An Empirical Study on the Impact of Crude Oil Price on Macro -Economic Variables of India

Payal Shankara Poojary
Student, MBA-Finance Management, Department of Management studies
Christ (deemed to be University)

Abstract: *In order to mitigate the inflation rates and speeding up the economic growth of the country, crude oil price plays a very important role as it's the basic natural resource required for the production of many output. India being one of the top importers of this basic fuel, has many effects from this crude oil price fluctuations. This study is conducted to check if the crude oil price changes have impact on selected macroeconomic variables of the Indian economy. The study also examines the volatility of the dependent and independent variables. For the purpose of this study, quarterly data of Gross Domestic Product (GDP), monthly data of inflation, monthly averaged exchange rates (USD/INR) and monthly averaged crude oil prices were collected for a period of 20 years (April 1996- March 2017) were collected. To test the impact linear regression is used, to test the cause-effect relationship Granger Causality test is used and for volatility purpose ARCH and GARCH is used. The results showed that there exist significant relationship between each of the dependent variable (GDP, Inflation and exchange rate) with the independent variable (crude oil prices). Also that crude oil price changes cause the changes in all the dependent variable. Also there exist volatility and volatility clustering among all variables.*

Key Words**:** *crude oil price, GDP, CPI, exchange rate, Granger causality, ARCH, GARCH*

1. INTRODUCTION:

Energy is the most important requirement for any country for their economic development. When energy resources are available at the right time and in the required quantity, the country will be able to produce more output and march towards economic growth. For this sole reason countries have been focusing on the energy security and finding ways to efficient and effectively use it. With the growing economic development it has become a great concern for the developing nations to manage their resources well.

Crude oil being one of the most used energy resource, is not just a source of energy but also forms a part of raw materials for many industries. Since this resource is not equally distributed all around the world, the price of this resource tends to affect both the importing and exporting country. India ranking second among the importers, the price changes of the oil will have some impact on the economic factors. Traditionally, the non-oil producing countries tend to have negative impact by the rising crude oil prices and are usually characterised by high net imports per GDP.

The global crude oil price have been very volatile in nature ranging from a high of $115/bbl in mid-2014 to a low of $28/bbl in the year 2016. This fall in price has improved the import bills as they show reduced cost which in turn has reduce the Current Account Deficit (CAD)[1]. This reduction in CAD, along with increased foreign capital inflows due to the initiatives taken up by the government, has led to increase in their foreign reserves. This made the Indian currency the best currency among the emerging market. When crude oil price falls the government can manage their budgets better as they would be paying lesser subsidy. From the nations point the falling prices tend to have positive effects but industries that are linked to petroleum and its product will be hit hard by this. This gives a vast scope for studying how the rising or falling prices or the volatility of crude oil prices tend to have impact on the various economic variables.

2. REVIEW OF LITERATURE:

Pankaj Bhattacharjee (2014) conducted a study to find out the effect of crude oil prices on the Indian economy by taking inflation (WPI) and gross domestic product as dependent variables and crude oil pieces as independent variable. In his study he used Karl Pearson's correlation coefficient model, regression and Grangers Casualty test to find results for his objective. His results showed that there is positive impact of crude oil price and WPI, the rising inflation has impact on declining GDP. He also found out that rise in the price of energy leads to decline in the current productivity of capital and labour [2]. Akansha Sanjay Jain and Nitish Sunil Patil (2015) tried to analyse the trend of production with consumption and production with the import levels and to check if crude oil prices have effect of fiscal and trade deficits, and Indian oil companies. For their study they used graphical method to analyse the data. The study concluded to say that India's demand for crude oil has been increasing, so has the imports of crude oil. So there is a necessity to find some alternative to this energy resource [3].

Apere O. ThankGod (2013) conducted a study to find out how oil prices have impact on the macroeconomic activity in Nigeria. They used Exponential generalized autoregressive conditional heteroscedasticity (EGARCH) and lag-augmented VAR model to analyse this. He found out that there is unidirectional relationship between interest rate and exchange rate with the crude oil prices. His study stated that there exist no significant relationship between GDP and crude oil prices [4]. LI Cuiping (2016) tried to find out how the crude oil prices have impacted the GDP, CPI, monetary policy (M2) and unemployment rate of Kazakhstan using Grangers Casualty test, impulse response analysis and VAR. The study showed that the crude oil price does not cause the GDP to increase or decrease but it just affects the speed of it and the monetary policy and employment has positive impact with crude oil price change [5]. Alhassan Abdulkareem and Kilishi A. Abdulhakeem (2016) did a study on Nigerian economy and effects of crude oil price volatility. The study employed GARCH models and its variants to check volatility of the variables namely GDP, exchange rate, interest rate and crude oil prices. The study employed found that all the variables considered are highly volatile. It was found that Nigerian economy was prone to both internal shocks and external shocks. The study suggested that the Nigerian economy must try to improve their output from their agricultural sector and industrial sector in order to reduce their dependency on oil sector [6].

3. STATEMENT OF PROBLEM:

India being a country with not much of natural crude oil resources, it is necessity for them to import the growing oil demands. The country produces 23-24% of Crude oil requirement within the borders. But this production level is not enough to meet the consumption level of the country. India currently imports oil worth US$ 9.29 billion as on October 2017 which is an increase by 29.89% as compared to previous year. Imports at such high level will tend to have impact on the nations growth [7]. So this study aims to find out how the crude oil prices will affect the macro economic variables of the country.

Since India is not self-sufficient in producing within the country, it opts to import the oil to bridge the gap between growing demand and limited supply of the country. The studies previously conducted to find the relation between crude oil price changes and its effect on macroeconomic variables has mostly considered only the GDP and inflation as their dependent variables, but since crude oil is purchased using US dollars, it makes it necessary to study the impact on the exchange rates too. The study conducted till date in India was only to find relationship between the variables. No effort has been made to find the volatility of the variables used.

It is estimated that India's dependency on crude oil is to grow up to 94% by 2030 (Pankaj Bhattacharjee, 2014). Therefore, this paper aims to study the relationship between crude oil prices and the Gross Domestic Product (GDP), inflation by taking the Consumer Price Index (CPI) and the exchange rate (USD/INR). It also aims to find the direction of among the variables and to see how volatile the variables are.

4. OVERVIEW OF TOOLS USED IN THE STUDY:

Auto Regressive Conditional Heteroskedasticity (ARCH) model was developed by Engle in 1982 and enhanced by Bollerslev in 1986 and then by Nelson in 1991. ARCH model was an important improvement over the rolling standard deviation, which was used as a measure of volatility in those days (Engle, 2001)[8].

The discovery done in 1982, ARCH is a very famous tool of measuring the volatility present in the given series. Of the variants, the one that has become the most popular is **Generalised Autoregressive Conditional Heteroscedasticity (GARCH)** model, proposed by Bolllerslev. For the study the simple GARCH model, GARCH(1,1) is used, which is given in equation (1).

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \, \varepsilon_{t-j}^2 \qquad (1)$$

Where σ_t^2 is the variance for the time period t. $\alpha_i$and β_j are coefficients. ε_{t-i}^2 is the lagged residual from the mean equation and ε_{t-i}^2 is the lagged variance from the period t-j. Variance is always a positive number. In order to satisfy this constraint, α_i>0 and β_j>0 was also specified. The GARCH (1,1) model has three components, the constant α_0, the news about volatility from the previous period (ARCH term ($\sum_{i=1}^{p} \alpha_i \, \varepsilon_{t-i}^2$)) and the last period's forecasted variance (GARCH term-($\sum_{j=1}^{q} \beta_j \, \varepsilon_{t-j}^2$)). An ordinary ARCH model is a special case of a GARCH specification where no lagged variances are included in the equation (Natchimuthu, Ram & Hemanth S Angadi,2017)[9].

Granger Causality Test is used to study if one variable causes the other. The test assumes that the information provided of the variables used for prediction is solely present in time series data. The test uses the following pair of regression estimation- equation (2) & (3):

$$X_t = \sum_{i=1}^{n} \alpha_i \, Y_{t-i} + \sum_{j=1}^{n} \beta_j \, X_{t-j} + u_{1t} \qquad (2)$$

$$Y_t = \sum_{i=1}^{n} \lambda_i \, Y_{t-i} + \sum_{j=1}^{n} \delta_j \, X_{t-j} + u_{2t} \qquad (3)$$

Where the disturbance term u_{1t} and u_{2t} are assumed as uncorrelated. The causality between the two variables are studied using Bilateral Causality. (Gujarati, Porter, & Gunasekar, 2012)[10].

5. OBJECTIVES OF THE STUDY:

- To examine the impact of crude oil prices on the GDP, inflation (CPI) and exchange rates independently.
- To find the cause-effect relationship between crude oil prices and GDP, inflation and exchange rates, independently.
- To find the volatility of the dependent and independent variables used in the study.

6. RESEARCH METHODOLOGY:

The data used in the research is completely secondary database. The data regarding the Gross domestic product, inflation based on consumer price index and the exchange rates were collected from various authorized sites like Reserved Bank of India, petroleum planning and analysis cell (PPAC), ibef.com, Indiastats.com, fred.stlouisfed.org and OPEC annual reports. The study period that was taken into consideration was from April, 1996 to March, 2017. The GDP was collected quarterly basis and for the purpose of impact study the crude oil prices were averaged to quarterly basis. The Consumer price index considered has the base year set as 2010 (base year 2010=100). The exchange rates from USD to INR was averaged to monthly basis as the data available on Crude oil was on monthly basis.

For all the variables used in analysis the log differences were used in order to stabilise the data and to find better results. The logged differences were calculated using the equation (4):

$$R_t = \log(P_t) - \log(P_{t-1}) \qquad (4)$$

The analysis done in the study is all done using "Eviews 9.5" student version statistical software. The econometric analysis that was done was Augmented Dicker Fuller test, simple regression, Granger Causality Test, ARCH and GARCH.

7. LIMITATIONS OF THE STUDY:

- The study period is the limited to 20 years due to the availability
- The GDP data is only available on quarterly basis. For volatility, it would be better if more data is available.
- Only selected macroeconomic variables are used. There are a lot of other variables that can be tested.

8. EMPIRICAL RESULTS:

Results of Augmented Dicker Fuller Test- Unit root test

The augmented Dicker Fuller test (ADF Test) is conducted to test if the data collected is stationary or not. This is done because if the data collected is not stationary (non-stationary) then the result of the analysis would be wrong (Dicker & Fuller, 1979). For this test the null hypothesis considered would be that, there is unit root or the series is non-stationary and the alternative hypothesis would be that the series is stationary. The test was conducted on all the variables in the chosen for the study. The null hypothesis is rejected if the P-value is lesser than 5% (p-value< 0.05) and the alternative hypothesis is selected. If p-value is greater than 5% then null hypothesis is accepted. The study for stationarity revealed the following results.

Table 8.1: Results of ADF test (at level)

Variables	t-Statistics	P-value
Crude oil prices	-12.70839	0.0000
Gross domestic product	-8.253554	0.0000
Consumer price index	-11.61574	0.0000
Exchange rate	-11.52074	0.0000

Source: Author's calculation

The analysis showed that all the variables are stationary at level as all their p-value is all below 0.05. So for all the variables null hypothesis is rejected and alternative hypothesis is accepted. Therefore, all the variables are stationary.

Results of Simple Linear Regression

The simple regression is done to test the relation of each dependent variable with the independent variable. The analysis was done by analysing the coefficient of independent variable and the p-value. Also the R-squared value is analysed as check the significance of the relationship. The null hypothesis in each of the linear regression is that crude oil price does not impact the other variable (i.e. either GDP/ inflation/ exchange rate) and alternative hypothesis is that crude oil price impacts the dependent variable. The impact using the simple regression are stated below.

Table 8.2: Results of regression analysis

Regression variables	Probability	Coefficient	R-squared
Crude oil price on GDP	0.0011	0.029681	0.124212
Crude oil price on inflation	0.0000	0.011763	0.486671
Crude oil price on exchange rates	0.0000	0.146290	0.133173

Source: author's calculation

From the above table it is examined that crude oil has impact on the GDP of the India. The p-value is at 0.0011 which means that the coefficient is significant and is significant at 1% level. The coefficient value is 0.029681 which means that 1 unit increase in crude oil prices will lead to 0.029681 units of increase in GDP, or vice versa. The R-squared value is at 0.124212, which means 12% of the changes in GDP is explained by crude oil prices changes. The results also suggest that there exist positive relationship among the variables.

The relation between crude oil and inflation shows significant. The p-value is at 0.000 which means that the coefficient is significant and is significant at 1% level. The coefficient value is 0.011763 which means that 1 unit increase in crude oil prices will lead to 0.011763 units of increase in inflation, or vice versa. The r-squared value stands at 11.48810, meaning that 11% of changes in consumer price index is explained by crude oil price changes. This relationship between the variables is also said to be positive in nature.

The results of crude oil and exchange rate of the India is also significant. The p-value is at 0.000 which means that the coefficient is significant and is significant at 1% level. The coefficient value is 0.146290 which means that 1 unit increase in crude oil prices will lead to 0.146290 units of increase in inflation. The r-square results (0.133173) show that 13% of fluctuations in exchange rates are caused by the crude oil fluctuations. Also the variables show a positive relationship among them.

Results of Granger Causality Test

The test helps to analyse if one variable causes the other variable. The casualty is analysed by interpreting the f-statistics. The null hypothesis in each of the case is that the variable does not "Granger-cause" the other variable. The critical value for the analysis of the f-statistics is 2.50. If the value is above 2.50 then we reject the null hypothesis and accept alternative hypothesis that is the variable does Granger causes the other variable. But if below 2.50 then we accept null hypothesis.

Table 8.3: Results of Granger Causality test

Cause	Effect	f-statistics
Crude oil price	GDP	3.79511
GDP	Crude oil price	0.25765
Crude oil price	CPI	5.09106
CPI	Crude oil price	0.03140
Crude oil price	Exchange rate	3.13525
Exchange rates	Crude oil price	0.74435

Source: Author's calculation

From the crude oil prices does granger cause GDP to increase or decrease, it causes inflation and also that it causes the volatility in the exchange rates too. But in all the other cases the other way round cause-effect relationship doesn't work out i.e. neither does GDP, nor do inflation nor exchange rate fluctuations cause the crude oil fluctuation.

Results of volatility of the variables

This tool was used to check the volatility of each of the variables considered in the study and to see if there is any clustering affect among the variables considered. For finding the volatility effects ARCH was analysed and for the clustering effect GARCH is analysed. The coefficients were used for analysing the effects, provided the effect probability value was significant (that is below 0.05).

Table 8.4: Results of ARCH and GARCH analysis

Variables	ARCH term	GARCH term
Crude oil prices	0.269313 (0.0023)	0.615584 (0.0000)
Gross domestic product	0.317824 (0.0525)	0.742146 (0.0000)
Inflation (CPI)	0.107379 (0.0066)	0.896797 (0.0000)
Exchange rate (USD/INR)	0.864423 (0.0003)	0.298570 (0.0042)

Source: Author's calculation

The results show that coefficients of ARCH and GARCH terms are significant at 5% level. That means there is volatility and volatility clustering present in the data set considered. The coefficient values above 0.7 is considered to have strong effect. Therefore, ARCH effect is seen to be very strong in case of exchange rates. On the remaining there's moderate volatility existence. When GARCH is analysed it can be observed that GDP and inflation data seems to have strong volatility clustering within the data. For the remaining there's moderate volatility clustering.

Results of ARCH LM test

This test is conducted to check the significance of ARCH model that is used. The null hypothesis for this test would be that the results of GARCH residuals do not have ARCH type of heteroscedasticity. The test results are inferred using the probability value. If the probability value is above 0.05 then we accept the null hypothesis. That means that the residuals have ARCH type of heteroscedasticity and the GARCH model is fits well for the data.

Table 8.5 Results of ARCH LM test

Variable	Observed R-Square	Probability
Crude oil price	0.243279	0.6218
Gross domestic product	0.227101	0.6337
Inflation (CPI)	7.395050	0.9931
Exchange rate	0.367258	0.5445

Source: Author's calculation

From the above it interpreted that all the variables probability value is above 0.05. Which means the model is best fitted for the data set used.

9. FINDINGS:

From the above study it can be concluded that the exist relationship between the dependent variable and the independent variable. The objective of finding relationship between the variable shows that there exist positive relationship between GDP and crude oil. That is if crude oil prices increase then it would lead to increase of GDP too. There is very low level increase happening in GDP. Also while doing the Granger cause effect it was found out that crude oil price changes cause changes in GDP but the inverse relation does not exist. And speaking of the volatility of GDP, it is moderately volatile in nature but has strong volatility clustering effects. And speaking of the volatility of the crude oil prices, it is moderately volatile and moderate clustering effects are found.

Coming to the other dependent variable inflation based on consumer price index, the relationship of this with the crude oil price changes seems to be significant. There exist positive relationship among them. On conducting Granger Causality Test, it was found that crude oil price changes does cause changes in inflation but vice versa does not exist. And the volatility of the CPI data was found to be very moderate but highly clustered data is found.

And the last dependent variable being exchange rates, had again significant relationship with the crude oil prices. There exist a positive relationship among the variables. They are highly correlated with each other. They seem to have positive relationship that is if one increases, the other also increases. On testing granger causality it was observed that crude oil prices fluctuations causes exchange rate fluctuations. However, the inverse cause-effect relationship between the variables does not exist. The volatility of exchange rates are highly volatile but they are moderately clustered.

10. CONCLUSION:

India's dependency on crude oil has been increasing over the years. The effort made to reduce the dependency does not seem to match the growing demand. As observed in the study, crude oil prices tend to affect a lot of macro-economic variables and therefore huge efforts need to be made to control the dependency and reduce the effect of crude oil price volatility. Also speaking of crude oil prices, this resource is a non-renewable resource. So the prices of crude oil are every volatile in nature. If at all this resource becomes scares or if the supply is reduced, the prices might shoot up. This will lead to heavy government expenditure. As it is India has been running of deficit economy, if expenditure increases more then they might have to opt for borrowing. Which again slows down the growth of the country. So a better option would be to find out some alternative resources to reduce the dependency on importing of crude oil. The current government has aimed at reducing the dependency of importing at 80% levels to 65% by 2022 for which initiatives have been taken by limiting import levels. More efforts need to be put in for finding out more of the domestic reserves. India must ensure that till the dependency on importing crude oil is reduced, it must see to it their other goods export levels are increased so that they will be able to pay for the imports and deficit situations can be avoided. Also proper planning of petroleum imports at right quantity and at the right time would help in faster economic growth of the country.

REFERENCES:

1. Pankaj, b. (2013). a study of the impact of crude oil prices on indian economy.
2. Akansha, S., & Nitish, S. (2015). Crude Oil Prices and Its Impact on Indian Economy . *International Journal of Social Science and Humanities Research*.
3. Apere, O. T., & Ijomah, A. M. (2013). Macroeconomic Impact of Oil Price Levels and Volatility in Nigeria . *International Journal of Academic Research in Economics and Management Sciences* .

4. Cuiping, L. (2016). Crude oil Price Fluctuations to Kazakhstan Economic Impact Analysis . *International Conference on Energy and Environmental Prote*.
5. Abdulkareem, A., & Abdulhakeem, K. A. (2016). Analysing Oil Price- Macroeconomic Volatility in Nigeria . *CBN Journal of Applied Statistics Vol. 7 No. 1(a)* .
6. 5_1_ReportStudies @ ppac.org.in. (n.d.). Retrieved from
7. http://ppac.org.in/content/5_1_ReportStudies.aspx
8. Engle, R. (2008). GARCH 101 : The Use of ARCH / GARCH Models in Applied Econometrics, 15(4), 157–168.
9. Natchimuthu, N. (2017). Is Gold Price Volatility In India Leveraged ?, 21(3),1–10.
10. Gujarati, Porter, & Gunasekar. (2012). *basic econometrics.* new delhi: Mc Graw HIll Education.