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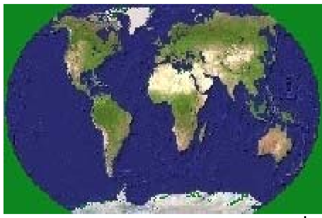

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International Linkage of Crude Oil futures Markets of India: Empirical evidences from Indian Crude Oil futures Markets

Upananda Pani, Pravin Jadhav

Abstract
Commodity futures markets in India are growing rapidly since establishment of three national level commodity exchanges in the year 2003. Crude Oil continues to be a major commodity in the energy basket since net imports of crude oil constitutes 82% of the total available crude oil in the economy. Hence, Prices in the Crude oil markets (spot and futures) in India are aligned with the International crude oil price. However, it is important analyze the interlink age of international crude oil futures markets with Indian markets as Indian crude oil futures price acts as a price signal for the various market participants in the Crude oil industry. The present study explores the international linkage (short run and long-run relationship) of Indian crude oil market using various time series techniques such as Vector Error Correction Model (VECM) and Granger Causality test. Commodity future price daily data from Multi Commodity Exchange (MCX) and New York Mercantile Exchange (NYMEX) is used in the study to explore the linkage. VECM model suggest both short run and Long-run linage of International Commodity futures market with Indian commodity futures markets. However, Granger Causality test suggests unidirectional causality from International markets to Indian markets.

Keywords: Commodity Futures, VECM, and Granger Causality Test. JEL classification: Q02, C58, G12[1]

Introduction

Crude oil price experiences wide price swings in times of shortage or oversupply. The crude oil price cycle may alter over several years responding to changes in demand as well as supply by OPEC and non-OPEC. Origin of market linkages lies in the efficient market hypothesis which states that all the markets incorporate any new information simultaneously and there does not exists any lead- lag relationship across the markets. However, frictions in markets, in terms of transaction costs and information asymmetry, may lead to return and volatility spillovers between these markets. Moreover, all the markets do not trade simultaneously for many commodities. Understanding information flow across the markets is very important for hedge funds, portfolio managers and hedgers for hedging and devising cross-market investment strategies. Efficient functioning of futures markets depends on the volatility dynamics with spot markets. Volatility spillover also explains the interdependence between the spot and futures markets.

Commodity futures trading came into existence in India since 1875. However, the commodity futures market was in a state of hibernation for the past few decades owing to a lot of government restrictions (Kabra, 2007). Significant developments took place in 2003-04 in terms of commodity futures market. The government issued a notification on April 1, 2003 withdrawing all previous notifications, which prohibited futures trading in a large number of commodities in the country. This was followed by a notification in May 2003 revoking prohibition on non-transferable specific delivery forward contracts. The futures market was opened in anticipation of sound market institutions and market design. In order to set up proper markets, GoI on recommendation of the Forward Market Commission (FMC) granted recognition to National Multi-Commodity Exchange of India Limited (NMCEIL), Ahmedabad in 2002, Multi Commodity Exchange (MCX), Mumbai and National Commodity and Derivatives Exchange Limited (NCDEX), Mumbai in the year 2003 followed by Indian Commodity Exchange Limited (ICEXL), Gurgaon in 2009. This resulted manifold increase in futures trading. The total turnover of future trading increased from Rs. 1,294 billion to Rs. 170,468 billion from the year 2003-04 to 2009-10. Whereas, the total turnover to gross domestic product increased from 4.6% in 2003-04 to 169.99% in 2012-13 (Forward Market Commission, 2010). This shows the exponential growth of the commodity future segment in the Indian economy. In recent years, commodity futures markets drew attention from the researchers regarding its functions and contribution to the Indian economy. As futures market play an important role in managing price risk and also serve the price discovery role for the spot market in the economy, there is a need to look at the volatility dynamics of the price behavior of future market. In this context, question arises about how does the future price behave? How to interpret the information it conveys to the market? Whether future contracts are effective in reducing the price risk? These issues are more pertinent for assessing performance of commodity future market in India. The present study thus attempts to find out the volatility spillover role of the commodities traded in newly established futures exchanges.

Literature Review

Kumar and Pandey (2012) [27]**,** has examined the return and volatility spillover between Indian and international commodity futures markets. For this it is important to understand the market linkages, its origin in the efficient market hypothesis which says that all markets incorporate new information simultaneously and there does not exists any lead-lag relationship across these markets. However, frictions in markets, in terms of transaction costs and information asymmetry, may lead to return and volatility spillovers between markets. Moreover, all the markets do not trade simultaneously for many assets and commodities.

The relationship between the Indian and world commodity futures markets has not been studied in depth and hence, there is a scope for investigating the linkages of Indian commodity futures markets with the counterparts elsewhere in the world trading the futures contracts on the same underlying.

Singh and Jotwani (2012) [33] analyzed the relationship between fundamental macroeconomic variables of the economy and stock market is an essential one. It affects the perspective of monetary and fiscal policy decisions, portfolio management and economic development. It has been studied that macroeconomic variables can influence investors' investment decisions. Over the world, many researchers have investigated the relationships between stock market prices and various macroeconomic variables. The focus of the current paper is to investigate whether the share price index can be considered as a reflection of economic activities in India. This study investigates the impact of five selected macroeconomic variables on Stock Market Liquidity of S&P CNX Nifty. As a result of this analysis, a simple model of the influence of macroeconomic fundamentals on the stock market index has been suggested. For better stock market performance, policy makers should put in place measures that will ensure a stable macroeconomic environment.

Jecheche (2006) [25] investigated the Arbitrage Pricing Theory for the case of Zimbabwe using time series data from 1980 to 2005 within a vector autoregressive (VAR) framework. The Granger causality tests are conducted to establish the existence of causality among the variables like inflation, exchange rate and Gross Domestic Product. The VAR estimates as shown by the impulse response and variance decomposition together with the Granger causality test show that there is unidirectional causality from Consumer Price Index to Stock

Prices. Although the Granger causality test has indicated that there is no causality between RGDP and Stock Prices, the variance decomposition has shown that the real GDP explains deviations in the Stock Prices in the long run. Granger causality tests found no meaningful relationships between Stock Prices and Exchange Rate but considering impulse response functions the effect is significant as early as the first period.

Sarver and Philippatos (1993) [32] explored the nature of the spot foreign exchange risk premium in their paper "The Arbitrage Pricing Theory and Foreign Exchange Risk Premia. Employing Ross's Arbitrage Pricing Theory (APT) as a vehicle, it tests the hypothesis that cross-sectional differences in pure currency returns depend on measures of systematic (covariance) risk. These tests have greater power, in the sense of an enhanced ability to reject the hypothesis, since they explicitly allow for the possibility that idiosyncratic risk is priced. A battery of tests is unable to reject the hypothesis that expected exchange returns can be explained by a single-factor APT. One implication of these results is that official intervention in exchange markets is unnecessary and undesirable.

Korajczyk (1989) [26] evaluated the pricing performance of alternative domestic and international asset pricing models. The models are compared when pricing assets within national economies and, in their international versions, when pricing assets across economies. The pricing models together with the hypothesis of capital market integration imply testable restrictions on multivariate regression models relating asset returns to various benchmark portfolios. Conditional on capital market integration, the tests provide information on the validity of the model. Conversely, given that the assumed type of pricing model is correct, the tests provide information about integration across markets. We compare domestic and international versions of the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT) where the pervasive factors are estimated by an asymptotic principal components technique.

Litzenberger and Rabinowitz (1995) [28] intoduce a model based on the option pricing theory. According to their model, oil reserve is observed as a call option on oil, and therefore its value is high, the higher the oil price volatility (based on the option pricing theory). Their model deliberates the effects of oil price volatility and observes the relation between volatility and the slope of the forward curve. When volatility is high, the value of delaying production increases, causing current prices to increase relative to future prices. Their model indicates that, when riskiness increases, oil production is non-increasing and inter-temporal oil price spreads are non-decreasing. This study used data on U.S. oil production, U.S. oil reserves, and West Texas Intermediate futures and options prices show that the coefficient on implied volatility is significantly positive over the period from December 1986 through December 1991.

Brennan and Schwartz (1985) [13] as well as Gibson and Schwartz (1990) [23] develop the minimal convenience revenue. The convenience revenue is the benefit of owning the physical asset and it processes the market's potentials about the future availability of the commodity. The greater the perceived risk of future shortages in supply, the greater the convenience yields. If the convenience yield is greater enough and exceeds the cost of carry, the future market is likely to shift into backwardation.

Milonas and Henker (2001) [29] discuss that backwardation could be explained by supply and demand imbalances. This model used the Brent crude oil and West Texas Intermediate (WTI) futures spread as a function of the convenience yields of the two contracts. This directs that the regional supply and demand imbalance is an important factor in determining oil futures prices. Using oil futures market data since 1989, Alquist and Kilian (2010) display that the movements in the price of oil prompted by this shock are highly correlated (as high as 80%), with independent measures of the precautionary demand component of the real price of oil based on crude oil futures prices.

According to Larson (1994), Considine and Larson (2001) [17] the convenience yield and risk premium is important elements of crude oil backwardation. In fact, Carlson, Khokher, and Titman (2007) [16] developed a model allied with model of Litzenberger and Rabinowitz (1995) [28] model. Carlson et al. (2007) illustrates that volatility of price changes can arise as a natural result of the production decisions made by value maximizing resource owners and that this volatility is related to the extent of backwardation as well as contango (futures price greater than spot price).

Moebert (2007) [30] illustrate a modest effect of OPEC's capacity utilization on crude oil. His outcomes indicate that the upward trend at the spot market can be clarified by an increasing crude oil demand of emerging markets rather than OPEC's market power. In fact, this study considers OPEC as a passive observer than a price setter.

Horan, Peterson, and Mahar (2004) [24] observed the behavior of crude oil implied volatility and found that volatility tend to upward as the meeting approaches. Similarly, Wang, Wu, and Yang (2008) [34] illustrate that the realized crude oil futures volatility responds with an increase in the weeks immediately before the OPEC events recommending price increases.

The above literature review indicates that most of the studies found the International Linkage of Crude Oil futures but no study has been done with respect to India. Accordingly the objective of the present study are:

Objective

1. To examine the short-run and long-run relationship between domestic futures price and world futures prices of crude oil.
2. To examine volatility spillovers from International crude oil market to Indian Crude oil Market.

Research Methodology and Sources of Data:

Time Series Technique:

a) Unit Root Test (Augmented Dicky Fuller Test)

The Dickey-Fuller test says that in the equation, the first order difference equation has a unit root. Specifically, assuming the absence of trend term in equation (1), the modified form as;

$$Y_t = \mu_0 + \mu_1 t + \alpha Y_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta Yt = \mu 0 + \delta\ Yt\text{-}1 + \varepsilon t \quad (2)$$

Where ΔYt = Yt - Yt-1. Here the null hypothesis is the {Yt} process has a unit root, i.e. H0: δ= α – 1. Since -1 ≤ α ≤ 0, it follows that -2 ≤ δ ≤0.

More generally, if the above equation follows a pth order autoregressive process, then it is called Dickey-Fuller test. But if it follows both pth and qth order of both autoregressive and moving average process [ARIMA (p,q)], this extended Dickey-Fuller test is called augmented Dickey-Fuller test. Specifically, if the time series follows AR(p), it can be represented as,

$$Y_t = \mu_0 + Yt\text{-}1 + \varepsilon t \quad (3)$$

After the mathematical manipulation, equation (3) can be written as,

$$\Delta Y_t = \mu_0 + \delta y_{t-1} + \sum_{i=2}^{p} \beta_i\, \Delta y_{t-1+1} + \varepsilon_t \quad (4)$$

Where $\delta = -(1 - \sum_{i=1}^{p} \alpha_i)$ and $\beta_i = \sum_{j=i}^{p} \alpha_j$.

Equation (4) is also recommended if the residuals sequence, $\{\varepsilon_t\}$ in equation (2), is not a white noise, for e.g. when εts are auto correlated. There are different forms of DF and ADF tests, which are possible by including trend terms in equation (2) and (4), and also excluding drift (intercept or constant) term, μ0 from these equations. DF test is a special case of ADF test when p=1. To test the significance of δ in equations (2) and (4), the usual Student's t-statistics critical values cannot be used but τ-statistics are made available under alternative assumption of drift, trend, sample size and level of significance. They are abbreviated as τ (no drift and no trend), τμ (only drift) and ττ (with both drift and trend). DF test has also provided the critical F-test values, known as Φ1, Φ2, and Φ3 for pair-wise joint tests of significance for μ0 and μ1. Thus, the null hypothesis that δ=0 can be rejected if the computed t value for the coefficient δ is greater than the critical τ-value in absolute magnitude. It has been shown that the same DF test critical values are valid for the ADF test as well

b) Co-Integration Method: Johansen Co-integration Test

1. Error Correlation Model: VECM Model

If both variables are *I(1)*, Johansen cointegration test are conducted. Consider a VAR with k^th lags containing these variables could be written as;

$$y_t = A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (3.6)$$

Where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t a vector of innovations. We can rewrite this VAR as

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} \ldots\ldots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \quad (3.7)$$

Where, $\Pi = \left(\sum_{j=1}^{k} \beta_i\right) - I_g$ and $\Gamma_i = \left(\sum_{j=1}^{i} \beta_j\right) - I_g$

Here, Y_t is an $(n \times 1)$ vector and $\Delta Y_t = Y_t - Y_{t-1}$, and Π and Γ are matrices of coefficients. If the variables are not cointegrated, then the rank of Π will not be significantly different from zero. Particularly, if the rank Π = 0, it implies no cointegration but there will be cointegration if the Π = 1. According to Johansen approach, there are two test statistics for cointegration;

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} ln\left(1 - \widehat{\lambda_i}\right)$$

$$\lambda_{max}(r, r+1) = -T\, ln\left(1 - \widehat{\lambda_{r+1}}\right)$$

Where r is the number of cointegrated vectors and $\widehat{\lambda_i}$ is the estimated value for the ith order eigenvalue from the Π matrix and T is the total time period. The null hypothesis should be tested for r= 0 and r = 1. The null hypothesis cannot be rejected if r = 0, that means there is no cointegration vector and there is no cointegration. On the other hand, if r = 0 is rejected, we conclude that there is cointegration between the variables. Thus the value of r is continually increased until the null is no longer rejected.

c) **Vector Error Correction (VEC) Model:** The Vector Error Correction Model (VECM) allows the short-run dynamic adjustment of variables to the long-run behavior of the endogenous variables. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Take a simple example of VECM model with two variables as:

$$\Delta y_{1,t} = \alpha_1(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$$

And $\Delta y_{2,t} = \alpha_2(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{2,t}$

In this model, the right hand side is the error correction term. In long run equilibrium, this term becomes zero. If y_1 and y_2 deviate from the long run equilibrium, this term will be non-zero and each variable adjusts partially to restore equilibrium. The coefficient α_i measures the speed of adjustment of the i^{th} endogenous variable towards the equilibrium.

Data: The required futures price of crude oil in domestic market was collected from MCX which is located in Mumbai, India. MCX is the ninth largest commodity exchange for trading of bullion, currency, metal and energy commodity futures. In the later part of the research we have shown as to how MCX has its importance in the international market and why we have chosen crude oil as the commodity for carrying out the market study. Data of few commodities like Agricultural, Bullion, metal and energy is collected from forward market commission in order to study the share of energy in the total commodities traded over MCX over the period of seven years. The data has been collected from the year 2006 to 2013.

Result and Discussions

Table 1 presents the energy commodities amongst the top 20 commodities being traded worldwide. The purpose of choosing these contracts is just to show the importance of crude oil in the commodity market worldwide. NYMEX futures and ICE futures have been among the most traded commodity contracts and hence, we chose to take NYMEX as the international exchange. Moreover, NYMEX is the exchange under CME group, over which energy commodities are traded. We already saw that CME group has been amongst the top exchanges for commodity trading and NYMEX comes under CME for the trading of energy commodities.

Table 1: Energy Contracts amongst the top Commodity Contracts

Commodity Contracts/ Year	2005	2006	2007	2008	2009	2010	2011	2012
WTI Crude Oil Futures, Nymex	59.65	71.05	121.52	0	137.42	168.65	175.03	140.53
Brent Crude Oil Futures, ICE Futures	30.41	44.35	59.72	68.36	74.13	100.02	132.045	147.38
WTI Crude Oil Futures, ICE Futures	0	28.67	51.38	51.09	46.39	52.58	51.097	33.14
WTI Crude Oil Options, Nymex	14.73	21.02	28.39	0	28.55	32.78	36.71	32.52

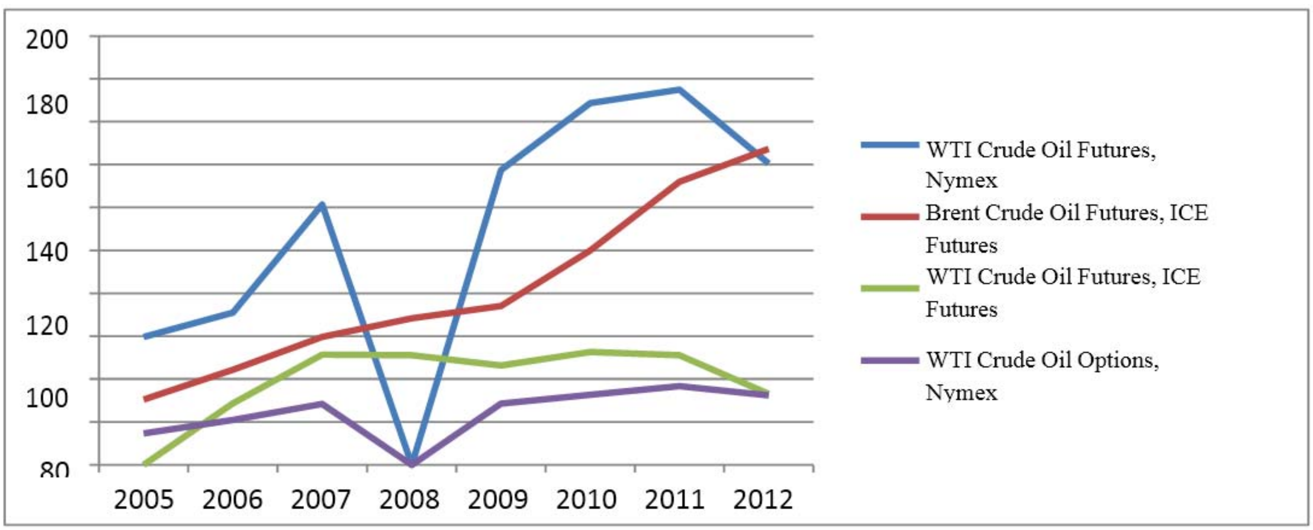

Fig 1: Energy Contracts traded globally

Table 2: Volatility of the energy contracts over the years

				Volatility			
Commodity Contracts	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
WTI Crude Oil Futures, Nymex	19.12%	71.04%	0	0	22.70%	3.78%	-19.70%
Brent Crude Oil Futures, ICE Futures	45.82%	34.69%	14.50%	8.40%	34.90%	34.93%	11.60%
WTI Crude Oil Futures, ICE Futures	0	79.22%	-0.60%	-9.19%	13.30%	-2.90%	-35.10%
WTI Crude Oil Options, Nymex	42.71%	35.13%	0	0	14.80%	11.98%	-11.40%

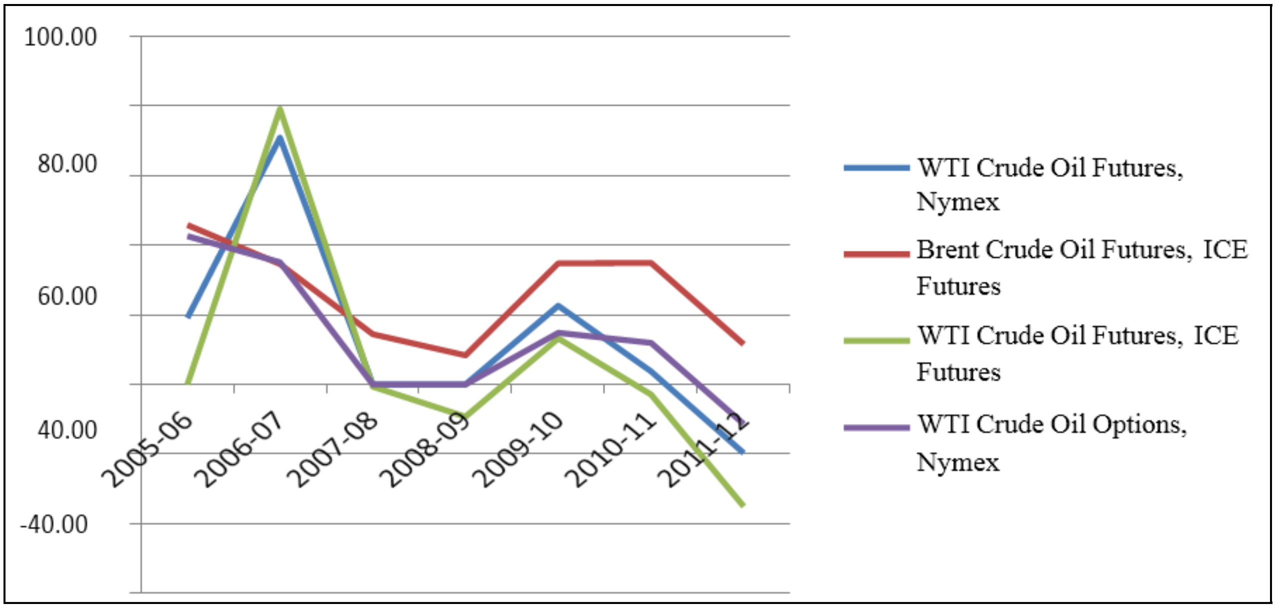

Fig 2: Volatility of the Energy Contracts

Table 3: Futures Price

Commodity	Exchange	Mean	Std.Dev.	Skewness	Kurtosis	Min.	Max.
Crude oil	MCX	4023.6	1124.9	0.3995	-0.56351	1641	7507
Crude oil	NYMEX	3957	1043.4	0.16748	-0.54348	1463.5	6524.4

Table 4: Futures Return

Commodity	Exchange	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Crude Oil	MCX	0.000387	0.020565	0.77352	11.447	-0.094389	0.23898
Crude Oil	NYMEX	0.000384	0.024915	0.15249	5.2337	-0.13229	0.16201

Table 5: Log of Futures Price

Commodity	Exchange	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Crude oil	MCX	8.2603	0.28404	-0.14062	-0.62365	7.4031	8.9236
Crude oil	NYMEX	8.2461	0.27922	-0.53334	0.27536	7.2886	8.7833

Table 3 presents the descriptive statistics of the crude oil futures of MCX and NYMEX. Table 4 presents the descriptive statistics of the futures return of the crude oil prices traded over MCX and NYMEX. Skewness is 0.77 in case of MCX and 0.15 in case of NYMEX. Kurtosis is 11.45 in case of MCX and 5.23 in case of NYMEX. The minimum futures return varies from -0.094 (MCX) to -0.013 (NYMEX). The maximum futures return varies from 0.23 (MCX) to 0.16 (NYMEX). Table 5 presents the descriptive statistics of the log of futures price. If we look at the log of the futures price, we find that the futures prices of crude oil are negatively skewed for domestic and international market. The futures return shows a leptokurtic type distribution.

Stationarity Test

Augmented Dicky Fuller (ADF) Test results are presented in Table **6.** This test shows that the log future price for level is non-stationary for both the exchanges' crude oil. The null hypothesis of non-stationary is statistically not significant at 1% level of significance as denoted by the test critical values. The result of the unit root test or the Augmented Dicky fuller test or the stationarity test indicates that we can proceed for the cointegration analysis, where the result of the first condition i.e. both the series have to be non-stationary in level and integrated of order one for the Johansen-Jusleius test is satisfied. Before testing the cointegration test, vector autoregressive framework, Granger causality test is conducted to know, if any unidirectional or bidirectional causality relationship exists between the futures prices of crude oil in the domestic market and the international market.

Table 6: Unit Root Test

Level (log)	
Constraint	**(MCX)**
I&T	-2.392361
I	-1.388852
None	0.789342

Level (log)	
Constraint	**(NYMEX)**
I&T	-2.731529
I	-1.777119
None	0.626206

First Difference (Log)	
Constraint	**(MCX)**
I&T	-20.07988
I	-44.67199
None	-44.66714

First Difference (Log)	
Constraint	**(NYMEX)**
I&T	-46.50288
I	-46.51282
None	-46.51304

The fuller critical values for ADE test at 1%, 5%, 10% are -3.43, -2.86 and -2.57 and respectively for constant (denoted by I)
The fuller critical values for ADE test at 1%, 5%, 10% are -3.96, -3.41 and -3.12 and respectively for constant and time trend (denoted by I and T)
The fuller critical values for ADE test at 1%, 5%, 10% are -2.58, -1.96 and -1.62 and respectively for no constant or time trend (denoted by None)
The test shows that the log of domestic and international market for level is non stationary. The null hypothesis of non-stationary is statistically not significant for both the price series in level.

Dickey-Fuller Stationarity Test

As was expected, the original series shown above (before we take returns) were not stationary with respect to the Dickey Fuller unit root test at a 1%, 5% or 10% probability level and not cointegrated, neither with an ADF test, nor with a Johansen test. We observed the autocorrelations in all return series (one, five, ten and one hour) and we attempted to build ARMA models for the univariate cases.
In the Dickey-Fuller and the Augmented Dickey-Fuller test, the observed τ statistic, the t statistics for δ (the coefficient for the lagged variable in the level in the test equation), is compared with the critical value provided by Mc Kinnon (1991), who has provided response surface estimated (optimal design) of the crucial values of the Dickey-Fuller statistics. The Monte Carlo tables given by Dickey (1976) were adjusted slightly by Dickey and Fuller. If τ in absolute values is smaller than the critical values, then the series will not be stationary even after the trend has been removed. In this case, it will be necessary to work with first differences. If the first differences are stationary, the series is I(1), meaning integrated of order 1. The differenced series is then I(0).
The trend stationary process can be written:

$$y_i = \beta_1 + \beta_2 t + u_t$$

Where u_t is stationary with, for instance, a constant sample mean ȕ equal to zero and a constant variance σ^2
In the difference stationary process (the random walk if α=0 or the random walk with rift) if α=0, we have

$$y_i - y_{t-1} = \alpha + u_i$$

Where α is constant

Granger Causality Test

Granger causality test is estimated below. The test helps in understanding the relationship among the futures price between domestic and international market before testing for cointegration. The estimation results from the Granger causality test is presented in the Table 7**.** the null hypothesis of future return of domestic market, MCX does not granger cause future return of the international market, NYMEX i.e $\Delta Frt(d) \neq> \Delta Frt(I)$ is rejected for the crude oil in both the markets.
Similarly, the futures return for international market does not Granger cause the futures return of the domestic market. Thus, the null hypothesis is rejected for both the markets for crude oil. Therefore, futures return of international market cause future return for the domestic market for the commodity crude oil.
Granger causality test suggests a bidirectional causality relationship between futures return of the international market and the domestic market for the price of crude oil. However, the domestic market here is affecting the international market as per the results but there are several other factors involved which are showing this result such as spot prices, which play a major role in both the markets and which affect the futures price.

Table 7: Granger Causality Test

Commodity	Exchanges	F-Stat	P-Value
Crude Oil	MCX	35.449	7.00E-16
Crude Oil	NYMEX	0.4719	0.6239

Johansen and Jusleius Cointegration Analysis Table 8: J-J Test

	H0: rank = 0 Vs H1: rank = 1	H0: rank = 0 Vs H1: rank = 1
Exchange	Max. Trace Value	Max. Eigen Value
None	20.98055	18.15261
At most 1	2.827931	2.827931

Note: [1]Critical values of $\lambda_{Trace}(r)$ = 0 for 1%, 5% and 10% significance level are 24.6, 19.96 and 17.85 respectively.

[2]Critical Values of λ_{Trace} (r) = 1 for 1%, 5% and 10% significance level are 12.97%, 9.24% and 7.52% respectively.

[3]Critical Values of $\lambda \max$ (r) =0 for 1%, 5% and 10% significance level are 20.2%, 15.67% and 13.752% respectively.

[4]Critical Values of $\lambda \max$ (r) =1 for 1%, 5% and 10% significance level are 12.97%, 9.24% and 7.52% respectively.
[5] AIC lag selection criteria is used for the estimation.

Following the stationarity test results from the previous section, J-J cointegration test is estimated for the futures price of the domestic and international market, which are integrated of order one. λ_{Trace} test statistic rejects null hypothesis at 5% level for crude oil. Hence, it accepts the null hypothesis of more than zero cointegrating vectors. Both the tests suggest presence of one cointegrating vector of crude oil. Hence, a dynamic VECM is estimated for crude oil, where there is a presence of cointegrating relationship between the domestic and international market.

Vector Error Correction Model

Table 9: VECM

Coefficient	MCX	NYMEX
α_f	1	-1.4214
	(0)	(-1.854)

Note:
1. Values in the parentheses are t-statistics
2. Statistical coefficients is considered for at 5% level of significance
3. αf represents the coefficient of error correction for futures price

Table 9 presents the results of the analysis of VECM on the futures return. We will look at the domestic market and international market one by one. The coefficient of the error correction term αf is negative in case of the international market (NYMEX) and positive in case of MCX, which implies that it is statistically significant and the international futures price has a positive impact on the domestic futures price, whereas the domestic market does not affect the futures price of the international market. It also shows that the short-run deviations of the future price would be adjusted in the upward direction towards the long-run equilibrium.

Conclusion

From the various analytical tools and preceding discussions, we conclude that both the Indian and International futures market influence each other, but NYMEX has a stronger impact on Indian prices. Existence of cointegrating relationship implies that both domestic and International futures market have a short-run disequilibrium, which can be corrected by arbitrage process. Unidirectional Volatility spillover from NYMEX to MCX is found. Granger causality test suggests a bidirectional causality relationship between futures return of the international market and the domestic market for the price of crude oil and VECM model indicate that there exists a one-way causality from world markets to Indian market.

Efficient market hypothesis says that all markets incorporate any new information simultaneously and there is no lead-lag relationship existing in these markets.

On the contrary, it can be argued that, given the size of the Indian economy, Indian market may also influence world market. This issue has interesting implications in gaining insight on the directionality of information flow and assimilation of the same. The long run relationship between Indian futures price and its world counterparts indicate that the Indian futures market is cointegrated with the world markets.

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