Crude oil relationship with Indian economic growth and influence on industrial products

Kiran Zaidi[1], Ahsan Z Rizvi[2], and Prof Gaurav Khanna[3] *
[1] Ph.D student, [3] PhD Supervisor, Madhav University, Abu Road, Rajasthan, India.
[2] Institute of Human Genetics, CNRS, Montpellier, France.
Email - gauravkhanna993@gmail

Abstract: *Crude oil price makes an impact on the global economy but differs from one country to another (I. Hazarika, 2016). It depends upon the supply and demand structure of the industries. Countries dependent on crude oil import are profoundly affected by international crude oil price fluctuation. This paper explains the relation of crude oil price with Indian GDP, inflations and industrial products. The data from 1961 to 2017 are downloaded from the authentic source. Mathematical relationships are derived between the different statistical tools those are commonly used for data relationship predictions. Python and R scripts are developed for the statistical analysis. Results show the forward relationship between crude oil price and Indian inflation.*

Key words: *Indian GDP, inflation, industrial product, Johnson cointegration test, Granger Causality test.*

1. INTRODUCTION:

Recently, many developed countries reduced the dependency on crude oil import and relied on the alternative energy source (S. Pandey et al., 2012). Hamilton (1983) show the impact of crude oil price on the US GDP after 1945. R. Barsky and L. Kilian (2004) find a forward relationship between macroeconomics and crude oil price. Similarly, S. Kim and T. Willet (2004), B. Trehan (2005), and B. Ewing, and M. Thompson (2007) also suggested the forward relation between crude oil price and microeconomics. S. Brown and M. Yucel (2004) explain the mechanism of oil price effect over the macroeconomics. Money flow from oil importer countries to oil exporter countries cause an imbalance in macroeconomics of an importer country. Nature of relations are not constant but change over the time. Therefore, every government try to control internal oil price so that domestic economy should be balanced.

The relationship between oil price with GDP, inflation, the industrial product is explained earlier. M. Hooker (2002) find a significant relation of oil price over the macroeconomics from 1962 to 1980. B. Trehan (2005) also has also studied oil price relation with macroeconomics. W. Roger (2005) explain the crucial ties of crude oil with European macroeconomics. C. Bermingham (2008) demonstrate the relationship of oil over the macroeconomics of Ireland and also explain inflations caused by oil price hike. Inflation fluctuations over the time are related to oil price hike is said by Castillo et al. (2010). A. Aparna. (2014) explained the relation of crude oil price with the Indian economy. K. Gokmenoglua et al. (2015) shows the statistics for the connection of oil price with Turkish GDP, inflation, and Industrial products. In this paper, we have related the price of crude oil with Indian GDP, inflation and industrial product. We have also derived the relations between different statistics and check the suitability of relationship prediction.

2. METHODOLOGY:

Crude oil price data are collected from the official website of OPEC (R. Golombek, 2018). These prices data are present in XML format which are converted into CSV file format and taken the average for each year. Similarly, GDP, inflations (Inf), industrial productions (IP) indexes for Indian economy are downloaded from the website of World Bank development indicator (K. Gokmenoglua et al., 2015). GDP is in constant 2010 US$ parameter while IP is in the percentages of GDP. These data are synchronised from the year 1961 to 2017. To study relationships among these data we have normalised them by dividing with their respective maximum values. This process makes amplitude variations in-between 0 to 1 for each data. Basic statistics like mean, variance, and auto-correlation are used to check stationarity of the normalised data. Stationary data shows constant mean, variance and auto-correlation over the time.

Unit root test

Unit root is one of the causes for non-stationarity of the data (N. Khraief et al., 2015); therefore unit root test is used in these studies before econometric analysis. Many unit root test is available, but Phillips Perron (PP) unit root test (D. Kwiatkowski et al., 1992) does not require specifying the lag length and ignores serial correlation in test regression. The test regression for PP test is

$$\Delta x_t = \gamma D_t + \pi x_{t-1} + u_t \qquad (1)$$

Where x is an input data, u_t is error I(0) and may be heteroskedastic, D_t is a deterministic linear trend and γ, π are constants. PP test is used to modify statistics $t_{\pi=0}$ and $T\hat{\pi}$ and given as

$$X_t = \left(\frac{\hat{\sigma}^2}{\hat{\vartheta}^2}\right)^{\frac{1}{2}} . x_{t-1} - \frac{1}{2}\left(\frac{\hat{\vartheta}^2 - \hat{\sigma}^2}{\hat{\sigma}^2}\right) . \left(\frac{T.SE(\hat{\pi})}{\hat{\sigma}^2}\right) \quad (2)$$

$$X_\pi = T\,\hat{\pi} - \frac{1}{2}\frac{T^2.SE(\hat{\pi})}{\hat{\sigma}^2}\left(\hat{\vartheta}^2 - \hat{\sigma}^2\right) \quad (3)$$

Given SE is the standard error, and $\hat{\vartheta}^2, \hat{\sigma}^2$ are the estimates for the variance parameters and defines as

$$\hat{\sigma}^2 = \lim_{T\to\infty}\left(T^{-1}\sum_{t-1}^{T} E[u_t^2]\right) \quad (4)$$

$$\hat{\vartheta}^2 = \lim_{T\to\infty}\left(\sum_{t-1}^{T} E\left[T^{-1}\left(\sum\nolimits_{t=1}^{T} u_t\right)^2\right]\right) \quad (5)$$

The sample variance of the least squares residual u_t is the estimate for $\hat{\sigma}^2$. Newey West (W. K. Newey et al., 1987) long run of u_t is the estimate for $\hat{\vartheta}^2$. X_t and X_π are showing asymptotic distributions under the null hypothesis $\pi = 0$.

Relationships among the time series data are established here by co-integration test (B. Sjö, 2008). This test detects time series data $x^1, x^2, \dots\dots, x^N$ have the unit root or converging together. For *N* time series data *N-1* co-integrating vectors can be obtained. By the regressive time series equation (1) with constant $\gamma D_t = 0$, we can get

$$\Delta x_t = \pi x_{t-1} + u_t \quad (6)$$

Now generalization of *N* variable

$$\Delta X_t = \pi X_{t-1} + u_t \quad (7)$$

The vector auto-regression (VAF) with N>0 is

$$\Delta X_t = \prod X_{t-1} + \sum_{i=1}^{N-1} \prod_i \Delta X_{t-i} + u_t \quad (8)$$

If the matrix $\prod = 0$, then the time series data are not co-integrated. The determinant of this matrix is zero if the rank of this matrix is less than *N*.

Co-integration test

The Johnson co-integration test is based on eigenvalues transformation of ΔX_t which has canonical correlations. The eigenvalues of *N***N* matrix *A* have *N* solutions for the polynomial equation of

$$\det(A - \lambda I_n) = 0 \quad (9)$$

Where I_n is an identity matrix and *det*(.) is the determinant of the matrix. If the rank and largest eigenvalues λ_1 of ΔX_t are zero then the co-integration is not present in the matrix. If $\lambda_1$is nonzero then more co-integration vectors are present. Test of remaining eigenvalues is the likelihood test which is given by

$$LR(r_0, r_0 + 1) = -T * ln\left(1 - \lambda_{r_0+1}\right) \quad (10)$$

Where *LR*(.) is likelihood ratio, and *r* is the rank of the matrix. This is the likelihood test among r_0 versus alternative hypothesis $r_0 + 1$.

Granger causality test

Causality in the time series data $x^1, x^2, \dots\dots, x^N$ is detected by Granger causality test (C.W.J. Granger, 2004). In this test, time series data $x^1, x^2, \dots\dots, x^N$ make relation with another time series data $y^1, y^2, \dots\dots, y^N$. Time series of *X* can be used to forecast *Y*. Both sets are having a time lag and can be correlated regarding VAR as given in equation (xx).

$$(X)_t = \alpha + \sum_{i=1}^{N} \beta_i\,(X)_{t-i} + \sum_{j=1}^{M} \Omega_i\,(Y)_{t-j} + \mu_t \quad (10)$$

$$(Y)_t = \phi + \sum_{i=1}^{M} o_i\,(Y)_{t-i} + \sum_{j=1}^{N} p_i\,(X)_{t-j} + \omega_t \quad (11)$$

Based on above equations (10) and (11), we can relate crude oil price, GDP, inflation, and industrial products.

3. ANALYSIS AND RESULTS:

Crude oil data in XML format is downloaded from OPEC official website (http://www.opec.org/opec_web/en/data_graphs/40.htm) dated 19 June 2018. Data for Indian inflation, industrial product, GDP (US$) is downloaded fr om the world-bank official webpage (http://databank.worldbank.org/). XML format is converted into CSV format by a developed Python script. This script also combined data of inflation, industrial product, and GDP. A combined table o f the data is given in table 1 (supplementary), and this table is further utilized for the statistical analysis. Table 2 is sho wing the basic statistics for the data, where the mean value 18.35 of crude oil is decidedly less than the maximum amo unt 109.45. Indian inflation rate shows negative value -7.634381 in the year 1976, which is minimum until recently. Lower standard deviations values of Indian inflation and industrial product indicate that the data scatter less from their mean values. We have analysed skewness to check the internal symmetry of the data. Crude oil prices and Indian GDP are highly skewed while Indian inflation and industrial product are moderately skewed. The flatness of the data is checked by Kurtosis, and the results show that leptokurtic distributions for the crude oil prices, Indian GDP, and inflation while Indian industrial product shows platykurtic distribution. Jarque-Bera tests show that all data are given in table 1 are non-normally distributed.

Table 3 is showing the results obtained from Phillips-Perron unit root test. This test is utilised here to check unit roots present in the data. Results show that crude oil prices, Indian GDP, inflation, and industrial product have unit roots. Unit root shows they are no stationary at higher order differences, but at the first difference, they are stationary. Johansen cointegration test is applied to check distant relations among the data. Results are given in table 4, which has that more than one cointegration factor. More co-integration factors show the long relationship between crude oil prices, Indian GDP, inflation, and industrial product. Table 5 is showing the results of Granger Causality test that is used to check interrelationships among the data. The high value of F statistics and low value of probability (>F) rejects the null hypothesis and show the direct relationship between the data. Results show that Indian GDP and IP, and IP and crude oil price have high F values with less probability (>F) values.

	GDP	Inflation	Industrial Product	Crude oil prices
Mean	684291850166	7.69431	29.26661	29.26661
Median	429663556535	7.525762	30.25468	18.35
Maximum	2.464933e+12	28.60169	34.66472	109.45
Minimum	141837050035	-7.634381	22.41802	1.21
Std. deviation	621445606856	5.02909	3.320517	29.50232
Skewness	1.316863	0.8479958	-0.5570575	1.429127
Kurtosis	0.6579808	4.490431	-0.9137912	1.153032
Jarque-Bera	18.549	60.07	4.6927	24.098
Sum	3.832034e+13	430.8814	1638.93	1594.45

Table 2: Results of the common statistics of the data.

	Dickey-Fuller Test value	Truncation lag parameter	p-value
DGP	11.354	3	0.99
Inflation	-5.2678	3	0.01
Industrial products	-0.65038	3	0.9693
Crude oil price	-2.3571	3	0.4306

Table 3: Results of Phillips-Perron unit root test.

Johansen-Procedure				
Test type: trace statistic , with linear trend, Eigenvalues (lambda):				
	0.607444921	0.489783323	0.061806828	0.001528956
Values of test statistic and critical values of test:				
	test	10pct	5pct	1pct
r <= 3	0.08	6.50	8.18	11.65
r <= 2	3.53	15.66	17.95	23.52
r <= 1	39.87	28.71	31.52	37.22
r = 0	90.36	45.23	48.28	55.43
Eigenvectors, normalised to first column: (These are the cointegration relations)				

	il.l2	Inflation.l2	IP.l2	GDP.l2
il.l2	1.0000000	1.000000	1.000000	1.00000000
Inflation.l2	-1.0047100	-7.276859	-0.188761	-0.02198106
IP.l2	-0.2421626	1.187201	-2.505027	0.54479720
GDP.l2	5.8920225	-5.395589	-1.014402	-1.62616121

Table 4: Results of Johnson co integration test.

	Observations	F statistics	Probability (>F)
GDP, Oil	53	0.2505	0.6189
Oil, GDP	53	0.1373	0.7125
GDP, Inflation	53	0.1474	0.7026
Inflation, GDP	53	0.1103	0.7411
GDP, IP	53	2.4899	0.1206
IP, GDP	53	0.1356	0.7142
Inflation, IP	53	0.0881	0.7678
IP, Inflation	53	0.0622	0.8041
Inflation, Oil	53	0.003	0.9568
Oil, Inflation	53	0.0307	0.8615
IP, Oil	53	4.7332	0.03415
Oil, IP	53	2.843	0.09776

Table 5: Results of Granger Causality test.

4. CONCLUSION:

Relationships of crude oil price with Indian GDP, IP, and inflation are studied here. Data are downloaded fr om the authentic source, and the developed Python and R scripts perform the analysis. This analysis gives the idea of l ong-term relationships among the data from 1960 to 2017. Results of Granger causality test show that Indian GDP is s ignificantly related to IP and IP with crude oil price. Indian industries are heavily dependent on the imported crude oil and GDP is dependent on IP. The price fluctuations on the crude oil price affect the industrial growth. Finding the alte rnative to oil as a primary energy source could lead to stable economy of India. Government control and subsidy on oil price are fundamental parameters for small and medium scale industrial survival. Small and medium scale industries i n India are one of the primary jobs. Therefore, Indian government control over the oil price is mandatory.

REFERENCES:

1. Indrani Hazarika (2016). An Analytical Study on the Impact of Recent Oil Price Plunge on Highly Oil Depend ent Economies and Oil Exporting Countries, 7 (5), pp 202-205. doi: 10.18178/ijtef.2016.7.5.523
2. Shreemat Pandey, Vijai Shanker Singh, Naresh PalGangwar, M.M.Vijayvergia, Chandra Prakash, and Deep NarayanPandey. (2012). Determinants of success for promoting solar energy in Rajasthan, India. Renewable and Sustainable Energy Reviews, 16 (6), pp 3593-3598. doi : https://doi.org/10.1016/j.rser.2012.03.012
3. J Hamilton. (1983). Oil and the macroeconomy since World War II. Journal of Political Economy, 91, pp 228-248.

4. R. Barsky and L. Kilian, 2004. Oil and the macroeconomy since 1970s. Journal of Economic Perspectives, 18, pp 115-134.
5. S. Kim, and T. Willett. (2000). Is the negative correlation between inflation and economic growth? An analysi s of the effect of the oil supply shocks. Applied Economics Letters 7, 141–147.
6. B. Trehan. (2005). Oil price shocks and inflation. FRBSF Economic Letter, 28, pp 1-3.
7. B. Ewing, and M. Thompson. (2007). Dynamic cyclical comovements of oil prices with industrial production, consumer prices, unemployment, and stock prices. Energy Policy, (35), pp 5535-5540.
8. S. Brown and M. Yucel. (2002). Energy prices and aggregate economic activity: an interpretative survey. Qua rterly Review of Economics and Finance, (42), pp 193-208.
9. M. Hooker. (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in re gime. Journal of Money, Credit, and Banking, pp 540-561.
10. W. Roeger. (2005). International oil price changes: impact of oil prices on growth and inflation in the EU or O ECD. International Economics and Economic Policy, 2, pp 15-32.
11. C. Bermingham, (2008). Quantifying the impact of oil prices on Inflation. Central bank and financial services authority of Ireland research technical paper.
12. P. Castillo, Montoro, Carlos, Tuesta, and Vicente. (2010). Inflation, Oil Price Volatility and Monetary Policy, Working Papers pp. 2010-002, Banco Central de Reserva del Perú.
13. A.Aparna. (2014). Impact of Oil Prices on the Indian Economy, NMIMS Management Review, XXIII, pp 140 -147.
14. K. Gokmenoglua, V. Azina, and Nigar Taspinara. (2015). The Relationship between Industrial Production, GDP, Inflation and Oil Price: The Case of Turkey, Procedia Economics and Finance, 25, pp 497-503.
15. R. Golombeka, A. A. Irarrazabalb, and L. Mac. (2018). OPEC's market power: An empirical dominant firm model for the oil market, Energy Economics, 70, pp 98-115.
16. N. Khraief, M. Shahbaz, A. Heshmati and M.Azam. (2015). Are Unemployment Rates in OECD Countries St ationary? Evidence from Univariate and Panel Unit Root Tests Institute for the Study of Labor (IZA) Working Paper No: 9571, Bonn, Germany.
17. D. Kwiatkowski, P.C.B. Phillips, P. Schmidt, and Y. Shin. (1992). Testing the null hypothesis of stationarity a gainst the alternative of a unit root, Journal of Econometrics, 54, pp 159-178.
18. W. K. Newey, and K.D. West. (1987). A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelati on Consistent Covariance Matrix, Econometrica. 55 (3), pp 703-708. doi:10.2307/1913610. JSTOR 1913610.
19. B. Sjö. Testing for Unitroots and Cointegration. (2008). https://pdfs.semanticscholar.org/7ce6/2a0c7f6dab85f264a5403bf9b99a0f20a156.pdf
20. C.W.J. Granger. (2004). Time Series Analysis, Cointegration, and Applications. American Economic Review , 94 (3), pp 421-425. doi:10.1257/0002828041464669.