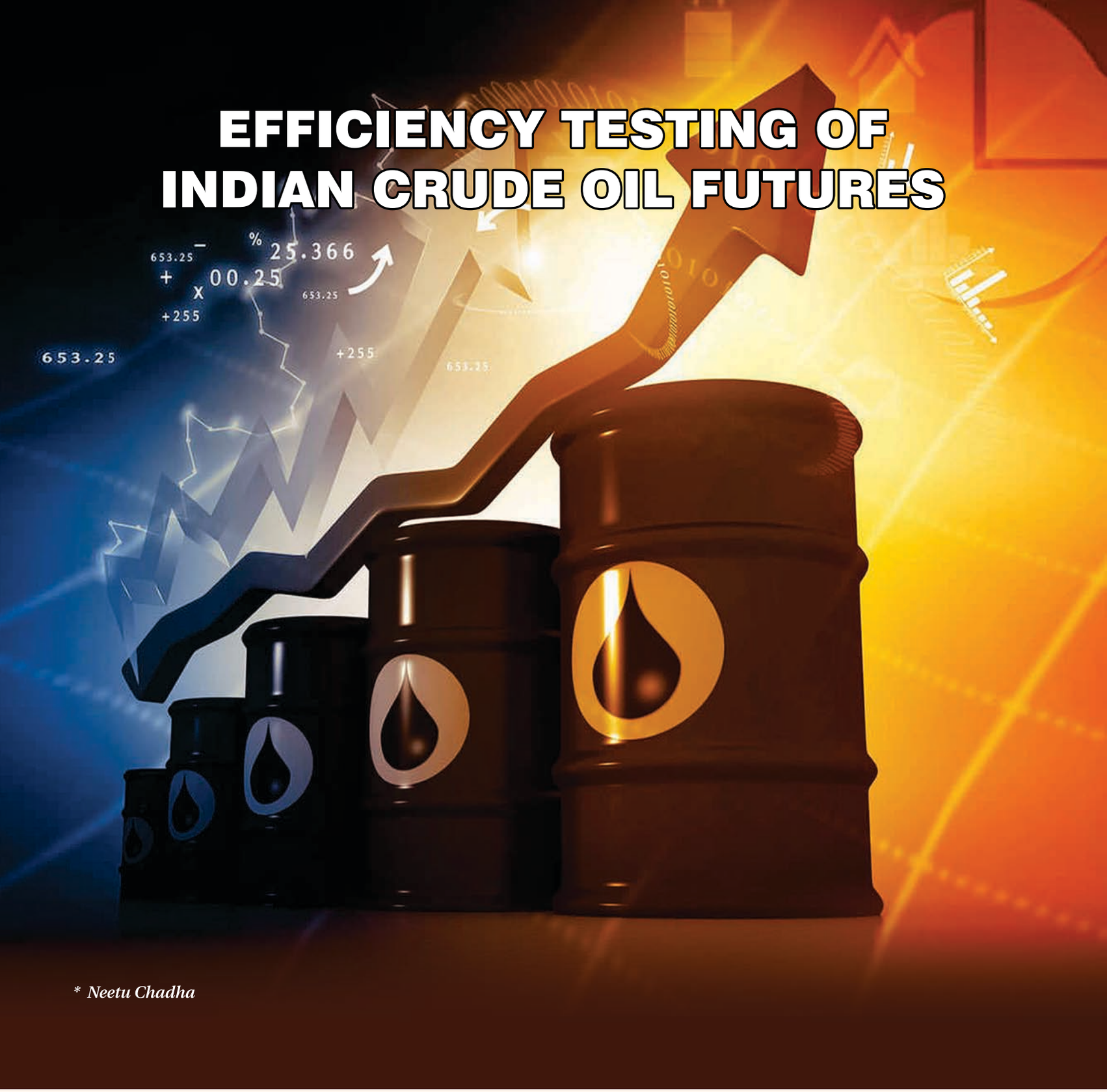
EFFICIENCY TESTING OF INDIAN CRUDE OIL FUTURES



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ABSTRACT

Crude oil is the backbone of any economy. The volatility in the oil prices can disturb the economic activities in the entire economy worldwide. Checking the performance of crude oil derivative products is the main area of concern now a days. The main purpose of the current study is to empirically inspect that whether Indian Crude Oil futures market is efficient and govern the way of information flow between the spot and futures of crude oil. Applied Econometric tests on time series daily data of closing spot and future prices of crude oil from January 2012 to December 2019 indicates that both crude oil spot and future markets are cointegrated and error correction also happens in both the markets. This study explored that in short run unidirectional causation flows from crude oil spot prices to Future crude prices and also proved long run association between both the variable series.

Key Terms: *Crude oil, Spot, Futures, Efficiency, Cointegration, Relationship, Correction*

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INTRODUCTION

Crude oil is an imperative requirement of a modern man that makes it inelastic. The availability of crude oil and its price fluctuations in the international market plays a crucial role in the stability of the currencies of many countries. Oil price fluctuations account for the fluctuations of all other commodities directly or indirectly; thus, playing a significant role in the stability of economies of the world. Since India is reliant on imported oil, any flare up in prices can have thoughtful consequences on our economy. Increasing domestic inflation is the main concern and this will stop RBI from reducing rates further. Oil Exporting and exploration companies will gain and rest other sectors that uses crude oil derivatives will be negatively impacted like coal, natural gas, etc. Continuously rising crude oil prices also increases the fiscal deficit of the oil importing countries. As crude oil is getting costlier, there might be some short-term profit booking.

With India spending $111.9 billion on oil imports in the year 2019, analysts were expecting a perfect storm in the energy markets that would have helped major consumers such as India manage inflationary and fiscal pressures. India is the world's third-largest oil buyer, and the fourth-largest liquefied natural gas (LNG) importer. The cost of the India's crude basket, which averaged $56.43 and $69.88 per barrel in the years 2018 and 2019 respectively, averaged $65.52 in December 2019.Throughout 2019, increases in U.S. petroleum production put downward pressure on crude oil prices. Iraq maintained its position as the largest crude oil supplier to India in 2018-2019, supplying more than 46.61 Million Tonnes (MT) of crude oil last financial year ended March 2019, Iraq's crude oil exports to India rose 2 per cent in the year beyond the prospects of manufacturers, investors and policy analysts. Demand-supply dynamics, geo-political events, and OPEC policy interventions are the important drivers of crude oil price fluctuations. Major variations in crude oil prices sternly influence oil trading countries. Hike in oil prices undesirably effect oil importing countries but support oil exporting countries in their progress. Any fall in oil prices strengthen the growth of importing countries by reducing the inflationary and fiscal pressures in their economy but negatively impact the oil exporting countries by reducing their exports, trade balances and increasing their fiscal deficit in those nations. Not only this investor sentiments are also affected by continuous decline in oil prices that will ultimately affect the different projects in the economy. Lowering oil prices in oil importing countries advances policy reforms, maintaining oil subsidies and increasing different taxes.

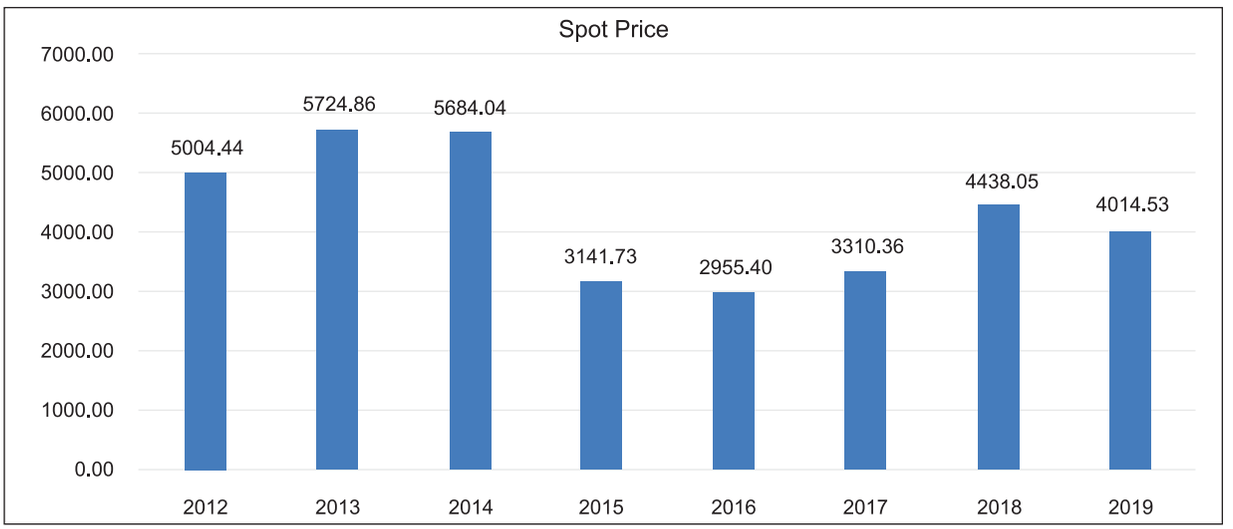
Following Figure 1 clearly depicts the Yearly Average Spot Prices of Crude Oil in India. It shows ups and down in the oil prices in the different years starting from 2012 till 2019.

From 2010 onwards there was an upward trend in the oil prices which lasted till 2014. From 2010 to 2011 the crude oil price increased heavily due to the heavy demand by the countries who were importing, and hence crude oil prices rose during the first quarter of 2012 as concerns about possible international supply disruptions pushed up the petroleum prices. The shift toward a stronger U.S. dollar in 2013 played a significant part in reducing oil and gas prices in 2014. India was adversely affected by rupee depreciation. A falling rupee adds to inflation but aids exports growth despite it not being an enough condition. In the year 2013, the rupee fell more than 24% against the dollar during the period, amplifying the price rise in the domestic market. In the international markets, crude oil jumped from $92.02 per barrel in April to $106.57 per barrel in August. In September 2013 automatic correction takes place and crude oil prices reduced more than 10% compared to fall in August in the same year on MCX trading.

Crude Oil prices declined almost by 50% in the years 2014 to 2015, i.e., prices of oil fell from $110 a barrel in June 2014 to $65 a barrel in December 2015; this fall was mainly due to the excess supply and also the decision taken by OPEC in November 2014, not to curtail crude production of oil that continued to be the reason for the drop in later years.

After 2014, the price fell drastically due to the fall in the demand by the importing countries and by the surprise decision of OPEC countries. In the year 2015, internationally around 61 million barrels per day of crude oil was traded. Oil

Figure 1: Yearly Average Spot Prices of Crude Oil in India



prices are notoriously volatile, and their actions in 2016 were no exception. Slowing growth in emerging markets, most importantly in China, had led to sharp drops in commodity prices almost across the board. Declining oil prices suggests that mounting supply is as imperative as dwindling demand. Year 2017 was no exception as oil prices dipped various times in the year in the worldwide market. Increasing demand along with various interferences and decisions of OPEC taken oil prices to $66 a barrel by end of 2017, which is more than twice the price experienced during 2016 lows.

Year 2018 proved to be another year of mixed fortunes for the oil and gas industry, with prices firming up to levels that were more common pre-2014, before dipping down in November as fears of global oversupply, amid retrenchment in global economic growth, began to kick in. Prices fell primarily because supply of crude oil had outstripped its demand. The sharp fall in crude helped cut India's import bill by Rs 2 lakh crore and reduced India's import bill and inflation. In the month of May 2018 crude oil price reached $80 per barrel which further impacted Indian Current Account Deficit.

The crude oil market has experienced numerous fluctuations over time and is considered to be one of the most volatile commodity markets. As such, it is essential for oil market participants to identify the main reasons for oil price jumps and the degree of such oil price changes when faced with specific triggers. Whenever there is an oil supply shock caused by political unrest, it would be expected that oil prices would experience a sharp increase over the period, and as such, investors can integrate this kind of behavior as part of their portfolio management strategies.

The different shifts and fluctuations in crude oil prices highlight the significance of interpreting the connection between the prices of oil-futures contracts and market expectations. Definitely, it is common for policymakers and market analysts to understand the price of the crude oil-futures contract traded in the market as a yardstick of market expectations of the future spot price of oil.

ITERATURE REVIEW

Various researchers and academicians examined price discovery and efficiency of commodity futures market in India and compared it with spot market. Gupta & Singh (2007) explored that in comparison to cash market, future market is more volatile and arbitrage opportunities exists in Indian futures markets which makes it inefficient in short run. Roy & Chakraborty (2020) using Johansen cointegration test, vector error correction model (VECM) and impulse response functions proved long run relationship between stock futures and underlying stocks.Both spot and future markets work for price discovery and there is possibility of arbitrage opportunities between stock futures and the underlying spot market when transactions costs are negligible because of auto correction in short run by spot prices. Bhatt (2014) explored bidirectional association among spot and futures market in India. Impact of futures on spot is comparatively high and this also provides profitable opportunities to traders.

Numerous policy makers made an attempt to forecast and make accurate inferences about specific commodity futures market efficiency. Sahi & Raizada(2006) studied the wheat future market efficiency for one week to three month futures and indicated that wheat future market is inefficient in short run and expansion of commodity future market in India has an impact on Indian inflation. Kumar and Pandey (2013) investigated the short run and long run efficiency of future market for eleven commodities and concluded that eight commodities futures are efficient predictors of their spot prices. In certain commodities of near month futures, futures prices are biased but efficient in long run and where trading activity is less, there are inefficiencies prevailing in the future market. Inani (2018) using daily data from January 2009 to October 2015 revealed that spot prices are highly cointegrated for all the ten commodities selected in the study. In case of six selected agricultural commodity, futures prices leads the spot prices but in the case of remaining selected four commodities, spot prices leads the future prices. Futures market is more efficient in price discovery in case of agricultural commodities. Sharma (2018) indicated that both the chilly spot and future prices are highly cointegrated and there is unidirectional causality flowing from Indian Chilly future prices to their spot prices and long run association was also found among spot and futures of Chilly. Nath et al (2019) concluded that the gold market price discovery happens in futures market not in spot market as spot prices are adjusted to follow long run equilibrium and future prices.

Extensive literature relating to futures markets is available, but only few studies have been carried out on efficiency testing of Crude oil Futures in India. Behra (2015) using daily futures and spot closing price series of gold, silver, copper, and crude oil from the year 2005 to 2011 proved that the price discovery happens firstly in the futures market then flows to spot market. In case of Gold market does not seems to be efficient as all information is not incorporated in their prices .Jiang et al. (2014) investigated that in short run WTI crude oil future market is inefficient only when major events like Oil price crashes and Gulf war, else future crude oil future market is efficient. Mensi et al. (2012)by adopting Symbolic Time Series Analysis with the Shannon entropy analyzed data from 1987 to 2012 and found weak form efficiency of oil market with varying time trends. Gulen (1998) empirically analysed the system of spot-futures-posted prices using the data of 1983 to 1985 and concluded that indicate that the futures price of crude oil traded at NYMEX shows a noteworthy role in price detection. Wang, Y., & Wu, C. (2012) using multifractality degree found that crude oil futures markets are efficient in the short-term but in the long-term the market is inefficient. Sharma(2017) checked the informational efficiency of Indian and US Crude Oil Future market and concluded that actually US market is informational supplier in short run. Diffferent trading strategies adopted by hedgers only provides limited profitable opportunities and on day to day basis both Indian and US crude oil futures markets are efficient but US market seems to be more efficient

BJECTIVE OF THE STUDY

The objective of this study is to empirically inspect the efficiency of Indian Crude Oil futures market and also to find the way of flow of information between the crude oil spot and futures.

METHODOLOGY

The current study employed daily closing spot and futures prices of crude oil from January 2012 to December 2019. The time series data was retrieved from Investing and MCX India, leading commodity exchange of India. Total 2096 observations were examined for this study.

The Augmented Dickey- Fuller (ADF) test is used to check the stationarity of the spot and Future price series of crude oil. For analysis purpose data is converted into log of daily closing spot and future prices of crude oil. The first differences of both the series i.e.spot and future log prices were taken to calculate the returns.

Further Johansen Co-integration test is applied to determine whether spot prices of crude oil in the market is co-integrated with the future prices of crude oil or not. If instead of two series stationarity their linear combination will not be stationary, then this means they are cointegrated with each other. If chosen data will be assimilated of similar order, then cointegration technique will be used to test the presence of long run association within the variables under study. Johansen Co-integration test further needs the right lag length to be chosen. For lag length selection both Akaike's information criterion (AIC) and final prediction error (FPE) are considered. Maximal Eigen value and trace test statistics values are further used to find that whether cointegration exists among variables or not that confirms the presence of long run relationship between spot and Futures of crude oil.

A Granger causality test is also applied on data series of Spot and futures of crude oil for checking the Lead lag association between two time series of variables

Deviations in short span of time is possible therefore it is required to adjust those deviations. For the purpose of adjusting the deviations VECM is essential. VECM investigate temporary deviationsand explore the relationship between the two-variable series by analyzing the variables' responses. Post identification of cointegrated equation between crude oil spot and future prices, a VECM is projected.

To inspect the coefficients of VECM, impulse response function and variance decomposition are used that help us to show the impact of variations in the value of one variable to another.

RESULTS & DISCUSSION

Descriptive statistics of Crude Oil Spot and Futures Daily Price series are brief descriptive coefficients that summarize the data series with the help of the statistical measures. The mean for Crude Oil Futures is 4315.14 and for Crude Oil spot is 4335.24. This means average of spot prices of Crude oil are

Table 1: Descriptive Statistics of Crude Oil Spot and Futures Daily Price Series

Series	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Spot	4335.242	1161.775	0.182628	2.297536	54.74654
Futures	4315.149	1177.643	0.266820	2.175150	84.28963

greater than the average prices of Crude Oil Futures. But the values of standard deviation in the table 1 reflects that the standard deviation for future prices is greater than spot prices. The kurtosis for both the series indicates that the distribution is leptokurtic. Jarque-Bera test statistic measures the difference of the skewness and kurtosis of the series with those

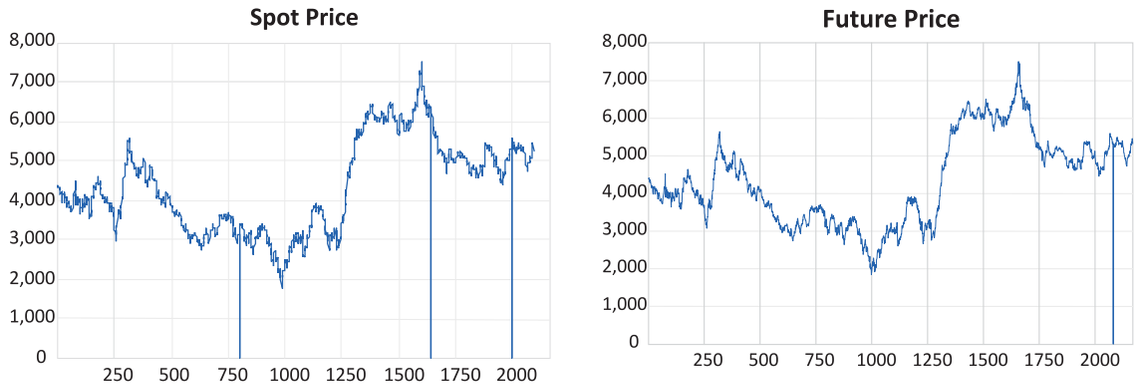
Table 2: Augmented Dickey Fuller Test(ADF)

Series	t-statistics	Probability
Spot Price	-1.605434	0.4796
Futures Price	-1.479323	0.5441
Returns of Spot	-51.34869	0.000
Returns of Futures	-47.17418	0.000

from the normal distribution. Values of Jarque-Bera statistic indicates that both the series are not normally distributed.

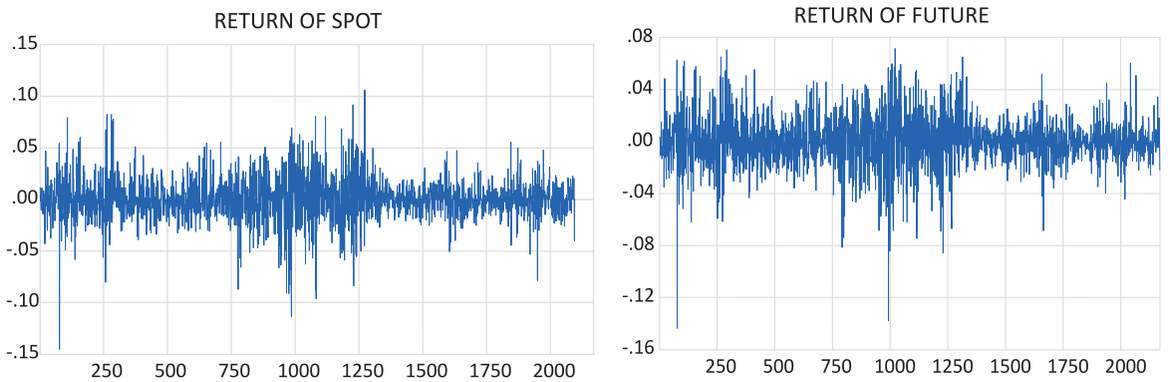
Table 2 results specify that the crude oil Spot prices and future prices series are not stationary at level and for the purpose of further analysis both the series are converted into stationary by using log of closing prices of spot prices and future prices and the results indicate that the null hypothesis is rejected. Thus, series of return of spot and futures in their first difference are stationary.

Figure 2: Daily Spot and Future Prices of Crude Oil



Source: Author's Own Compilation

Figure 3: Daily Spot and Future Returns of Crude Oil



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For additional acumens about the dynamics of crude oil prices, we portray in Figures 2 and 3 the daily crude oil spot and future prices and their daily logarithmic differences (returns) of Spot and futures. And we detect noticeable signs of price and return persistence which are episodic by some periods of strong fluctuations. This specifies the possible chances of conditional heteroscedasticity in the series of oil prices and returns.

Figure 4 clearly shows that the daily movements of Spot and Future prices of crude oil are almost similar which further proves that there is high level of cointegration between both the variables and that can also be tested by using Johansen Cointegration test

Cointegration test is used to verify whether there is any long-run relationship among the crude Oil futures and spot prices. For the study total 2096 observations are taken having a lag of 4. The results of the Johansen cointegration test are based on trace statistics and maximum eigen values test. The results of trace statistics and eigen values reflects that there exists more than 1 cointegrating equation and null hypothesis of no cointegration equation among variables is rejected. Both the values i.e. trace statistic and Eigen values value are greater than their critical value as shown in Table 3. This proves long run association among Crude oil Futures and spot prices.

Test results indicate that spot and futures prices are governed by the same set of fundamentals, such as the exchange rate, macroeconomic variables and demand and supply conditions, which are similar and interrelated in other markets for crude oil. As stated above, cointegration implies the existence of a long-run relationship between two or more non-stationary series. Therefore, it is related to arbitrage which is a representation of a long-run steady-state equilibrium relationship in a particular market. Arbitrage can be formally defined as any activity that would generate a riskless profit through substitutability between spot and futures markets. If two markets are cointegrated, in the long run arbitrage is the force that brings these markets together As oil spot and futures prices are cointegrated, the potential for making riskless excess profits on, say, the WTI spot market based on information from the Brent futures market is limited in the long run which further represents the efficiency of markets.

Figure 4: Daily Movements of Spot and Future Prices of Crude Oil

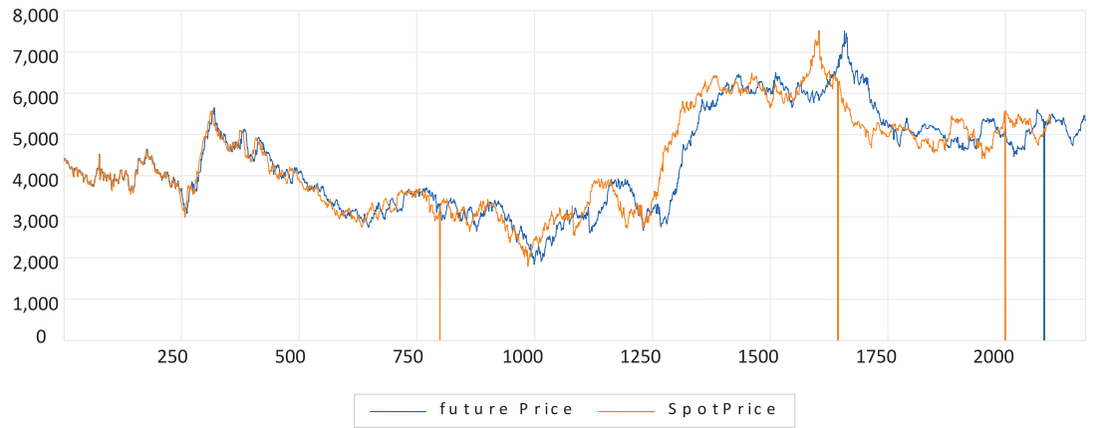

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Table 3: Johansen Cointegration Test

VARIABLES		Number of Hypothesised Equations	Maximum EIGEN Value	Critical Value at 0.05 Level	TRACE Statistic	Critical Value at 0.05 Level	Probability
Crude Oil Spot Prices	Crude Oil Futures Prices	None	380.7443	14.2646	731.5246	15.4947	0.000
Crude Oil Spot Prices	Crude Oil Futures Prices	Atmost 1	350.7804	3.84146	350.7804	3.84146	0.000

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The table 4 indicates that lag 4 is the optimal lag that is advised by the lag order length criteria and Akaike information criterion. Akaike's information criterion (AIC) and final prediction error (FPE) are better than the other criterions as they lessen the probability of under valuation while maximizing the chance of selecting the true lag length. So, Lag 4 is used to apply the Johansen Cointegration test. Optimum lag length is used for applying VECM.

Table 4: Lag Order Length Criteria Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	10187.14	NA	1.63e-07	-9.951287	-9.945792	-9.949272
1	10205.63	36.92736	1.61e-07	-9.965445	-9.948960*	-9.959399*
2	10206.57	1.860106	1.62e-07	-9.962448	-9.934973	-9.952371
3	10211.33	9.487671	1.61e-07	-9.96319	-9.924725	-9.949083
4	10218.25	13.78814	1.61e-07*	-9.966048*	-9.916593	-9.94791

Table 5: Estimates of Vector Error Correction Model

D(SPOTPRICE) = C(1)*(SPOTPRICE(-1) - 0.956140256965
*FUTURE_PRICE(-1) - 209.464784687) + C(2)*D(SPOTPRICE(-1))
+ C(3)*D(SPOTPRICE(-2)) + C(4)*D(SPOTPRICE(-3)) + C(5)
*D(SPOTPRICE(-4)) + C(6)*D(FUTURE_PRICE(-1)) + C(7)
*D(FUTURE_PRICE(-2)) + C(8)*D(FUTURE_PRICE(-3)) + C(9)
*D(FUTURE_PRICE(-4)) + C(10)

	D(DSP)	D(DFP)		D(DFP)	D(DFP)
CointEq 1	-0.008771 (0.01147) [-0.76504]	0.062355 (0.00756) [8.25288]			
S1	-0.682623 -0.02413 [-28.2877]	-0.060847 -0.0159 [-3.82636]	F1	0.002574 -0.0331 [0.07775]	-0.514464 -0.02181 [-23.5841]

S2	-0.457126 -0.02734 [-16.7218]	-0.037634 -0.01801 [-2.08908]	F2	-0.002402 -0.03696 [-0.06499]	-0.2795 -0.0244 [-11.4741]
S3	-0.272271 -0.02671 [-10.1919]	-0.02372 -0.0176 [-1.34741]	F3	-0.003336 -0.03692 [-0.09037]	-0.1424 -0.0243 [-5.85256]
S4	-0.126736 -0.02212 [-5.72878]	-0.010547 -0.01458 [-0.72348]	F4	0.001623 -0.03272 [0.04960]	-0.0417 -0.0216 [-1.93238]

Note: Standard error is given in ( ) and t-statistics in [ ]

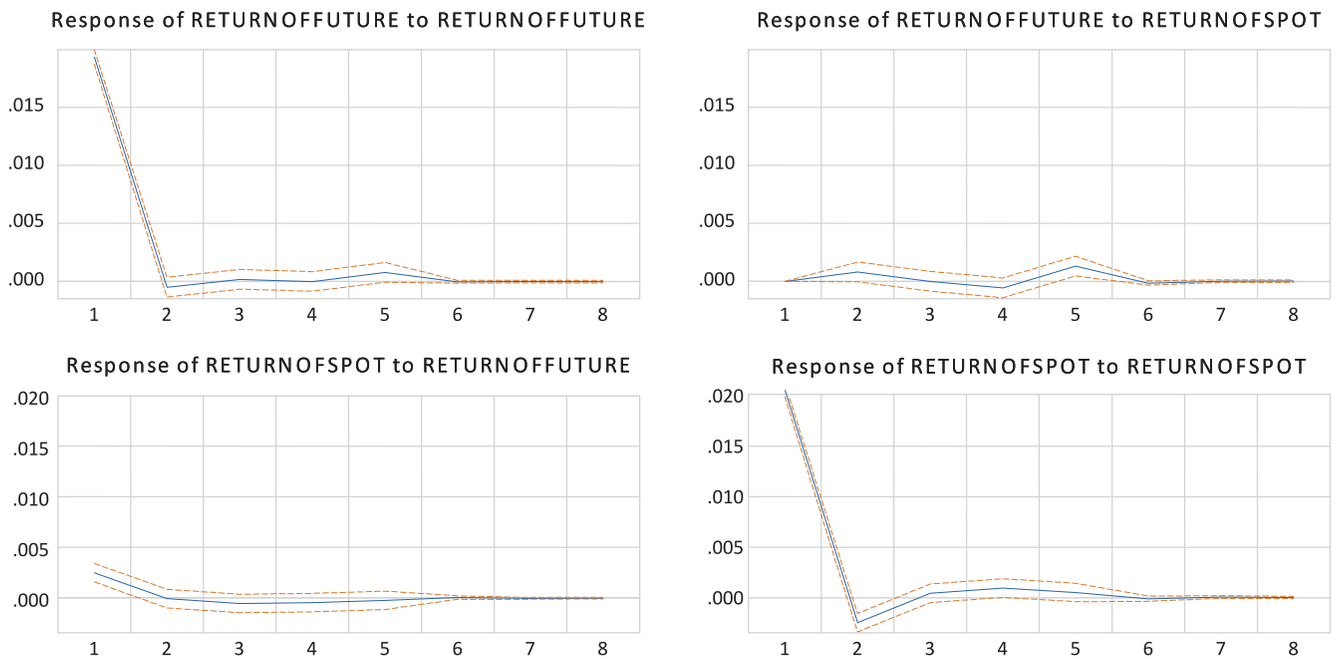
The term, error correction, narrates that the last period deviation from long-run equilibrium (the error) influences the short-run dynamics of the dependent variable. Thus, the coefficient of ECT, is the speed of adjustment, because it measures the speed at which one variable returns to equilibrium after a change in another variable. The results of VECM model shown in table 5 indicate that the coefficient of cointegrating equation is statistically significant. The coefficient of error correction term is negative, and the series move downhill to the balance. Since the error correction term in futures equation is greater than that in the spot equation, it implies that the spot prices of crude oil respond rapidly and leads to price detection. Error correction terms for both the spot prices and future prices series are significant in the elongated term. We find bidirectional causality among spot and future price of crude oil in the long term. This implies in case of crude oil, both spot and future markets respond to restore the balance whenever there is price inconsistency.

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. The results indicate that crude oil spot returns granger causes future returns of spot prices. This suggests that variations in spot price leads to future pricefluctuationsbut future prices fluctuations do not lead to change in spot prices. There is short term causality flowing from spot price to Future price.

Table 6: Granger Causality/ Block Exogeneity Wald Test

Null Hypothesis	F-statistics	Chi-Square	Probability
Crude Oil Future does not granger cause Crude Oil Spot	1.25627	5.025095	0.2851
Crude Oil Spot does not granger cause Crude Oil Future	3.71205	14.84820	0.0051

Figure 5: Response to Cholesky One SD Innovation



Source: Author's Own Compilation

Impulse response is used to discover the outcome of tremors on the variables. In response to future there is a decline in 2nd period again at 4th period and after 6th period it declined. The futures response to spot is significant and declined at 2nd and 4th period. In response of spot to future there is a decline from 2nd period but at 6th period it was positive rest it was negative during other periods. The spot response to spot there is a sharp decline in 2nd period and thereafter the prices rose and were positive and were constant from 6th period.

Variance decomposition

Variance decomposition aids in knowing what percentage of variation exists in both spot and future returns i.e. whether spot returns fluctuate due to its shocks against future returns shocks and vice versa.

Table 7: Variance Decomposition of Return of Spot

Period	S.E.	Return of Spot	Return of Future
1	0.020693	100.0000	0.000000
2	0.020842	99.99162	0.008379
3	0.020854	99.90043	0.099575
4	0.020881	99.81673	0.183269
5	0.020889	99.79190	0.208097
6	0.020889	99.79179	0.208212
7	0.020890	99.79018	0.209820
8	0.020890	99.78957	0.210432
9	0.020890	99.78949	0.210505
10	0.020890	99.78949	0.210505

Table 8: Variance Decomposition of Return of Future

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7	0.020890	99.79018	0.209820
8	0.020890	99.78957	0.210432
9	0.020890	99.78949	0.210505
10	0.020890	99.78949	0.210505

The table 7 indicates that when return of spot is taken as dependent variable then in the short run in the third year impulse or shock to return to spot causes 99.90 percent variation because of the fluctuation in the return of spot itself, shock to future can cause 0.09 percent fluctuation in return of spot prices. And in the long run spot prices can cause 99.78 percent fluctuation in spot price itself i.e. a little less as compared to short run, shock to future can cause 0.21 percent fluctuation in spot prices i.e. slightly more as compared to short run.

The table 8 highlights that when return of future is the dependent variable then in the short run in the third-year innovation to return of future brings 98.44 percent fluctuation in the return of future itself and 1.55 percent fluctuation in return of spot. And in the long run future prices cause 97.84 percent fluctuation in future price itself i.e. a less compared to short run, shock to spot can cause 2.15 percent fluctuation in future prices i.e. a slight increase as compared to short run.

ONCLUSION

Crude oil is one of the most volatile commodities apart from Gold. Large corporate houses HPCL, ONGC, IOC are the main players in the Crude oil Futures and these players have great underlying exposures because of fluctuations in Oil prices and they always use crude oil futures to hedge their risk. Crude oil futures offer a best opportunity to participants to participate in the movement of crude oil prices. From the year 2014 Crude oil prices started falling sharply as the economics of oil started changing as US heavily spend on extraction of oil and supply started coming in the market. Technology also makes cars more fuel efficient which reduced the demand in the market. All this exerted downward pressure on crude oil making it more volatile as global factors play important role in determining the volatility of the crude oil. Although India is a very small player in crude oil production but fastest expanding market for oil demand.

The present study examined the efficiency of crude oil futures markets found the way of flow of information between the crude oil spot and futures using Johansen Co-integration test, Granger Causality, VECM, Impulse response and variance decomposition models. This study observed the short run unidirectional causality flowing from spot prices to Future crude prices and long run co-movements and association between crude spot and Futures prices. Error correction terms for crude oil spot and futures price series are statistically significant. Error correction in the market helps in restoring the balance in both the markets which further indicates market efficiency.

Study results propose that spot and futures prices are administered by the same set of fundamentals, which are similar and interrelated in other markets for crude oil. Cointegration implies the existence of a long-run relationship between two or more non-stationary series. Therefore, it is related to arbitrage which is a depiction of a long-run steady-state equilibrium relationship in a market. If two markets are cointegrated, in the long run arbitrage is the force that takes these markets together. As oil spot and futures prices are cointegrated, the potential for making riskless excess profits based on information from the futures market is limited in the long run. If two markets are cointegrated each market contains information on the common stochastic trends which bind the stock market prices together, meaning that the predictability of each stock market can be enhanced through using information contained in the other stock market. The

findings of this research might be useful for the regulators, government, exchange and policy makers to form market structure policies and guidelines for the commodity markets in emerging economies.As the crude oil prices are continuously fluctuating and are naturally more volatile, on average, than stock or currency prices, it is decisive for successful investors and traders to have good evidence foundations that provide description about the various factors than can influence oil prices. Crude oil trading offers outstanding opportunities to yield excellent returns in nearly all market conditions due to its unique standing within the world's economic and political systems.

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