Decline in International Crude Oil Price and its Macro-economic Impact in India

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Abstract

The purpose of this paper is to look into the macroeconomic impact of fluctuations in international crude oil price, as well as retail price of diesel in India. It uses two vector auto regression (VAR) models, one with international crude oil price and the other one with retail diesel price in India. A comparison is made between the outcomes of the VAR in order to see which has a larger and more sustained effect on India's price level and output. The time period for study is from the first quarter of 2006 to the third quarter of 2015.

As far as the impact of oil price changes on GDP and price level is concerned this paper concludes the following:

(1) Retail diesel price changes have positive but delayed effect on inflation whereas crude oil prices have an immediate but un-sustained positive impact. The impact of retail diesel price is larger compared to that of crude oil price, on price levels.
(2) Retail diesel price negatively affect output for at least 6 months and this result is statistically significant. Crude oil price negatively impacts output with a lag but with a lesser magnitude.

In the period of study, that is 2006Q1 – 2015Q3, crude oil prices have gone through two episodes of sharp and sustained fall, once in 2008 and another time in 2014-15. But retail diesel price was reduced during these phases by a much lesser proportion. During the phases of rise in crude oil price, retail diesel price shows a rising trend, but again by a much lesser proportion. As the results of our VAR models suggest, it is the retail diesel prices which had a stronger impact on both output and price. Thus the two phases of significant crude oil price drops, India could have experienced a higher increase in GDP and controlled inflation more effectively if the retail diesel price would drop by similar proportions as that of international crude oil price . At the same time slowing of GDP growth and upward pressure on price level that was expected during phases of crude oil price increase did also not appear to have happened. This was possibly due to the dampened rise in retail diesel price compared to international crude oil price.

Key Words: Oil price, Macro-economy, India
JEL Classification: C21, E32, F43, Q43

Section 1: Introduction

Oil prices matter significantly for the health of economies around the world, and quite differently for the oil importing countries than for the oil exporting countries. The degree of

impact differs between advanced and developing nations as well as between times when oil price is rising and when oil price is falling. Some impacts of oil price fluctuations are delayed, some are long lasting and some come with a short memory. The purpose of this paper is to look into the macroeconomic impact of fluctuations in crude oil price, as well as retail price of diesel in India

The last 10 years (2006-2015) has been eventful in terms of fluctuations in crude oil prices. Crude oil prices (in USD) were on a rising trend between beginning of 2006 and middle of 2008, falling by more than 75% in the second half of 2008, rising thereafter till middle of 2014 and falling sustainably by around 67% through 2014 and 2015. We look into the impact of oil price movements on growth of macroeconomic activities and inflation in India during this ten years period beginning in first quarter of 2006 financial year till the third quarter of 2015. During the time period of study international crude oil prices have gone through large fluctuations as mentioned above. Retail oil prices in India also followed a similar tend but with a much lesser severity. We attempt to compare the impact of crude oil price movements and retail diesel price movements on macroeconomic activities and inflation in India. Vector auto regression (VAR) with 2 period lags has been used for this purpose. Two VAR models are conducted, with two different oil prices, namely the crude oil price, and retail price of diesel.

We conclude that retail diesel price has a larger but delayed positive impact on price levels whereas crude oil price has an immediate but short lived impact. We also conclude that retail diesel price affects output negatively and in a statistically significant manner. Crude oil price negatively impacts output with a lag but with a lesser magnitude and lesser statistical significance.

A short survey of empirical literature is presented in the next section. Section 3 is devoted to presenting the methodology and data. The results are discussed in Section 4 and the note is concluded in Section 5.

Section 2: A short literature survey:

The negative relation between oil price changes and economic growth had been established in the early literature. (Rasche and Totom (1977), Darby (1982), Bruno and Sachs (1982)). Hamilton (1983) shows that since the end of Second World War all but one US recessions have been preceded (Granger caused) by sharp oil price increases. The negative relation between oil price changes and macroeconomic growth have not proven to be always true in many of the empirical literature in more recent times. Hooker (1996) showed that oil price no longer Granger cause many of the US macroeconomic indicators after 1973. Barsky and Killan (2001, 2004) argues in a similar manner as Hooker (1996). Barnanke (1997) shows that an important part of the effect of oil price shocks on the economy results not from the changes in oil prices but from the resulting tightening of the monetary policy.

To test the validity of the prediction of negative relation between oil price changes and output growth, and the positive relation between oil price changes and inflation rates, vector auto regression (VAR) models in its various forms and Granger causality tests have been predominantly used in recent past. Baffes et. al. (2015) summarises the recent set of literature in this regard. This summary includes studies representing data covering the time period 1980-2008 for countries around the world. The results are mixed and do not

necessarily conform to the expected relation between oil price changes, output changes and inflation.

In this regard, there have been a few studies conducted on India. Here we present the main findings of three such studies. (Akram (2011), Kumar S. (2005), Aparna A. (2013)).

Kumar S. (2005) studied the time period of 1975Q1 – 2004Q3. This paper found that oil prices Granger cause industrial growth in India during the period of study. This paper also found higher impact of oil price changes when oil price was measured in the domestic currency than in US$. For the Indian economy this paper finds that a 100% increase in oil prices reduces growth rate of industrial production by 1%. The inflation rate and the short term interest rates are found to be positively affected by the increase in oil prices. Furthermore, an oil price shock in a stable environment was found to have larger economic consequence than one in a volatile price environment.

Akram (2011) studied the time period 1984-2009. This paper found that oil price increases have a negative impact on economic growth but it is insignificant. The negative impact is smaller in the second year. The impact of crude oil price decrease was found to be significant and stronger than that of the crude oil price increases. The results show that oil price decrease impacts economic growth positively and significantly in second lag, that is, in 6 months' time. This is probably because the real impacts of policy adjustments for oil price changes show into the economy after some time.

Aparna (2013) has used quarterly data for 1995-2008. Any positive change in the crude oil price is shown to have a negative impact on GDP and Index of Industrial Production and a positive impact on Wholesale Price Index. While GDP and IIP shows signs of oscillating decay over a period of time, WPI, after a positive increment returns to its original value in about 4 months.

Section 3: Methodology and Data:

In analyzing interaction between oil price and the macro-economy, the vector auto regression (VAR) model is one of the leading approaches since Sims' (1980). In this note, we also adopt the VAR model. Consider the following VAR model of order p:

$$X_t = c + \sum_{i=1}^{p} \beta_i \; X_{t-i} + \; \varepsilon_t$$

Where, $X_t = (X_{1t}, X_{2t}, X_{3t} \ldots.. X_{nt})$ is a nX1 vector of endogenous variables while X_{t-i} is the corresponding lag term in order i.

β_i is the nXn matrix of autoregressive coefficients of vector X_{t-i} for $i = 1, 2, 3 \ldots p$.

$c = c_1, c_2, c_3 \ldots. c_n$ is the nX1 intercept vector of the VAR model.

$\varepsilon_t = \varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \ldots. \varepsilon_{nt}$ is the nX1 vector of residual terms.

We consider two VAR models with four endogenous variables each. The first VAR model includes GDP, price level, crude oil price and money supply. The second VAR model includes GDP, price level, retail diesel price and money supply. Our primary objective is to look in the effects of oil price changes on GDP and inflation. Oil price appears as crude oil price in the first model and as retail diesel price in the second model. This helps us to compare the effects crude oil price changes and retail oil price changes on GDP and inflation. Money supply is included to capture the influence of oil price shocks on GDP and inflation

that might operate indirectly through the monetary policy. The VAR model is estimated with a constant and two lags. The endogenous variables are constructed as follows:

Crude oil prices: Quarterly end of period values of Europe Brent spot price has been used. This data has been collected from U.S. Energy Information Administration website. The price of crude oil was quoted in US $ per barrel. It has been converted to price quoted in India Rupee using the INR/USD exchange rate. The currency exchange rate vales are end of period values.

Retail diesel prices: Quarterly end of period values of retail diesel prices are used. Retail diesel prices vary across states in India. Prices prevailing in the capital city of Delhi are used as a proxy for retail prices in India. This data has been collected from the website of Petroleum Planning and Analysis Cell under the Ministry of Petroleum and Natural Gas, Government of India.

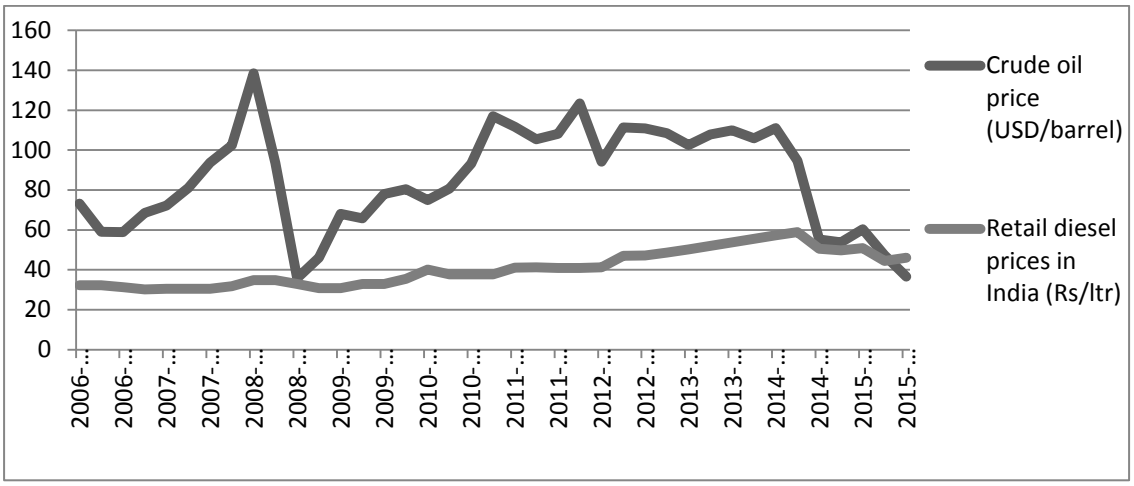
GDP: India's quarterly GDP data has been extracted from RBI statistical database. The GDP data is calculated at constant price of 2004-5.

Price level: Quarterly end of period values of Wholesale price index has been used to represent price level. The base year for WPI is 2004-5. This data is also extracted from RBI data base.

Money supply: Quarterly end of period values of M3, extracted from RBI data base, has been used to represent money supply in India.

Quarterly data have been used for the time period of study is 2006Q1- 2015Q3. Log values of all data series have been used. Augmented Dickey-Fuller unit root test has been applied to test the stationarity of the time series data and it was found that none of the data series was stationary at level, but all were stationary at first difference in lag 2. Hence for all the data series first log difference was used.

Figure 1



Section 4: Results

The vector-auto-regression estimates of the two models are given in Appendix in Table A1 and Table A2. Here in this section we discuss the main results.

Oil price and macroeconomic output is expected to be negatively related as per our discussion in section 2. The VAR estimate with crude oil price suggest that crude oil price and output carry a negative relation only in lag 2, that is in 6 months' time, while in lag 1 (in 3 months) the relation is positive. The rising (or falling as the case may be) import bill due to crude oil increase (decrease) should leave lesser (more) for domestic absorption and hence lead to a fall (rise) in GDP. The time taken for this adjustment may be reflected in the negative relation being established only with 6 months' lag. The VAR estimate with retail diesel price suggests that retail diesel price and output have a negative relation both in lag 1 and in lag 2. The magnitude and significance of the coefficient of retail diesel price in the equation with GDP as dependent variable is more in the second lag than in the first. The macroeconomic adjustment could possibly be the following. Rising (falling) diesel prices raises (reduces) cost of production reducing (raising) profit, followed by reduction (rise) in output. This works through the production processes in goods market and hence the effect is probably enhanced with a lag.

Oil price and price level is likely to be positively related. The VAR estimate with crude oil price suggests a positive relation between crude oil price and WPI in lag 1 and a negative relation in lag 2. A rise (fall) is crude oil price worsens (improves) the current account and hence devalues (appreciates) the currency. This will in turn raise (reduce) the price level. This adjustment seems to be quick and reverses in lag 2. The VAR estimate with retail diesel price suggests that retail diesel price and WPI is positive only in lag 2 and negative in lag 1. Diesel price is likely to affect price level through cost of fuel in production and transport. It seems from the VAR result that this adjustments manifests only in the second lag. Interestingly, and predictably, the coefficients of retail diesel price is larger in magnitude than that of the crude oil prices signifying a stronger relation between diesel price and WPI than between crude oil price and WPI.

Money supply is observed to have a positive effect on GDP in lag 1 and a negative effect in lag 2. Money supply and price levels have a sustained positive relation in lag 1 and lag 2. This holds true in both the VAR models. This results confirms the well-established prediction of macroeconomic theory that monetary policy is likely to be effective on output in the short run but not so in the longer term, where as it leaves the price level with a sustained positive impact.

It also appears from the results of both the VAR estimates that money supply changes have a stronger effect on output that oil price changes.

Section 5: Conclusion

As far as the impact of oil price changes on GDP and price level is concerned we conclude the following:

(3) Retail diesel price changes have positive but delayed effect on inflation whereas crude oil prices have an immediate but un-sustained positive impact. The impact of retail diesel price is larger compared to that of crude oil price, on price levels.

(4) Retail diesel price negatively affect output for at least 6 months and this result is statistically significant. Crude oil price negatively impacts output with a lag but with a lesser magnitude.

In the period of study, that is 2006Q1 – 2015Q3, crude oil price has gone through two episodes of sharp and sustained fall, once in 2008 and another time in 2014-15. But retail diesel price was reduced during these phases by a much lesser proportion. During the phases of rise in crude oil price, retail diesel price showed a rising trend, but again by a much lesser proportion. As the results of our VAR models suggest, it is the retail diesel prices which had a stronger impact on both output and price. Thus the two phases of significant crude oil price drops, India could have experienced a higher increase in GDP and controlled inflation more effectively if the retail diesel price would drop by similar proportions. At the same time slowing of GDP growth and upward pressure on price level that was expected during phases of crude oil price increase did also not appear to have happened possibly due to the dampened rise in retail diesel price.

Appendix

Table A1
Vector Auto Regression Estimates with GDP (Y), WPI (P), M3 (M) and Crude oil price (OE)
(DLNY, DLNP, DLNM, DLNOE stands first log difference of the above variables)
Standard errors in ( ) & t-statistics in [ ]

	DLNY	DLNP	DLNM	DLNOE
DLNY(-1)	-0.1168	0.043834	0.21377	1.309471
	-0.07083	-0.0515	-0.04304	-0.71665
	[-1.64911]	[0.85112]	[4.96704]	[1.82721]
DLNY(-2)	-0.954833	0.107044	-0.078797	-0.229075
	-0.08458	-0.0615	-0.0514	-0.85582
	[-11.2891]	[1.74047]	[-1.53316]	[-0.26767]
DLNP(-1)	-0.320559	0.221009	0.028487	6.217785
	-0.36257	-0.26365	-0.22032	-3.66863
	[-0.88413]	[0.83828]	[0.12930]	[1.69485]
DLNP(-2)	-0.024235	-0.010628	0.230249	-2.962809
	-0.29878	-0.21726	-0.18155	-3.02319
	[-0.08111]	[-0.04892]	[1.26821]	[-0.98003]
DLNM(-1)	0.32219	0.223787	-0.016358	3.696671
	-0.2396	-0.17423	-0.1456	-2.42442
	[1.34468]	[1.28442]	[-0.11235]	[1.52476]
DLNM(-2)	-0.434024	0.124979	0.581788	2.172455

	-0.21956	-0.15966	-0.13342	-2.22162
	[-1.97678]	[0.78280]	[4.36066]	[0.97787]
DLNOE(-1)	0.034763	0.016341	-0.011634	-0.266413
	-0.02273	-0.01653	-0.01381	-0.22996
	[1.52957]	[0.98876]	[-0.84239]	[-1.15850]
DLNOE(-2)	-0.008399	-0.000267	-0.020923	-0.443611
	-0.02124	-0.01545	-0.01291	-0.21493
	[-0.39541]	[-0.01727]	[-1.62095]	[-2.06395]
C	0.045871	-0.005856	0.009429	-0.275694
	-0.01473	-0.01071	-0.00895	-0.14901
	[3.11496]	[-0.54689]	[1.05375]	[-1.85022]
R-squared	0.892715	0.477224	0.686173	0.39515
Adj. R-squared	0.860927	0.322328	0.593187	0.215935
Sum sq. resids	0.011401	0.006028	0.00421	1.167235
S.E. equation	0.020549	0.014942	0.012486	0.207921
F-statistic	28.08329	3.080922	7.37932	2.204895
Log likelihood	93.95504	105.4249	111.8884	10.63807
Akaike AIC	-4.719724	-5.356937	-5.716023	-0.091004
Schwarz SC	-4.323844	-4.961057	-5.320143	0.304876
Mean dependent	0.016628	0.012632	0.036786	-0.00201
S.D. dependent	0.055101	0.018151	0.019577	0.234813
Determinant resid covariance (dof adj.)		2.30E-13		
Determinant resid covariance		7.29E-14		
Log likelihood		340.1736		
Akaike information criterion		-16.89853		
Schwarz criterion		-15.31501		

Table A2

Vector Auto Regression Estimates with GDP (Y), WPI (P), M3 (M) and retail diesel prices (RD)
(DLNY, DLNP, DLNM, DLNRD stands first log difference of the above variables)
Standard errors in ( ) & t-statistics in [ ]

	DLNY	**DLNP**	**DLNM**	**DLNRD**
DLNY(-1)	-0.10669	0.055714	0.212693	0.034225
	-0.07056	-0.05156	-0.04137	-0.18258
	[-1.51204]	[1.08060]	[5.14066]	[0.18746]

DLNY(-2)	-0.955632	0.113118	-0.08434	0.522365
	-0.08471	-0.0619	-0.04967	-0.21919
	[-11.2813]	[1.82753]	[-1.69798]	[2.38321]
DLNP(-1)	0.027788	0.451645	-0.043819	1.352069
	-0.30518	-0.22299	-0.17895	-0.78964
	[0.09105]	[2.02540]	[-0.24488]	[1.71226]
DLNP(-2)	0.055691	-0.120864	-0.03328	1.274821
	-0.30851	-0.22543	-0.1809	-0.79827
	[0.18052]	[-0.53616]	[-0.18397]	[1.59699]
DLNM(-1)	0.261853	0.247801	0.036477	0.008822
	-0.25122	-0.18357	-0.14731	-0.65004
	[1.04231]	[1.34991]	[0.24762]	[0.01357]
DLNM(-2)	-0.546929	0.151202	0.666042	-0.449168
	-0.23379	-0.17083	-0.13709	-0.60492
	[-2.33944]	[0.88512]	[4.85859]	[-0.74252]
DLNRD(-1)	-0.012352	-0.030609	-0.061633	-0.280587
	-0.08681	-0.06343	-0.0509	-0.22462
	[-0.14228]	[-0.48256]	[-1.21080]	[-1.24917]
DLNRD(-2)	-0.156482	0.02909	0.097711	-0.210155
	-0.09882	-0.07221	-0.05794	-0.2557
	[-1.58351]	[0.40286]	[1.68627]	[-0.82189]
C	0.048895	-0.009513	0.008112	-0.012279
	-0.01494	-0.01091	-0.00876	-0.03865
	[3.27333]	[-0.87159]	[0.92618]	[-0.31768]
R-squared	0.891472	0.466016	0.704386	0.349113
Adj. R-squared	0.859316	0.307799	0.616797	0.156257
Sum sq. resids	0.011533	0.006158	0.003965	0.077214
S.E. equation	0.020667	0.015102	0.012119	0.053477
F-statistic	27.72306	2.945415	8.041913	1.810228
Log likelihood	93.74772	105.043	112.9646	59.52278
Akaike AIC	-4.708207	-5.335724	-5.775811	-2.806821
Schwarz SC	-4.312327	-4.939844	-5.379931	-2.410941
Mean dependent	0.016628	0.012632	0.036786	0.010794
S.D. dependent	0.055101	0.018151	0.019577	0.058218

Determinant resid covariance (dof adj.)		2.05E-14		
Determinant resid covariance		6.48E-15		
Log likelihood		383.7222		
Akaike information criterion		-19.3179		
Schwarz criterion		-17.73438		

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