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Relationship between Crude Oil and the Indian Economy

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Introduction

Crude Oil, commonly known as 'Petroleum' is one of the most valuable natural resources in the world. Some people call petroleum black gold, but it may be better described as the lifeblood of industrialised countries. Most industrialised nations depend heavily on imported petroleum to meet their energy needs. As a result of this dependence, oil-exporting countries have been able to use petroleum as a political and economic weapon by restricting exports to some of these nations.

For most countries, the Industrial sector has a huge weight attached to it in terms of importance for economic growth of that country. In today's competitive global environment, the key strategic objective for any country is to find ways of achieving and enhancing growth. In order to guarantee the long-term profitability, it is imperative for any country to form policies to tackle the price movements of important commodities failing which shall hamper the growth prospects of that country and consequently the growth prospects of the world, magnitude depending on the country's contribution to the World Economic Growth. Oil exporters have also strained the economies of a large number of countries, particularly the poorer ones, by drastically increasing the price of petroleum. Many nations, rich as well as poor, have suffered petroleum shortages since the early 1970's, further contributing to the oil price fluctuations.

Due to the great importance accorded to oil with respect to its influence on the Indian GDP Growth, it is important to study the relationship between oil price movements and the country's economic growth measured by the GDP at current prices. The research paper provides a backdrop against which the truth in the traditional view about the effect of oil prices on the Indian economy, that is, an increase in oil prices leads to a deceleration of the economic growth, can be tested.

Objectives

1. To test the validity of the traditional viewpoint regarding the relationship between the world oil price movements and the Indian GDP growth, using multiple regression model.
2. To test for problems of multicollinearity, autocorrelation and heteroskedasticity and remove, if any.

Scope and Limitations of the Research

For the purpose of paper, GDP of India at current prices has been regressed on Real Interest Rate, Fiscal Deficit and the Price of Crude Oil. This has been done to complete the model and also because both interest rate (which has been used as a proxy for monetary policy) and fiscal deficit of the government (which has been used as a proxy for fiscal expenditure) have strong direct effects on the GDP of an economy through their effects on investment, business confidence, etc. The accuracy of the results and relations obtained maybe cramped due to

statistical limitations and the dynamic nature of the variables in the real world, hence, permitting only broad conclusions.

Research Methodology

This research is carried out in two steps namely *data collection, statistical computations* and *analysis.* The data used has been obtained through various sources (mentioned in the end). To ensure credibility, the data has been randomly verified by comparison with data published by governmental and non-governmental international agencies such as *International Energy Agency (*IEA), *Central Intelligence Agency* (CIA), World Bank, etc.

Statistical analysis involves multiple linear (in parameters) regression analysis using Ordinary Least Squares Method. To provide an unbiased view the confidence level for each sample estimate has been calculated by Testing of Hypotheses using Student's t-test (to check for significance of individual partial regression coefficients) and the F-test (to check for significance of all the variables together). All the calculations have been made using the computer software Stata.

First, Ln (GDP) was regressed on Price of Crude Oil, Real Interest Rate and Fiscal Deficit and the model was tested for heteroskedasticity using the Breusch-Pagan test, also known as the Cook-Weisberg test; for autocorrelation using Durbin-Watson test and the Breusch-Godfrey LM test; for multicollinearity by calculating the Variance Inflation Factor (VIF). Second, on observation it was found that some results obtained were not in accordance with the economic theory. To remove this discrepancy, the model was transformed and the regressors were changed to natural logarithm of fiscal deficit, natural logarithm of price and real interest rate. This model also provided better economic logic as compared to the previous model. The same tests were then repeated for this model.

Assumptions underlying the CLRM (Classical Linear Regression Model) are given as below:

1. Linear regression model. The regression model is linear in the parameters,

$$Y_i = \beta 1 + \beta 2 X_i + u_i$$

2. X values are fixed in repeated sampling. Values taken by the regressor X

are considered fixed in repeated samples. More technically, X is assumed to be nonstochastic.

3. Zero mean value of disturbance u_i. Given the value of X, the mean, or

expected, value of the random disturbance term u_i is zero. Technically, the conditional mean

value of u_i is zero. Symbolically, we have

$$E(u_i \mid X_i) = 0$$

4. Homoscedasticity or equal variance of u_i. Given the value of X, the variance of u_i is the same for all observations. That is, the conditional variances of u_i are identical. Symbolically, we have

$$\text{var}\,(u_i \mid X_i) = E[u_i - E(u_i \mid X_i)]^2$$

$$= E(u_i^2 \mid X_i) \text{ because of Assumption 3}$$

$$= \sigma^2$$

where var stands for variance.

5. No autocorrelation between the disturbances. Given any two X values, X_i and X_j ($i = j$), the correlation between any two u_i and u_j ($i = j$) is zero. Symbolically,

$$\text{cov}\,(u_i, u_j \mid X_i, X_j) = E\{[u_i - E(u_i)] \mid X_i\}\{[u_j - E(u_j)] \mid X_j\}$$

$$= E(u_i \mid X_i)(u_j \mid X_j)$$

$$= 0$$

where i and j are two different observations and where cov means covariance.

6. Zero covariance between u_i and X_i, or $E(u_iX_i) = 0$. Formally,

$$\text{cov}\,(u_i, X_i) = E[u_i - E(u_i)][X_i - E(X_i)]$$

$$= E[u_i (X_i - E(X_i))] \text{ since } E(u_i) = 0$$

$$= E(u_iX_i) - E(X_i)E(u_i) \text{ since } E(X_i) \text{ is nonstochastic}$$

$$= E(u_iX_i) \text{ since } E(u_i) = 0$$

$$= 0 \text{ by assumption}$$

7. The number of observations n must be greater than the number of parameters to be estimated. Alternatively, the number of observations n must be greater than the number of explanatory variables.

8. Variability in X values. The X values in a given sample must not all be the same. Technically, var (X) must be a finite positive number.

9. The regression model is correctly specified. Alternatively, there is no specification bias or error in the model used in empirical analysis.

10. There is no perfect multicollinearity. That is, there are no perfect linear relationships among the explanatory variables.

Discussion and Findings

The Indian economy is ranked ninth in the world in terms of nominal GDP and in terms of purchasing power parity (PPP). It is a member of BRICS and is a part of the G-20 major economies. The country is ranked 129th in the world in terms of per capita GDP, implying that it is a lower-middle income economy. India has a decent growth rate in the period and is expected to be able to accelerate the growth rate further in the coming years, being a developing economy. The growth rate will further be translated to a manifold increase in energy requirements in the years to come. Therefore, it is of interest to study the relationship between the oil price movements and the GDP growth of Indian Economy.

Year	LN (GDP at current US$)	*Crude Oil Price ($US per Barrel)	Real Interest Rate (%)	Fiscal Deficit Combined for Centre and States (in 1000 crores)	LN (Crude Oil Price)	LN (Fiscal Deficit)
1990.00	26.51	43.04	5.27	53.58	3.59	3.98
1991.00	26.34	36.19	3.62	45.85	3.57	3.83
1992.00	26.40	35.64	9.13	52.40	3.44	3.96
1993.00	26.37	31.33	5.81	70.72	3.40	4.26
1994.00	26.53	29.89	4.34	71.25	3.47	4.27
1995.00	26.63	32.25	5.86	77.12	3.64	4.35
1996.00	26.71	38.15	7.79	86.55	3.59	4.46
1997.00	26.77	36.13	6.91	110.02	3.20	4.70
1998.00	26.78	24.49	5.12	156.09	3.52	5.05
1999.00	26.86	33.73	9.40	183.44	3.97	5.21
2000.00	26.89	52.91	8.33	198.24	3.82	5.29
2001.00	26.92	45.61	8.63	224.69	3.85	5.41
2002.00	26.98	46.81	7.91	232.59	3.99	5.45
2003.00	27.15	54.14	7.29	232.06	4.26	5.45
2004.00	27.30	70.59	4.71	233.24	4.61	5.45
2005.00	27.45	100.00	6.25	239.56	4.79	5.48
2006.00	27.58	120.67	4.48	230.43	4.89	5.44
2007.00	27.85	133.53	6.87	203.92	5.20	5.32
2008.00	27.83	182.15	4.28	472.81	4.75	6.16
2009.00	27.94	116.15	5.87	604.67	5.00	6.40
2010.00	28.15	148.54	-0.14	589.27	5.28	6.38
2011.00	28.25	195.90	2.01	610.52	5.29	6.41

Conducting tests on the data obtained using Stata, we obtain the following results -

Source	SS	df	MS
Model	6.99437891	3	2.33145964
Residual	.604397496	18	.033577639
Total	7.59877641	21	.361846496

Number of obs	= 22
F(3, 18)	= 69.43
Prob > F	= 0.0000
R-squared	= 0.9205
Adj R-squared	= 0.9072
Root MSE	= .18324

lnGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CrudeOilPr~e	.0068765	.0014663	4.69	0.000	.003796	.0099571
RealInterest	.0212973	.0208264	1.02	0.320	-.0224573	.065052
FiscalDefi~t	.0014603	.0004093	3.57	0.002	.0006004	.0023202
_cons	26.14174	.1747544	149.59	0.000	25.7746	26.50889

The value of r- square tells us that 92.05% of the variations in the growth of GDP can be explained by the three variables, namely, price of crude oil, real interest rates and fiscal deficit, together. The p-value for the F-statistic also tells us that the value of R- square is statistically significant, implying that the model is a good fit.

The regression coefficient of crude oil prices tells us that a unit change in the price of oil, keeping all other factors constant results in an increase in the rate of change of GDP by 0.0068 units.

Similarly, the regression coefficient of the real interest rate tells us that a unit change in real interest rates, keeping other factors constant, leads to around 0.02 unit increase in the growth of GDP. However, since the p-value of 0.320 > 0.05, the coefficient is statistically insignificant.

Lastly, the fiscal deficit too shows a positive relationship with the dependent variable. A unit change in fiscal deficit leads to about 0.0014 units of the variations in the growth of GDP. Here the coefficient is statistically significant.

Next, we test the model for the presence of multicollinearity by calculating the Variance Inflation Factor (VIF).

Variable	VIF	1/VIF
CrudeOilPr~e	3.77	0.265495
FiscalDefi~t	3.43	0.291404
RealInterest	1.47	0.679501
Mean VIF	2.89	

According to the rules of this method, there is evidence of multicollinearity in the model if:

1. The largest VIF is greater than 10 (some choose a more conservative threshold value of 30).
2. The mean of all the VIFs is considerably larger than 1.

Here we can observe from the table above that the largest VIF is only 3.77, considerably smaller than the threshold level of 10. Secondly, the mean of all the VIFs is only 2.89, which is not considerably larger than 1. Thus, the test shows that there is no multicollinearity in the model specified. However, we observe that interest coefficient has the wrong (positive) sign, and by economic logic we expect it to be negative through its effect on investment, which is a major component of the GDP. Also, coefficient of crude oil price is positive, seemingly refuting the conventional theory. But using economic intuition we can argue that this perverse result maybe a result of multicollinearity since Fiscal Deficit and Price of Crude Oil are expected to be strongly positively related, especially keeping in mind the large share of petroleum subsidy in India.

To confirm this, we regress fiscal deficit on price of crude oil and we obtain the following results:

Source	SS	df	MS
Model	486618.557	1	486618.557
Residual	201163.856	20	10058.1928
Total	687782.413	21	32751.5435

Number of obs	= 22
F(1, 20)	= 48.38
Prob > F	= 0.0000
R-squared	= 0.7075
Adj R-squared	= 0.6929
Root MSE	= 100.29

FiscalDefi~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CrudeOilPr~e	2.876142	.4135004	6.96	0.000	2.013595	3.738689
_cons	16.12825	37.01965	0.44	0.668	-61.09339	93.34988

The high value of t=6.96, lying outside the confidence interval, confirms the suspicion of presence of multicollinearity.

Next, in order to test if the model satisfies the assumption of constant variance, we conduct the Breusch-Pagan test, also known as the Cook- Weisberg test for heteroscedasticity.

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnGDP

         chi2(1)      =     2.10
         Prob > chi2  =   0.1477
```

Since, the p-value > alpha value of 0.05, therefore, the null hypothesis of homoscedasticity will not be rejected, implying no problem of heteroskedasticity in the model.

In order to check for serial correlation among the error terms we compute the Durbin-Watson statistic for the data obtained.

Durbin-Watson d-statistic(4, 22) = 1.404312

The d-statistic can be interpreted using the lower and upper limits. The upper and lower limits were computed as follows – $d_l = 0.958$ $d_u = 1.797$, $4 - d_u = 2.203$ $4 - d_l = 3.042$. Since the d_{stat} lies between 0.958 and 2.203 which is the zone of indecision, we use another test, viz. the Breusch-Godfrey LM test for autocorrelation.

Breusch-Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	2.595	1	0.1072

H0: no serial correlation

Here again, p > alpha, which implies that the null hypothesis of no serial correlation cannot be rejected. Therefore we can safely conclude that the model does not suffer from autocorrelation.

Now, to remove the discrepancy observed above, we transform the model and use natural log of fiscal deficit and natural log of price. The results of this new model are summarised as below:

Source	SS	df	MS
Model	7.35415744	3	2.45138581
Residual	.244618966	18	.013589943
Total	7.59877641	21	.361846496

Number of obs = 22
F(3, 18) = 180.38
Prob > F = 0.0000
R-squared = 0.9678
Adj R-squared = 0.9624
Root MSE = .11658

lnGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnCrudeOil~e	.5017594	.0718252	6.99	0.000	.3508603	.6526585
lnFiscalDe~t	.30214	.0578386	5.22	0.000	.1806256	.4236545
RealInterest	-.0199164	.0125166	-1.59	0.129	-.0462127	.00638
_cons	23.59171	.220095	107.19	0.000	23.12931	24.05412

The value of ESS (Explained Sum of Squares) has increased as compared to the previous model, from around 6.99 to 7.35.

The value of R-square has also increased significantly from around 92% to almost 97% now, a finding that can be confirmed as statistically significant from the p-value of the F-statistic, however at the same time making one suspicious about the presence of multicollinearity.

The coefficient of natural log Crude Oil prices tells us that when price of crude oil increases by 1 per cent, GDP grows by 0.5 per cent. 0.5 can also be interpreted as a measure of elasticity of demand. However since the sign of the coefficient is positive, crude oil would have to be

considered as a Giffen good, which is a special type of inferior good for which the income effect outweighs the substitution effect.

The value of partial regression coefficient of LN (Fiscal Deficit) shows that with an increase in fiscal deficit of 1 per cent, the GDP grows by approximately 0.3 per cent. 0.3 can also be interpreted as the elasticity of GDP to the fiscal deficit. Lastly, for every unit change in real interest rates, the growth of GDP slows by approximately 0.02 per cent.

Testing for Multicollinearity, we obtain the following values for the VIF;

Variable	VIF	1/VIF
lnCrudeOil~e	3.90	0.256707
lnFiscalDe~t	3.38	0.296177
RealInterest	1.31	0.761403
Mean VIF	2.86	

Again, none of the VIFs is significantly greater than the threshold level of 10, neither is the mean VIF significantly greater than 1. Thus, the results show no multicollinearity in the model specified. However, even though the interest rate now has a negative sign which is in keeping with the economic logic, the price coefficient is still positive, denying the traditional view regarding the detrimental effects of high crude oil prices on Indian GDP Growth. Hence, we regress the natural log of Fiscal Deficit on natural log of crude oil price and we obtain the following results:

Source	SS	df	MS
Model	9.55444873	1	9.55444873
Residual	4.16165703	20	.208082852
Total	13.7161058	21	.653147894

Number of obs	= 22
F(1, 20)	= 45.92
Prob > F	= 0.0000
R-squared	= 0.6966
Adj R-squared	= 0.6814
Root MSE	= .45616

lnFiscalDe~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnCrudeOil~e	.9649168	.1423984	6.78	0.000	.6678789	1.261955
_cons	1.126219	.5977867	1.88	0.074	-.1207422	2.37318

Again, the high value of t-statistic confirms the suspicion of multicollinearity. However, we cannot completely rely on multicollinearity as being the sole reason for the positive sign of the coefficient and hence, we try to explain some of the factors responsible for the perverse result.

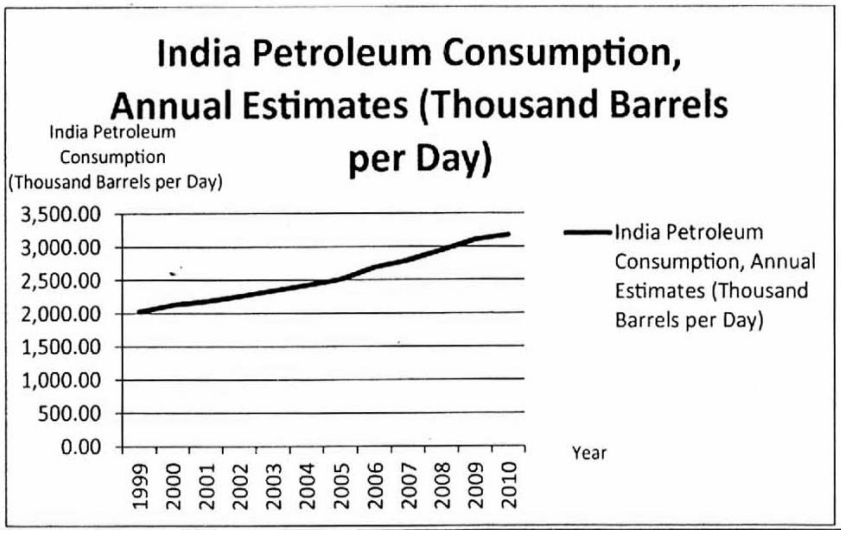
India is the fourth largest consumer of crude oil after US, China and Japan, as estimated by the US Energy Information Administration in 2008. But, given its huge population size the per capita oil consumption still remains low compared to the other oil consuming nations. This is because only 24 percent of India's energy requirements are fulfilled by oil, whereas coal constitutes about 42 percent and combustibles, renewable and waste constitute another 24 percent, as

estimated by the IEA in 2009. It means that even though on aggregate terms, India contributes significantly to the oil consumption worldwide, but considering the fact that it holds the second largest population of people in the world, and supplemented by the fact that only a small portion of India's energy requirements are fulfilled by oil, crude oil price fluctuations did not hamper the growth of India's GDP growth significantly.

In general, Oil has a wide variety of uses for both the industrial and consumer markets. The industrial market has a far larger effect on oil's general uses, as its demand is bigger. But, In India, GDP contribution is largely made by the less energy-intensive services sector, that is, India is a service-oriented economy. Industry and agriculture play a relatively small role. For example, the agriculture sector contributed 17.2 percent; industry contributed 29.1 percent while the service sector made a contribution of 52.7 percent, according to 2008 estimates. Therefore, it is evident that changes due to price fluctuations in the industrial sector do not affect the GDP growth significantly.

Also contributing to the positive relationship is India's oil intensity. Oil intensity, which is defined as the ratio of oil consumed per unit of GDP, is very high in the country. Integrated Energy Policy Commission estimated it to be almost three times more than the OECD countries. Even though India's oil intensity has declined from 0.05 in 1999 to 0.04 in 2004, it is still high enough to not be affected by price fluctuations.

Also, trend observed between the crude oil price fluctuations and its consumption is unlike the usual trend in the sense that generally the demand for a commodity has a negative relation with its price. But, for India, demand for oil has been increasing substantially over the past decade even in the presence of continuously rising oil prices and unfavourable economic situations (refer Fig.1). The strong demand for oil may be due to surging economic output of India (being a developing economy) as is evident from an average of approximately 8 percent GDP growth rate in the given period.



On the back of a significantly strong economic growth despite the economic unrest, India's oil demand has been booming. To justify the increase in demand for oil due to strong economic growth, is the fact that Oil demand by the transport sector, which is the main driver of oil demand in India, increased from 32 percent in 2000 to 37 percent in 2010; an increase of 5 percentage points, its annual growth rate being 5.5 percent over this period, which resulted in an increased demand for oil overall.

Since the period beginning 2009, India's contribution to oil demand has been, and will remain substantial as it entered the 'sweet spot' in the U.S. $ 3,000 – $ 9,000 per capita GDP range which is the period when oil demand normally booms.

Another factor contributing to increased consumption of oil despite of increasing fuel prices is that fuel in India is largely subsidized. Subsidies can lead to a number of perverse outcomes. For example, the regulated pricing system leads to excessive and inefficient use of automobile fuel which is evident from a shift away from public to private transport and increase in the number of vehicles owned per person during the period. A price band ensures that the price does not increase much in India following a rise in International oil prices and therefore will have minimal effects on its consumption.

A close analysis of the data shows that rise in oil prices in effect does lead to a slowdown, however with a lag of 1-3years. From a completely microeconomic perspective, the effect of oil price hike would show only in a later business cycle when firms are actually in a position to revise their production capacity. This could be a reason behind the lag. But the fact that consumption actually rose does not endorse this theory.

These factors justify that the relation as shown by the regression results are not completely invalid for the Indian economy.

Testing For heteroskedasticity in the transformed model, we have,

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnGDP

         chi2(1)      =     0.88
         Prob > chi2  =   0.3474
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The results so obtained, where the p value of 0.3474 > 0.05, imply that there is no heteroscedasticity in the new model.

Testing for Serial Correlation of order one, we have

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Durbin-Watson d-statistic(  4,     22) =  1.295125
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Yet again, the d_{stat} lies in the zone of indecision, hence we proceed to conduct the Breusch-Godfrey LM test for autocorrelation, and we obtain the following results:

Breusch-Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	3.686	1	0.0549

H0: no serial correlation

Given a p-value of 0.0549, we can conclude that we cannot reject the null hypothesis of no serial correlation; hence the model is devoid of any serial correlation in its error terms.

Conclusion

We can conclude from the above analysis that interest rate has a significant negative impact on GDP growth; change in fiscal deficit has a significant positive impact; while the change in crude oil price has a seemingly significant positive impact. India shows some degree of inelasticity of demand in response to price changes as can be deduced from the fact that it exhibits a positive relationship between price and consumption. The reasons for this behaviour in violation of the 'Law of Demand' are listed above.

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