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A Dynamic Relationship between Us Dollar Exchange Rate and Indian Crude Oil Prices: An Empirical Analysis

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Abstract

Present paper investigates the relationship among oil prices and exchange rates in Indian market. Present paper uses two econometrics tools of dependence to establish co-movement amongst the variables viz. Johansen co-integration and Granger Causality tests to demonstrate that the foreign exchange value of the US dollar (Crude oil prices) has a substantial impact on the prices of crude oil (Exchange rate of US dollar) in long-term as well as short-term or not. The results evidenced that data is stationary at first difference order. However, Johansen co-integration suggests no co-integrating equation. It signifies the possibilities to take advantage from arbitrage activities in the long-run through diversification of the investment portfolios in these two non-integrated markets. Granger causality and Wald statistics evidences unidirectional causality flowing from exchange rate to oil prices but not vice-versa. Since exchange rate granger causes the oil prices, the participants in the foreign exchange market can use information of exchange rates to improve the forecast of crude oil prices. The results of present study have policy implications for oil importing countries to frame foreign exchange risk management, fiscal and monetary policies in such a way to control exchange rate induced pressures on crude oil prices as crude oil prices predominantly affect the emerging oil dependent industrialised economies like India.

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I. INTRODUCTION

Understanding the importance of oil as the world's most important and highly demanded energy source to support the growth of any industrialised economy,with the payments being made in the US dollars as both Brent and WTI (West Texas intermediate) crude oil benchmarks are always traded in USD, interactions between movements in crude oil prices and dollar-rupee exchange rate can be safely presumed to exist. Any movement in price of one can become a cause for positive or negative movement in price of another.On theoretical grounds, foreign exchange value of the dollar affects oil prices as with the fall in the value of the dollar, the price of crude oil enhances so as gain same worth in the market (Akram, 2009).Similarly, oil prices can transmit to exchange rates due to the reason that countries which are largely dependent on oil imports experience depreciation in their currency due to higher inflation (Benassy-Quere et al, 2007). Crude oil's being a highly volatile constituent of consumer price index (CPI). It is having considerable involvement in forces of inflation and deflation in a country further aggravates these interrelationships during both

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upward and downward trending periods. Amano and van Norden (1998) explained how oil prices affect general price level in the economy which in turn affects the real exchange rate. Theoretically, there is strong consensus worldwide among policymakers, academicians and the media that there exists a fundamental relationship between exchange rates and crude oil prices. However, empirical literature does not clearly establish the direction of causality, as the results are mixed. Some researches established oil price fluctuations causing movements in USD that is rise in oil price consequently appreciating US dollar, while other researches reversed the flow of causality wherein appreciation of the USD became the cause for fall in these in the oil price or vice versa. These contradictory directional causalities between the oil prices and the exchange rates still remains the major subject to be revisited by present paper. India,third largest consumer of crude oil in the world after US and China, importing 86 percent of its annual crude oil requirement as it is an oil importing country, its trade deficit is dependent on the interactions between crude price as well as on the USD/INR exchange rates, making the economy quite vulnerable to the fluctuations in the crude oil prices and exchange rate movements. As per energy statistics on crude oil reserves issued by U.S. EIA(Energy Information Administration) in 2017, India ranked 24th on proven oil reserves availability as compared to US which is at 11th and China at 12th rank. Lesser availability of oil reserves depreciates the country's currency in relation to currencies of countries having more oil reserves(MacDonald, 1998). Oil importing countries significantly evidence the relationship between oil prices and exchange rates as compared to oil exporting countries which fail to establish any long term relationship(Aziz,2009). This vulnerability of Indian economy to interactions between exchange rate and oil prices has spill over implications for monetary policy, consumption and investment behaviour in the economy. In the era of globalisation where all the economies are interlinked, all these are expected to employ a greater influence over the world economy. Therefore, present paper attempts to re-examine the linkage between USD exchange rate and oil price in Indian context as India's over dependence on crude oil imports justified by lower ranking in availability of natural oil reserves and its global repercussions as it is one of the emerging economies has become the major issue to be investigated by researchers. The remaining part of the research paper is organised into four sections. Section 2 encompasses review of already existing research work on the linkage between exchange ratesand crude oil prices. Section 3 is dedicated to data and research methodology. Section 4 presents analysis and experiential results and, fifth and concluding section summarises the findings of the study and defines future scope of the work.

II. REVIEW OF LITERATURE

A number of researches over a vast number of countries have explored the linkage between the price of oil and the US dollar exchange rate by employing variety of econometrics tools. Many of these works are focused on the bilateral association between these two to find whether these two variables are related to each other in long-term, and also the direction of causality between them and the results confirmed the two series are cointegrated. Amano andNorden (1998) established long-term relationship between oil prices and exchange rate, and established unidirectional causality flowing from oil prices to the real exchange rate, whereas no evidence of the reversal of direction was shown in three countries under consideration, Germany, Japan and the United States. Chaudhuri and Daniel (1998) proved oil to be main factor contributing to exchange rate fluctuation in US.Sadorsky(2000) with co-integration tests and error correction models concluded existence of long-run co-integration and granger causality. Results supported exchange rates conveying

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exogenous jolts to oil futures prices.Chen and Chen (2006) deployed panel co-integration and panel regression for G-7 countries for the time period 1972-2005 and supplemented the already existing literature by evidencing oil prices being leading factor for real exchange rate variations.Along the lines, Benassy-Quere et al (2007) also added to same literature by establishing a co-integrating relation between the two series in China against a causality running from oil to the dollar, over the time period under consideration (1974-2004). Gounder and Bartleet(2007) with the help of VAR (Vector Auto Regression) model proved significant effect of price of oil on currency rate of exchange in New Zealand.Narayan et al (2008) utilized GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model to explain how volatility of both the series are linked and affirmed Fijian currency appreciating in response to increase in oil prices. Aziz (2009) employed month-wise data for 28 years (1980-2008) on eight countries to evaluate the relationship between three macro variables viz. oil prices, exchange rate and interest rates and supported that all these variables were related to each other in long-run. Short-run causal relationship was also confirmed wherein oil prices were found to affect the exchange rate.Nikbakht (2010) also used OPEC (Organization of the Petroleum Exporting Countries) member'scountries data and determined that the oil prices are to be decisive variable amongst the two (exchange rates and crude oil prices).Coleman et al (2011) displayed long-term relationship between the variables in African Countries and portrayed oil as the leading and deciding variable for exchange rates.Al-Ezzee (2011) employed VEC (Vector Error Correction) model to confirm long-run relationship between the variables in Bahrain.Aziz et al (2013) on exploring integrational properties of the series on panel data from 1983-2008 in ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) evidenced long-run co-integration and further come across a negative relationship viz. oil price rise invoking currency depreciation. Shafi et al(2013) concluded positive impact of oil price on exchange rate in the long-runover the time period of 1971-2012 in Russia. Shaari et al (2013) while evaluating this relationship in Malaysian market with VAR,VECM and Granger causality tests affirmed co-integration but in short-run, no granger causality could be seen from any direction. Brahmasrene and Sissoko(2014) explored the series from five source countries over 1996-2009 time in US and observed in short-run causality being unidirectional from rate of exchange to prices of crude oil. Although researchers strongly consented that both the series are co integrated, there are some studies that failed to establish relationship between the two. Benjabib et al (2014) indicated no long-run relationship using co-integration tests,however, VAR displays rise in oil price having depreciating effect on Algerian currency. Jiranyakul(2015) also contributed to failure of co-integration and non-causality tests to establish relationship between oil price and exchange rate in Thailand during the time 1997 to 2013.Olayungbo(2019) on Nigeria found no co-integration and no granger causality between the variables.

While a number of studies have been conducted worldwide, the studies on interactions between oil and foreign currency markets in India are still lacking. Present study is an attempt to attend to this concern. Also, the results are mixed. Hidhayathulla et al (2014) found significant causality running from energy prices to Indian currency rate of exchange, whereas Kaushik et al (2014) detected no such causality. Thian-HeeYiew(2016) in Indian market over the period 1991-2013 affirmed presence of long-run relationship using Engle–Granger two-step co-integration test and Johansen co-integration and suggested oil prices can be used to forecast the direction where the exchange rate would lead to. Kumar (2017) employed Granger causality and ARDL (Autoregressive-Distributed Lag) tests to

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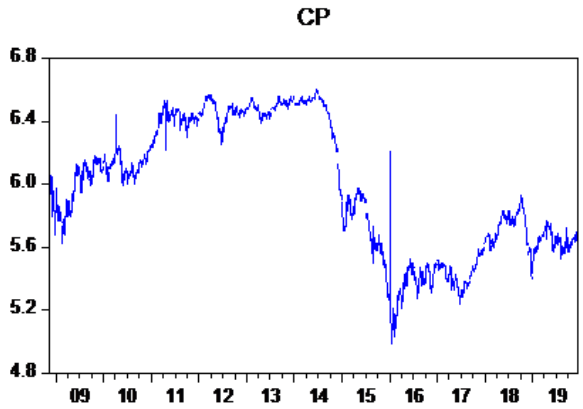
study the interaction between crude oil prices and currency exchange rate and established bidirectional nonlinear relationship between them. Tiwari et al (2017)employed wavelet analysis and Granger-causality tests and reached the conclusion of long-run Granger causality but form exchange rate to oil price. On the basis of above discussion, present study has formed the following objectives:

1. To investigate long-term relationship between crude oil prices and exchange rate in India.
2. To examine direction of causality to determine leading or lagging variable.

III. DATA AND METHODOLOGY

The secondary data on Brent crude oil prices(US Dollars),which is a benchmark for Indian crude oil prices has been taken from www.investing.com. Data relating to exchange rate of rupee per 1$(US Dollar) is taken from Organisation for Economic Co-operation and Development (OECD) database. The secondary data has been consideredfrom 01 November 2008 to31 December2019. The relations between crude oil (CP) prices and Indian currency exchange rate (ER) against US dollar has been investigated using Johansen co integration and granger causality test. Results have been obtained using Microsoft Excel and E views-10 software. Figure 1 shows the graphical representations of crude oil prices and exchange rates over the sample time period.



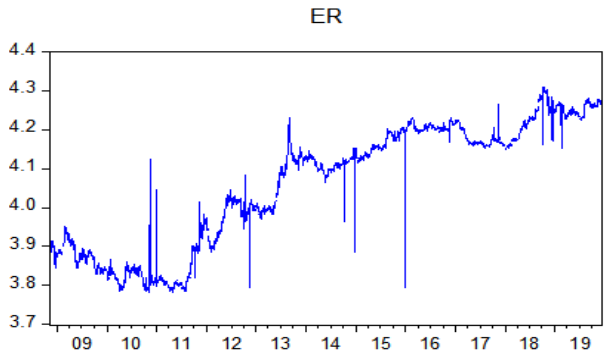


Figure 1: Graphical representations of crude oil prices and exchange rates

IV. FINDINGS and INTERPRETATIONS

4.1. Descriptive Statistics

The study initiates with descriptive statistics before deploying econometrics tools.First phase of this study evidences fundamental statistics that help in understanding properties of the series.Table 1 affirms two properties of the time series, volatility and non-normality. It is marked that the crude oil prices are highly volatile ranging from minimum value of as the value of 146.44 to maximum value of 738.31 with mean being 432.1004. Standard deviation of 172.7645 asserts instability in crude oil prices. On the other side, ER for the period under consideration also evidences instability.Maximum value being 74.33 and minimum being 43.9 is revelation of their variability. This phase of analysis also supports the property of not normally distributed series on the basis of measures of Skewness, Kurtosis and JarqueBera.

Table 1: Results of Descriptive statistics

Statistics	Crude oil	Exchange Rate
Mean	432.1004	58.7808
Median	403.49	61.54
Maximum	738.31	74.33
Minimum	146.44	43.9
Std. Dev.	172.7645	8.9228
Skewness	0.234	-0.2764
Kurtosis	1.5401	1.6478
Jarque-Bera	274.7157	249.4234
Prabability	0.0000	0.0000
Observations	2805	2805

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It is apparent from the Table 1 that exchange rate is negatively skewed with long left tail and more values on the lower side. However, crude oil is positively skewed with more values on the higher end.The kurtosis statistics confirms platykurtic distribution being followed as less peakedness than normal distribution. Jarque-Bera statistic further adds to the previous confirmation of non-normality.P-value being zero in both the series means rejection of null hypothesis of Jarque-Bera test at 1 percent significance level.

4.2. Results of Long-run analysis

Present study deploys the Johansenco-integration testto establish long-run relationship. Application of Johansen co-integration test is having pre conditions like same order of integrationfor the two stationary series, determination of the optimal laglength for the application of VAR model so as to authenticateno auto correlation amongst the residuals and finally approximationof the VAR model to ascertain the trace statistics and themax-eigen value. The results of above mentioned steps are discussed here:

4.2.1.Unit root test

Table 2presentsresults of unit root test both at level and at first difference.ADF tests results show variables are non-stationary at level for both constant and constant-trend asnull hypothesis of unit root being rejected at 5% significance level, they are tested for stationarity at first difference and prove to be integrated of order one.

Table 2: Result of unit root (ADF)test

Variables	t-statistics (P-value)		t-statistics (P-value)		I(0)
	At level		At first-difference		
	With Intercept	With Trend and intercept	With Intercept	With Trend and intercept	
Crude oil	-1.0607 (0.7332)	-1.7176 (0.7435)	-37.2991 (0.0000)	-37.3004 (0.0000)	I(1)
Exchange Rate	-.8021 (0.8179)	-2.3239 (0.4201)	-12.2471 (0.0000)	-12.2422 (0.0000)	I(1)

4.2.2.Selection of optimum lag length

Next, the study decides the optimum lag length as it is a pre requisite to conduct Johansen's co-integration test. The lag-lengthis selected on the basis of Akaike information criteria (AIC), Schwarz information criteria (SIC) or Hannan-Quinn information criteria (HQC) are presented in Table 3. The AIC criteria recommended 8 lag length whereas SIC recommended a lower lag length of 5. The study has tried to keep away from the risk of over parameterization of taking excessive lags by selecting SIC criteria of lag length 5.

Table 3: VAR lag-length selection criteria

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	258.2946	NA	0.0028	-0.1832	-0.179	-0.1817
1	12628.46	24713.78	4.12E-07	-9.0257	-9.0129	-9.0211
2	13133.16	1007.601	2.88E-07	-9.3837	-9.3625	-9.376
3	13283.01	298.9478	2.60E-07	-9.4881	-9.4583	-9.4773

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4	13337.07	107.7724	2.51E-07	-9.5238	-9.4856	-9.5101
5	13362.49	50.64314	2.47E-07	-9.5391	-9.4924*	-9.5222
6	13374.89	24.69058	2.45E-07	-9.5451	-9.4899	-9.5252*
7	13380.28	10.71543*	2.45E-07	-9.5461	-9.4824	-9.5231
8	13384.85	9.082797	2.45e-07*	-9.5465*	-9.4743	-9.5205

4.2.3. Johansen co-integration test.

The calculated values of trace statistics and maximum eigen tests statistics for crude oil prices and exchange rates are presented in Table 4.The study has used SIC for selection of optimum lag length to ease the problem of over-parameterization or under-parameterization. Present study has not rejected the null hypothesis of co-integration (r=0) at significant level (5 percent), which shows the non-existence of long-term co-integration. Results supported the rejection of alternative hypothesis. Results found out that the calculated values of both trace and maximum eigen tests statistics are lower than the MacKinnon-Haug-Michelis critical values at 5 percent level offreedom. So,the conclusions can be drawn on the basis of Johansen's test outcome that exchange rateand crude oil price are not co-integrated considering all the five assumptions presented in table 4.

Table 4: Results of Johansen's Co-integration test

Data Trend	None*	None*	Quadratic**	Linear***	Linear***
Data Type	*No Intercept No Trend*	*Intercept No Trend*	*Intercept Trend*	*Intercept Trend*	*Intercept No Trend*
Trace Statistics	0	0	0	0	0
Max-Eigenvalue	0	0	0	0	0
Optimum critical values (0.05 level) are based upon Mackinnon-Haug-Michelis,(1999). * Shows no deterministic trends in data. *** Shows for Quadratic deterministic trend in data. ***Shows for linear deterministic trends in data.					

4.2.4. Granger causality test

Granger causality approach (1969) is applied to examine the short-term relationship between the sample variables. Present methodology helps to answers the question of whether crude oil prices (x)granger causes exchange rate $(y)$to check how much of exchange rate (y)can beexplained by past values of exchange rate $(y)$and then adding lagged values of crude oil(x) can improve the prediction of exchange rate (y).

For all the possible pairs of series(x,y), bivariate regressions of the form can be written as:

$$\gamma_t = \alpha_0 + \alpha_1\gamma_{t-1} + \cdots\cdots + \alpha_l\gamma_{t-1} + \beta_1 x_{t-1} + \cdots\cdots + \beta_l x_{-l} + \varepsilon_t \quad (1)$$

$$\gamma_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots\cdots + \alpha_l x_{t-1} + \beta_1\gamma_{t-1} + \cdots\cdots \cdot + \beta_l\gamma_{-l} + \varepsilon_t \quad (2)$$

The stated F-statistics are the Wald statistics for the joint hypothesis:

$$\beta_1 = \beta_2 = \cdots\cdots = \beta_l = 0 \quad (3)$$

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Table 5: Results of Granger Causalitytest

Null Hypothesis	Observation	Lag-length	F-Statistic	Probability	Decision
ER does not Granger Cause CP	2800	4	9.0832*	2.745E-07	Rejected
CP does not Granger Cause ER			0.5591	0.6924	Not Rejected
Optimum lag length is observed as per SIC. * shows significance at 1% level of significance.					

Table 5 summarises Granger causality results.Results reject the null hypothesis asER does not Granger cause CP that show unidirectional short-run relationship exist between ER and CP. Results shows the unidirectional causal effect from exchange rate to crude oil prices. So, exchange rate experiences the new information first in between the both marketsand serves as a leading indicator for decision making.

V. CONCLUSION

To examining the relationship between crude oil prices and exchange rates in India, which is third largest consumer of crude oil, present study applies the Johansen's co-integration and Granger causality tests. The empirical results of Johansen's co-integration (bivariate) test establishes that the crude oil prices and exchange rates (USDollar/India) has no long-run relationship. To examine the short-term causal relationship between these two variables, study has used the Granger causality test. This technique allows for detecting short-term causation between the sample variables on their return values. The empirical results reveal that the crude oil price volatility does not impact the effective exchange rate to appreciate as found in previous empirical studies (Sadorsky,2000; Gounder and Bartleet,2007; Aziz, 2009). An important finding is that the change in exchange rate causes the change in crude oil prices in short-run, which can increase/decrease the cost of many products instituted with crude oil.Since exchange rate granger causes the oil prices, the participants in the foreign exchange market can use information of exchange rates to improve the forecast of crude oil prices. Exchange rate is the factor which relies on many variables (interest rates, speculations, inflation, relative strength of other currencies, balance of payment and many more). So, Policy makers should have more conscious about the change (positive or negative) in exchange rate to control the crude oil prices. Present study only uses one energy variable to check the linkages with exchange rate. The scope of the future researches can be enhanced with other energy products (natural gas, solar power, ethanol, nuclear power and wind power).

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