inflation and WPI index number for mineral oils as measures of inflation and domestic oil price respectively. Real GDP, WPI inflation and WPI index number for mineral oils are in 2004-05 prices. Broad money supply (M3) is adjusted for inflation using WPI. All data series are in quarterly frequency ranging from quarter 1, 1996 to quarter 4, 2017. We use splicing technique to convert the data series into a common base year. The source of the data set is indiastat.com website.

3. Methodology

Before starting the econometric analysis, we test for the stationarity of the variables using Augmented Dickey Fuller (ADF) Test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. We select these two tests considering their opposite null hypothesis, ADF test has a null hypothesis that the variable has a unit root, whereas in case of KPSS test the null hypothesis is that the series is stationary.

The variables considered in the study are either stationary at level form or non-stationary at level and first differencing makes it stationary[4]. Therefore, relationship between real GDP, real G-Sec rate, WPI inflation, real money supply (M3) and real oil price is tested in the ARDL framework.

$$RGDP_t = \alpha_0 + \sum_{l=1}^{L} \beta_i RGDP_{t-l} + \sum_{r=0}^{R} \gamma_i RGSEC_{t-r} + \sum_{s=0}^{S} \delta_i WPI_{t-r} + \sum_{u=0}^{U} \varepsilon_i RM3_{t-r} + \sum_{w=0}^{W} \theta_i ROP_{t-r} + \mu_t \qquad (1)$$

where $RGDP_t$ is the real GDP of India, $RGSEC_t$ is real rate of return on government security, WPI_t is the WPI inflation rate, $RM3_t$ is real money supply (M3) and ROP_t is real price of oil at time *t.* Appropriate lag lengths for variables in the equation are chosen based on the Schwarz Bayesian Criterion (SBC).

There is a possibility of long-run relationship among the variables in the equation (1). Therefore, we adopt Bounds testing procedure for the presence of long run relationship. If there is a long-run relationship, ARDL model can be transformed into a

[4] A detailed note on the stationarity of the variables is presented in the empirical results section.

long run relationship based on the long-run response of the dependent variable for changes in the explanatory variables. Cointegration models like Engle-Granger (1987), Johansen (1991, 1995), Fully Modified OLS (FMOLS), Dynamic OLS (DOLS) require that either the variables in the equation are to be integrated of order one, I (1) or a beforehand knowledge about the order of integration of the variables. However, Pesaran and Shin (1999) developed ARDL framework to cointegration where I (1) or I (0) variables can be included in the model.

Cointegrating form of ARDL is specified as follows:

$$\Delta RGDP_t = \alpha_0 + \sum_{l=1}^{L} \beta_i \Delta RGDP_{t-l} + \sum_{r=0}^{R} \gamma_i \Delta RGSEC_{t-r} + \sum_{s=0}^{S} \delta_i \Delta WPI_{t-r} + \sum_{u=0}^{U} \varepsilon_i \Delta RM3_{t-r} + \sum_{w=0}^{W} \theta_i \Delta ROP_{t-r} + \vartheta_1 RGDP_{t-1} + \vartheta_2 RGSEC_{t-1} + \vartheta_3 WPI_{t-1} + \vartheta_4 RM3_{t-1} + \vartheta_5 ROP_{t-1} + \mu_t \qquad (2)$$

Here, ϑ_1, ϑ_2, ϑ_3, ϑ_4, and $\vartheta_5$are long run multipliers and the current and lagged values of ΔGDP_t, $\Delta RGSEC_t$, ΔWPI_t, $\Delta RM3_t$, and ΔROP_t are used to model the short run relationship. The Bounds test for the absence of long run relationship is tested by excluding the coefficiens of lagged level variables viz. ϑ_1, ϑ_2, ϑ_3, ϑ_4, and ϑ_5 in equation (2). While 'no long-run relationships exist' is the null hypothesis; existence of long relationship is the alternative hypothesis. Pesaran et al. (2001) have given the critical values for the I (1) and I (0) bounds. Null hypothesis of 'no long-run relationships exist' is rejected if the F statistic is greater than the critical value at a stated level of significance.

We also test inflation and oil price relationship using ARDL framework and Bounds testing approach to cointegration and long run relationship in the same manner as explained above in equations (1) and (2).

Structural Vector Auto-Regressive (SVAR) Framework

We use a Structural Vector Auto-Regressive (SVAR) framework for analyzing the long-term general equilibrium. To describe the transmission mechanism of oil price shock, we specify a reduced form of Vector Auto-Regressive (VAR) model. Oil price shock can directly affect the output and inflation. Further, persistent inflation can affect the output, interest rate as well as money supply in the economy. We chose four variables viz. real G-Sec rate, WPI inflation, real money supply (M3) and real oil price influencing real GDP. The reduced form of VAR model is specified as follows:

$$Z_t = a_0 + \sum_{i=1}^{K} B_i Z_{t-i} + \mu_t \qquad (3)$$

Z_t is the vector of endogenous variables, μ_t is the vector of residuals, a_0 and B_i are vectors of constants and coefficients to be estimated respectively. K is the lag length of the variables. VAR model is very much sensitive to the lag length chosen; as a result, we use Schwarz Bayesian Criterion (SBC). It has given a lag length of 1-5 as appropriate for the model.

The reduced form VAR model has only lagged terms in the right hand side of the equation. As a result, it is not equipped to deal with the contemporaneous relationship among the variables which could result in cross correlation among the residuals. Therefore, as structural restrictions, we introduce a contemporaneous coefficients matrix to the VAR model as follows:

$$C_0 Z_t = a_0 + \sum_{i=1}^{K} D_j Z_{t-i} + \pi_t \qquad (4)$$

C_0 is a matrix of structural restrictions and is specified as follows:

$$Co = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} \\ C_{41} & C_{42} & C_{43} & C_{44} & C_{45} \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} \end{bmatrix}$$

Using the above matrix, left hand side of the equation (4) can be represented as:

$$\overline{Z_t} = \begin{bmatrix} C_{11}*RGDP & C_{12}*RGSEC & C_{13}*RM3 & C_{14}*WPI & C_{15}*ROP \\ C_{21}*RGDP & C_{22}*RGSEC & C_{23}*RM3 & C_{24}*WPI & C_{25}*ROP \\ C_{31}*RGDP & C_{32}*RGSEC & C_{33}*RM3 & C_{34}*WPI & C_{35}*ROP \\ C_{41}*RGDP & C_{42}*RGSEC & C_{43}*RM3 & C_{44}*WPI & C_{45}*ROP \\ C_{51}*RGDP & C_{52}*RGSEC & C_{53}*RM3 & C_{54}*WPI & C_{55}*ROP \end{bmatrix}$$

$\bar{Z}_t$ contains the contemporaneous relationship among the variables. For the purpose of identifying the restrictions, we refer to the economic theory. We assume that oil price is exogenous at the current period i.e. real GDP, real G-Sec rate, WPI inflation, and real money supply (M3) are not the determinants of real oil price. It means that coefficients C51, C52, C53, and C54 are equal to zero. WPI inflation is determined by WPI inflation itself and real oil price only, implying that C41, C42, and C43 are zero. Further, real money supply (M3) is not determined by real GDP and real G-Sec rate in the contemporaneous period. Therefore, C31 and C32 are zero.

Finally, real G-Sec rate is not determined by real GDP in the contemporaneous period. Incorporating all restrictions, C0 matrix can be rewritten as follows:

$$Co = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} \\ 0 & C_{22} & C_{23} & C_{24} & C_{25} \\ 0 & 0 & C_{33} & C_{34} & C_{35} \\ 0 & 0 & 0 & C_{44} & C_{45} \\ 0 & 0 & 0 & 0 & C_{55} \end{bmatrix}$$

Using a Structural Vector Auto-Regressive (SVAR) model, we estimate the 15 elements in the matrix.

5. Empirical Results

Empirical results of the study are presented in this section. Figure 1 shows the trend in the production, consumption, import and export of crude and petroleum products in India from 2000-01 to 2016-17. Domestic crude oil production has remained more or less stagnant. However, consumption of petroleum products has shown a consistently increasing trend during the same period in question. As a result, the gap between domestic production and consumption is bridged by importing the crude oil and refining it domestically. It is also reflected in the consistent rise in the production of petroleum products. Till 2005- 06, both production and consumption of petroleum products has been more or less the same. But, since 2009-10, there has been a jump in excess of 40 Million Metric Ton (MMT) in production over consumption which has occurred due to the expansion of the refining capacity in the country. It shows that India is importing crude oil and exporting the petroleum products by adding refining capacity.

Table 1 presents the summary statistics i.e. mean, standard deviation, skewness, and kurtosis of the variables used in the study. Real GDP is measured in Rupees (Rs) billion in 2004-05 prices. GDP data has a positive skewness as expected in the case of a series like GDP and kurtosis shows that the series is platykurtic. WPI Inflation, Real Money Supply (M3), and Real Oil Price have positive skewness and platykurtic in nature. Real G-Sec rate has an average real rate of 3% and WPI inflation is around 5.69%.

As a preliminary diagnostic check before proceeding to any econometric analysis, we carry out unit root tests for identifying the order of integration of the variables by applying ADF and KPSS tests. Results in the Table 2 show that real GDP is non-stationary in the level form and stationary in first difference as per both tests. WPI inflation and real G-Sec rate are stationary in the level form. Finally, real money supply (M3) and real oil price are non-stationary in the level and stationary in the first difference.

Relationship between inflation and oil price is presented in the Table 3. WPI inflation is positively related to its own lag one and negatively related in lag two. Further, as expected, oil price and inflation are positively related in the current period. However, there is a negative relationship between the two at lags one and four of the real oil price and the relationship is statistically significant at 5% level of significance. This could be due to the lagged response of monetary policy to changes in the inflation. Bounds test confirms a long run relationship between WPI inflation and real oil price. Cointegrating form and long run relationship confirms a statistically significant positive relationship between WPI inflation and real oil price.

Relationship between real GDP with real G-Sec rate, WPI inflation, real money supply (M3) and real oil price is shown in Table 4 based on ARDL model. Most of the lagged coefficients of real GDP are positive and statistically significant. Real G-Sec rate has a positive and significant contemporaneous relationship with real GDP but it turns out to be significantly negative at lag one. This relationship is justified from the point of view that investment decisions are long term in nature and as a result it may not change in the current period for changes in the interest rate. However, in the longer run, investment and output respond negatively to changes in the interest rate. Real money supply (M3) does not have statistically significant relationship with the real GDP. In the case of WPI inflation, it has a positive relationship with real GDP in contemporaneous period and turns out to be negative at lag one. In both cases, the relationship is statistically significant. This could be due to the fact that producers may be having purchase agreements or hedge the risk using derivative contracts. As a result it takes time to show the impact of inflation on the output. Main variable of interest is real oil price, it has negative relationship with real GDP and the relationship is statistically significant at 5% level of significance. Therefore, it confirms that a rise in the oil price has detrimental impact on the real GDP. For testing possible long run relationship, we conduct Bounds test. It confirms long-run relationship as the null hypothesis of 'no long-run relationships exist' is rejected at 5% level of significance for both I (0) and I (1) bounds. Based on this finding, we estimate cointegrating and long run relationship. Real GDP has a negative relationship with real G-Sec rate, WPI inflation, real oil price, and positive relationship with real money supply (M3). Though the results are on expected lines, the estimated coefficients are not statistically significant.

Estimate of SVAR model is presented in Table 5. GDP is positively related with itself and real G-Sec rate, but only former coefficient is significant at 5% level of significance. Real money supply (M3) does not have significant relationship with either real GDP or real G-Sec rate. WPI inflation does not have a significant relationship with real GDP, but it has statistically significant negative relationship with real G-Sec rate and real money supply (M3). It is clear that as inflation rises, real values of inertest rate and money supply decrease because changes in money supply and interest rate depend on monetary policy responses which tends to respond with lag. Oil prices do not have a significant relationship with the real GDP. However, oil price has negative relationship with real G- Sec rate and real money supply (M3) and positive relationship with WPI inflation. This is also justified on the ground that when rise in oil price leads to inflation instantaneously especially after the liberalization of market for petroleum products in India and monetary policy responding to inflation with lag, the net outcome is the reduction in the real money supply (M3) and real G- Sec rate as nominal values of these variables do not change instantaneously. Therefore, real G- Sec rate and real money supply (M3) have negative relation with the real oil price.

Figure 2 shows the impulse response function of various macroeconomic variables to innovations in the real oil price. Specifically, it shows the response of macroeconomic variables to one standard deviation innovation in the real oil price and two standard error upper and lower bands. The figure is generated using VAR model. It is clear from the figure that real GDP takes nearly three years (15 quarterly periods) after an oil price shock to recover and the response is negative and persistent. The response of real G-Sec rate is negative till four periods as it takes time for the monetary authorities to raise interest rate in the wake of inflation. In the same manner, real money supply also responds negatively to innovations in oil price and it takes longer (8 quarterly periods) than real G-Sec rate to turn positive. However, the response of both real G-Sec rate and real money supply (M3) are not persistent as it can be seen when their response turns negative after 16 quarterly periods. WPI inflation responds positively to innovations in oil price up to four quarterly periods indicating that that inflation increases instantaneously to oil shock. It turns negative at 5^{th} quarterly periods and remains negative up to 16 quarterly periods. Overall, it is clear from the impulse response functions that negative response of real GDP is more persistent compared with other macroeconomic variables.

6. Conclusion

Developments in the market for energy resources like oil are crucial for modern economies. Hence, a lot of research has been undertaken mostly on developed countries like the United States to examine the likely impact of developments in the oil market such as supply shocks and consequent increase in price on the aggregate economic activities. These studies broadly disagree on the nature of impact of oil price shock on macroeconomic aggregates and at the same time, acknowledge that the underlying cause of oil price shock in the last decade has changed from supply driven to demand driven with profound analytical implications on the oil and macro economy relationship. Given this background, in this paper we revisit the nature of relationship between oil price and GDP since 1996 to 2017 using ARDL and SVAR models.

Empirical results indicate that oil price shock had persistent negative effect on real GDP and in the short run output is largely determined by real factors rather than monetary factors like money supply. Estimates also reveal that effect of oil price shock on general inflation is not clear which could be attributed to massive subsidization of energy resources in India during most of the study period. Subsidization of the energy resources would have ameliorated the negative effect of oil price shock on consumption and hence on inflation. As expected, a negative relationship between aggregate output and interest rate is noticed in the long-run as investors are expected to adjust their investment decisions keeping in view of the long-run trajectory of variables like interest rate. Thus, overall, the results appear to validate the proposition of the theory of uncertainty that uncertainties in oil price will deter investors with negative macroeconomic implications.

The finding of this study has important policy implications on many grounds. First, India imports three-fourth of its total energy requirements which is expected to increase. Second, while India is home to about 18 % world population, its share in global energy consumptions is just 5.3% implying that there would be increase in energy demand in the future. Third, as illustrated by figure 1, India's domestic production of oil is stagnant implying that India's dependence on conflict-ridden Middle East countries will increase in the future. In the light of these facts, policy makers have to make adequate safeguards to ensure that negative effect of oil price on economy is kept at bay without ordinary citizens being hurt. Also, a new thrust must be given to explore India's existing energy potential, both renewable and non-renewable so that its heavy reliance on external sources can be reduced. Finally, government must promote the efficient use of energy resources especially by promoting innovation and technology so that energy intensity of GDP can be decreased further.

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Results

Table 1 – Summary Statistics

Variables	Mean	Std. Dev.	Skewness	Kurtosis
Real GDP at Factor Cost	9725.17	3988.71	0.35	1.76
Real G-Sec Rate	0.03	0.05	0.12	2.09
WPI Inflation	5.69	4.39	-0.19	3.39
Real Money Supply (M3)	31730.59	17743.86	0.495672	1.996251
Real Oil Price	123.89	60.49	0.22	1.86

Note: All values are in quarterly frequency, GDP and Money Supply (M3) data are in Rs billion.

Table 2 – Unit Root Test Statistic

	Level			First Difference		
Variables	t-Statistic	Prob.	LM-Stat.	t-Statistic	Prob.	LM-Stat.
Real GDP	-1.30	0.88	0.25	-3.93	0.02	0.09
WPI Inflation	-3.74	0.03	0.11	-6.20	0	0.03
Real Oil Price	-2.29	0.44	0.07	-8.70	0	0.05
Real G-Sec Rate	-3.31	0.07	0.17	-6.37	0	0.04
Real Money Supply (M3)	-1.24	0.90	0.20	-3.47	0.05	0.08

Note: Asymptotic critical values for KPSS test are 0.216, 0.146, and 0.119 for 1%, 5%, and 10% respectively.

Table 3 – Inflation and Oil Price Relationship

Variable	Coefficient	t-Statistic	Prob.
WPI Inflation (-1)	0.817	7.277	0
WPI Inflation (-2)	-0.257	-2.847	0.006
Real Oil Price	0.175	8.396	0
Real Oil Price (-1)	-0.093	-2.887	0.005
Real Oil Price (-2)	0.013	0.406	0.686
Real Oil Price (-3)	-0.024	-0.841	0.403
Real Oil Price (-4)	-0.062	-2.440	0.017
C	0.686	1.671	0.099
Cointegrating Form and Long-Run Relationship			
Real Oil Price	0.020	3.076	0.003
C	1.556	1.722	0.089

Note: Adjusted R-squared of ARDL model is 0.90. ARDL Bounds Test F statistic is 22.31 for the null hypotheses of no long-run relationships exist. 1% critical value bound is 6.48 and 7.48 for I0 and I1 bound respectively.

Table 4 – Result from ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Real GDP (-1))	0.135	0.061	2.199	0.031
Real GDP (-2))	-0.125	0.068	-1.842	0.070
Real GDP (-3))	0.112	0.055	2.028	0.046
Real GDP (-4))	0.822	0.060	13.620	0
Real G-SEC RATE	0.850	0.378	2.249	0.028
Real G-SEC RATE (-1)	-1.107	0.351	-3.155	0.002
Real Money Supply	0.072	0.087	0.820	0.415
WPI Inflation	0.010	0.004	2.731	0.008
WPI Inflation (-1)	-0.012	0.003	-3.575	0.001
Real Oil Price	-0.0004	0.000	-2.298	0.025
C	-0.423	0.223	-1.898	0.062
Cointegrating Form and Long-Run Relationship				
Real G-SEC RATE	-4.558	14.084	-0.324	0.747
Real Money Supply	1.270	1.486	0.854	0.396
WPI Inflation	-0.033	0.114	-0.286	0.776
Real Oil Price	-0.007	0.019	-0.377	0.707
C	-7.502	16.277	-0.461	0.646

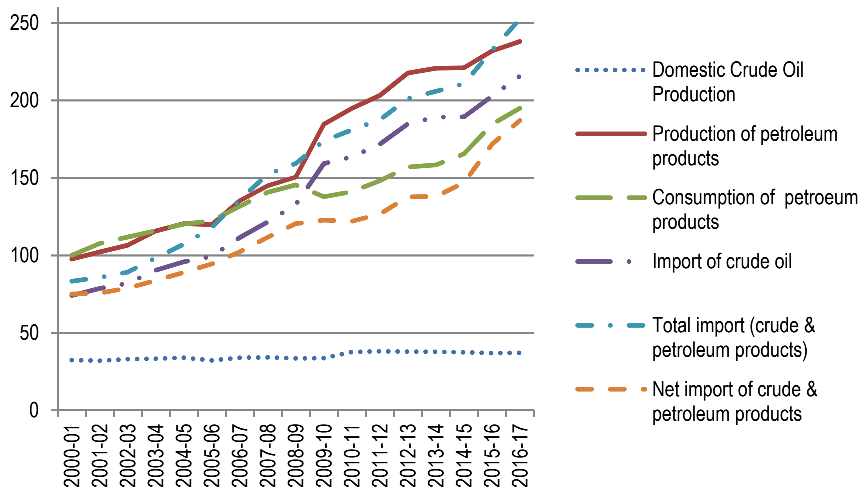
Note: Adjusted R-squared of ARDL model is 0.998. ARDL Bounds Test F statistic is 4.43 for the null hypotheses of no long-run relationships exist. 5% critical value bound is 2.86 and 4.01 for I0 and I1 bound respectively.

Table 5 – Estimated Matrix for GDP at FC

Estimated C_0 matrix					
	GDP	G Sec	M3	WPI- Infl	Oil Price
GDP	0.016*	0.002	0.002	0.001	0.001
G Sec	0	0.005*	-0.001	-0.011*	-0.011*
M3	0	0	0.015*	-0.006*	-0.010*
WPI- Infl	0	0	0	1.121*	1.324*
Oil Price	0	0	0	0	7.553*

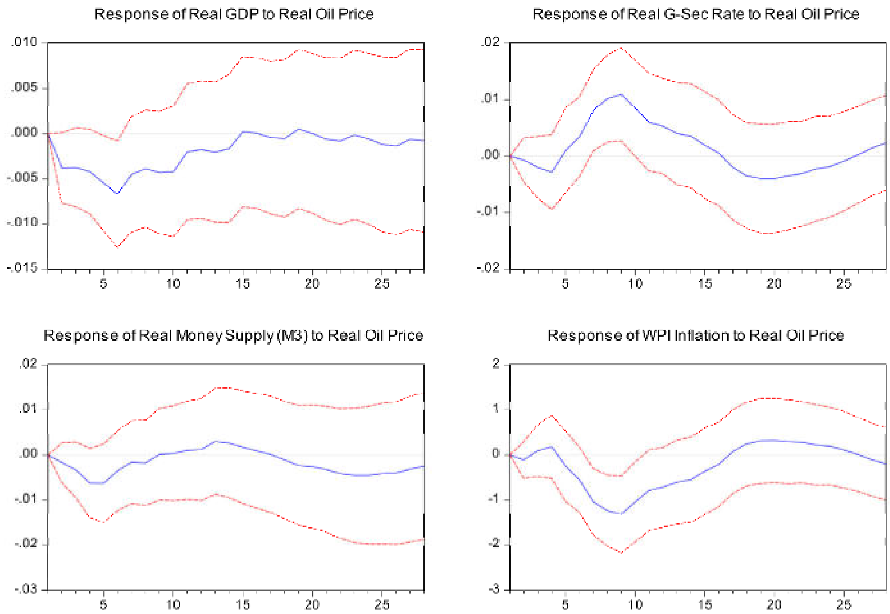
Note: * indicates significance at 5% level and ** at 10% level.

Figure 1 – Trend in the Production, Consumption, Import and Export Of Crude and Petroleum Products



Note: Unit of measurement is in Million Metric Ton (MMT)

Figure 2 – Response of Macroeconomic Variables to Shocks in Real Oil Price



Note: Response of Cholesky one standard deviation innovations and 2 standard error positive and negative bands.