PRICE DISCOVERY IN THE ENERGY FUTURE MARKET IN INDIA

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[The paper attempts to find out long run relationship between Spot Price and Future Price in the Indian commodity future market with an application to two important energy products, Crude oil and Natural gas. We have applied Time Series Econometrics by exercising Stationarity Test, Johanson Co-integration test and Granger Causality test for our study of long run relationship between Spot and Future Prices. Econometric exercises show that there is long run lead lag relationship and two-way Granger Causality in between log value of spot and future prices both for crude oil and natural gas. There is also long run Co-integrating relationship between the variables for both the energy products. Estimation of our error correction model indicates for both the energy products, speed of adjustment coefficient is significant. There is bi-directional error correction for the series of log value of Spot and Future prices for both the energy products.

Keywords: *Future Market, Spot Price, Crude Oil, Natural Gas]*

Introduction

A commodity futures market is a public market where commodities are contracted for purchase or sale at an agreed price for delivery on a specified date. This process of purchase or sale of commodities must be made through an organized exchange broker and the purchase should be made under the terms and conditions of a standardized futures contract (Choudhry, 2004). Commodity, besides being a unique hedging instrument, also provides for efficient portfolio management arising from diversification benefits. These benefits result in improved returns to domestic as well as international investors. The commodity futures market furnishes commercial commodity producers and consumers with a way to express price risk to speculators who have no direct commercial concern in the commodities themselves (Silber, 1985).

There are 23 exchanges operating in India and carrying out futures trading activities in as many as 146 commodity items (Sahoo and Kumar, 2010). The Government of India recognized the National Multi Commodity Exchange (NMCE), Ahmadabad; Multi Commodity Exchange (MCX) and National

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Commodity and Derivative Exchange (NCDEX), Mumbai, as nationwide multi-commodity exchanges as per the recommendation of the FMC. In November 2003, MCX commenced trading and NMCE in November 2002 and NCDEX in December 2003. A total of 94 commodities were traded in December 2006 in the commodity futures market, as compared to 59 commodities in January 2005. These commodities comprised major agricultural commodities such as rice, wheat, jute, cotton, coffee, major pulses, edible oilseeds, spices, metals, bullion, crude oil, natural gas and polymers, among others. In price discovery for trading commodities, an efficient and well-organized commodities futures market is generally acknowledged to be helpful (Yang et al., 2001).

This paper has been addressed one of the very important aspect of commodity future market, namely price discovery that expresses interrelationship between spot price and future price. We studied the relationship for the energy commodity market in India using Time Series Econometrics.

Price Discovery

Price discovery is a mechanism to determine the price of an asset or a commodity in the market place through the interactions of buyers and sellers. It helps in identifying whether the spot market dominates the futures market or the futures market dominates the spot market. It involves buyers and sellers arriving at a transaction price for a specific item at a given time. In a dynamic market, the price discovery takes place continuously. It helps in finding the exact price for a commodity or a share based on inputs regarding specific market information, the demand and supply equilibrium, weather forecasts, expert views and comments, inflation rates, government policies, market dynamics like hopes and fears, futures trading and so on. This transforms in to continuous price discovery mechanism. Spot contract or spot transaction is a contract of buying or selling a commodity, security or currency for settlement (payment and delivery) on the spot date, which is normally two business days after the trade date. The settlement prices are called spot price. Commodity futures contract refers to an agreement to buy or sell a set amount of a commodity at a predetermined price and date. Unlike cash markets a futures market is based on buying (or selling) commodity contracts at a fixed price for potential physical delivery at some future date.

Literature Review

Following literatures are available in this area of our study.

Sl. No.	*Literature*	*Data Taken*	*Data Applied*	*Conclusion*
1	Oellermann and Farris(1985)	Daily closing price of live cattle contract on Chicago Mercantile Exchange(CME) and average daily cash price from 1966 through 1982	Econometric Models	Future Market is the centre of price discovery

Sl. No.	*Literature*	*Data Taken*	*Data Applied*	*Conclusion*
2	Gellermann et. al. (1989)	Daily closing prices of the live cattle and feeder cattle future contracts traded on CME from 1979 through 1986	Granger Causality Test	Feeder cattle future prices generally lead cash prices in incorporating new pricing information.
3	Koontz et. al. (1990)	Cash market and Live cattle futures market between 1973 through 1984	Granger Causality Test	Price discovery is dynamic and cash markets have deceased their reliance on the future market as an overall price discovery mechanism but the future market is relied upon to register information which emerges late in the week and is reflected in the cash markets in the following week.
4	Quan(1992)	Monthly data of crude oil spot and 1 month and 3 months futures prices from 1984 through 1989	Garbet and Silver approach and Error correction model(ECM)	Spot market dominates over the futures market in incorporating new information.
5	Chan (1992)	Data from August 1984 – June 1985 and January 1987 – September 1987 on MMI and an Index coprising of 20 actively traded stocks have been analysed.	Lead- Lag relationship a) Under bad news and good news b) Under different intensities of trading activities c) Market wide movement	There is an asymmetric lead –lag relationship between the two markets with strong evidence that cash index leads the futures.
6	Wahab and Lasgari (1993)	Daily closing value of stock index and stock index futures prices for both S&P 500 and FT-SE 100 indices from 1988 to 1992.	Vector ECM (VECM)	Feedback relationship exists between cash and future markets for both the indices but spot to futures lead appears to be more pronounced across days relative to future to spot lead.

Sl. No.	*Literature*	*Data Taken*	*Data Applied*	*Conclusion*
7	Raju and Karnde(2003)	Daily closing values of S&P CMNX Nifty futures and spot prices from June 2000 to October 2002.	VECM	Price discovery occurs in the future markets.
8	Figuerola-Ferretti and Gonzalo (2006)	London Metal Exchange (LME) traded metals – Aluminium, Copper, nickel and zinc on daily spot and 15 month future from Jan 1989 to June 2006.	VECM and Permanent Transitory Decomposition	In case of aluminium, copper, nickel, and zinc, price discovery occurs in the future market and in case of lead it occurs in the spot market.
9	Karande (2006)	Castor seed future market in India, from 1985 to 1993 and 1994 to 1999.	VECM	There exist bidirectional causality in the Mumbai and Ahmadabad future market dominates the spot market.
10	Gupta and Singh(2007)	Daily closing values of Nifty Future index, stock futures and spot prices from 12 June 2000 to June 2006.	Granger Causality Test and VECM	Future market leads the spot market.
11	Karmakar (2009)	Daily price series of S&P CNX Nifty spot and the Nifty futures from 2000 to 2007.	VECM	Bi directional causality exists in future and spot prices but future market is more informationally efficient than the underlying spot market.
12	Chaihetphon and Pavabutr (2010)	Daily future and spot prices from MCX data of Gold.	VECM	Future prices lead Spot prices for both standard as well as mini contracts.
13	Kumar and Arora (2011)	Daily closing values of spot and nearby future contracts of gold traded on MCX from 2005 to December 2009.	Johansen Co integration test and Granger causality test.	The series of spot and future prices are co integrated and the market plays an important role in price discovery.

Revisiting the literatures it is found that Relationship between spot and future price for energy commodities are not done for the economy. Hence our research work will address that research gap.

Objective of the Study

Price discovery is an important function of the future market. This paper intends to examine how Indian commodity future market functions with respect to Indian energy sector products like, crude petroleum and natural gas.

Econometric Technique to Test Price Discovery

Return

Daily series of the closing prices have been converted to continuous daily return series by applying the formula:

$$R_t = \ell n P_t - \ell n P_{t-1} \quad (1)$$

Here R_t is the return and P_t and P_{t-1} are the closing spot price of day t and its previous trading day.

Testing for Stationarity of Data

For testing the role of spot and future prices in price discovery and their long run relationship, we first test the stationarity in series of log of spot prices and log of future prices. We shall apply graphical representation and b ADF (Augmented Dicky Fullar) test on the series of log of future and spot prices. We use following representation of ADF statistics for testing stationarity.

$$\Delta Y_t = \beta_1 + \beta_2 .t + \Delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i .\Delta Y_{t-i} + \varepsilon_t \quad (2)$$

If after investigation it is found that time series is non-stationary we shall apply methods other than standard regression like Johanson Co-integration test. In a non-stationary series application of standard regression will lead to spurious regression. Hence we may transform the series into a stationary one after suitable transformation.

A non-stationary time series can be converted to a stationary time series by taking the first difference

$$\Delta X_t = X_t - X_{t-1} \quad (3)$$

A series will be called of having order d, if the series is non stationary but remain stationary after differentiating it by d times.

Co-integration

Following Engel and Granger (1987) co-integration can be defined in terms of following condition:

Let w_t be a kx1 vector of variables, then the components of w_t are co-integrated of order (d, b) if:

i. All components of w_t are I(d)

There is at least one vector of coefficients α such that (b > 0)

$$\alpha' w_t \sim I(d-b)$$

In practice many financial variables contain one unit root and are thus $I(1)$, so we shall restrict our analysis to the case where d=b=1.

In this context a set of variables is defined as co-integrated if a linear combination

of the variables is stationary. Many time series are non-stationary but move together over time, i.e., there exist some influences on the series (For example market forces) which imply that two series are bound by some relationship in the long run. A co-integrating relationship may also be seen as a long term or equilibrium phenomenon, since it is possible that co integrating variables may deviate from their relationship. In the short run but their association would return in the long run.

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g}\ln\left(1-\hat{\lambda}_i\right) \quad (4)$$

and

$$\lambda_{\max}(r, r+1) = -T.\ln\left(1-\hat{\lambda}_{r+1}\right) \quad (5)$$

Error Correction Model

According to Quan (1992) the error correction model (ECM) for co-integrating variables is commonly interpreted as reflecting partial adjustment of one variable to another. The concept of co integration and error correction are closely related. It is a proven fact that if two variables are co-integrated has an ECM representation. An ECM for two variables relates the changes in the variables to the lagged changes and a lagged linear combination of levels. The linear combination of levels which enters the ECM is just that combination which is stationary in levels. When two variables are co integrated there always exists a valid ECM.

It clearly emerges that individually two series may be non stationary, yet they may be co integrated. The co-integrating equation gives long-run relationship between the two variables. Co-integrating equation does not represent any dynamic adjustment behaviour of the short run forces despite the very presence of those short run forces, responsible for the long run relationship to be intact. Thus it is possible to construct a more comprehensive model which may capture both short run and long run dynamics.

To understand the feature of ECM considers two series Y_t and X_t which are $I(1)$, so that their linear combination $\hat{\varepsilon}_t = Y_t - \hat{a} - \hat{b}X_t$ is $I(0)$. Then the long run equilibrium relationship between the two variables is represented by $\hat{Y}_t = \hat{a} + \hat{b}X_t$. Corresponding to this long run equilibrium relationship, we can write the ECM as

$$\Delta Y_t = \phi + \gamma\Delta X_t + \lambda\hat{\varepsilon}_{t-1} + W_t \quad (6)$$

Here $\hat{\varepsilon}_{t-1} = \left(Y_{t-1} - \hat{Y}_{t-1}\right) = \left(Y_{t-1} - \hat{a} - \hat{b}X_{t-1}\right)$ is one period lagged value of the error from the co-integrating regression and W_t is the error term in the ECM. The ECM equation states that aY_t depends not only on aX_t but also on the equilibrating error term £̂$_{t-1}$. When £̂$_{t-1}$ is non zero, there is disequilibrium in the short run. Equilibrium will be restored back in the long run if and only if ª ≤ 0. here ¥ captures the impacts of short run disturbances of X_t on Y_t while ª captures the adjustments towards long run equilibrium. The ECM for our analysis could be presented in terms of the following equations.

$$\Delta F_t = \delta_f + \alpha_f . \hat{u}_{t-1} + \beta_f . \Delta S_{t-1} + \gamma_f \Delta F_{t-1} + e_{f,t}$$
$$\Delta S_t = \delta_s + \alpha_s \hat{u}_{t-1} + \beta_s \Delta F_{t-1} + \gamma_s \Delta S_{t-1} + e_{s,t}$$

(7) & (8)

Each of the equation 5 and 6 can be interpreted as having two parts. The first part $(\hat{u}_{t-1})$ is the equilibrium error. This measures how the left side variables adjust to the previous period's change in price on current period's deviation. The coefficient $\sim_f$ and $\sim_s$ are the speed adjustment coefficient and they have important implication for the ECM. At least one speed adjustment coefficient must be non zero for the model to be an ECM. The coefficient serves the role of identifying the direction of causal relation and also indicates the speed at which the deviation from the equilibrium is corrected. If $\sim_f$ is statistically insignificant the current period's change in future price does not respond to last period's deviation from long run equilibrium. If both $\sim_f$ and $_f$ are statistically insignificant, the spot price does not Granger cause future price.

Lag Length

Lag length in this study has been determined by Swartz information criteria (SIC). This uses a function of the residual sum of squares together with a penalty for a large number of parameters. SIC minimises the expression; $T \times \log(RSS) + K \times (\log T)$, where T is the number of observations, RSS is the sum of the squared residuals and K is the number of repressors.

Data Set

Daily closing price of spot and its near month future contract of two important energy products, crude petroleum and natural gas. Data has been taken from the website of MCX website and NCDEX website for the period 2010 to 2015. The data has been analysed with the help of Eviews - 9.5. We have taken log values of the data for our analysis.

Period of the Study

Period of our study spans from January, 2012 through June, 2017.

Descriptive Statistics

	LOG_FUTURE	LOG_SPOT	LOGFP	LOGSP
Mean	2.292503	2.279318	3.645283	3.630908
Median	2.295347	2.279439	3.695569	3.681693
Maximum	2.489255	3.524240	3.876737	3.876622
Minimum	2.000868	1.995635	3.312389	3.253822
Std. Dev.	0.096910	0.110607	0.124453	0.134335
Skewness	-0.407802	0.749227	-0.297519	-0.323393
Kurtosis	2.742871	13.31894	1.757147	1.854696
Jarque-Bera	44.33652	6591.513	115.1119	104.8846
Probability	0.000000	0.000000	0.000000	0.000000

	LOG_FUTURE	LOG_SPOT	LOGFP	LOGSP
Sum	3335.591	3316.408	5303.886	5282.971
Sum Sq. Dev.	13.65543	17.78799	22.52047	26.23866
Observations	1455	1455	1455	1455

Results of Our Study

Stationarity Test Results

After running the ADF test for log of spot price of crude oil at the level we find that test statistic falls in the acceptance region and p value is not small. Hence null hypothesis is accepted and there is the presence of unit root in the data. However, at first difference of log of spot price of crude oil, ADF test result shows null hypothesis to be rejected and therefore there is no unit root at first difference. Similarly for log future price of crude oil, test shows unit root is present at level but data is found to be stationary at first difference.

For Natural Gas, log of spot price data at level shows the presence of unit root at 1% and 5% level. However, at fist difference of log spot price of natural gas data shows stationarity at 1%, 5% and 10% level. Log value of natural gas future price at level shows the presence of unit root as there p value is not small and test statistic falls in the acceptance region. But, at first difference, corresponding data shows stationarity at 1%, 5% and 10% level.

Hence, the series of log value of spot price of natural gas and crude oil and log value of future price of natural gas and crude oil exhibit the presence of unit root at the level but data are stationary at the first difference.

Results of Co-integration Test:

We performed Johanson Co-integration test for log of spot price and log of future price of crude oil. Two kinds of test are performed a) Maximum Eigen Value Test and b) Trace Test. Trace test indicates 1 co-integrating eqn(s) at the 0.05 level. Presence of no co integrating equation has been rejected at the 5% level. Max-eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level. p-value for no co-integrating vector is rejected at the 5% level. We have used MacKinnon-Haug-Michelis (1999) p-values for our analysis.

We also have performed Johanson Co-integration test for log of spot price and log of future price of Natural gas. In this case also two kinds of test are performed a) Maximum Eigen Value test and b) Trace Test. Trace Test indicates 2 co-integrating eqn(s) at the 0.05 level. The reason behind this is, null hypothesis that at most one co-integrating relation has been rejected at 5% level and presence of no co integrating equation has been rejected at the 5% level. Max-eigenvalue test indicates 2 co integrating eqn(s) at the 0.05 level. p-value for the hypothesis that there is no co integrating vector is rejected at the 5% level. In this test also we have used MacKinnon-Haug-Michelis (1999) p-values for our analysis.

JOHANSAN CO-INTEGRATION TEST For CRUDE OIL

Date: 07/28/17 Time: 23:04

Sample (adjusted): 5 1459

Included observations: 1440 after adjustments

Trend assumption: Linear deterministic trend

Series: LOGFP LOGSP

Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.040348	61.18633	15.49471	0.0000
At most 1	0.001305	1.880954	3.841466	0.1702

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.040348	59.30537	14.26460	0.0000
At most 1	0.001305	1.880954	3.841466	0.1702

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOGFP	LOGSP
-87.96479	80.88989
-2.564161	9.824056

Unrestricted Adjustment Coefficients (alpha):

D(LOGFP)	0.001364	-6.44E-05
D(LOGSP)	0.000520	-0.000312

1 Cointegrating Equation(s):	Log likelihood	10090.48

Normalized cointegrating coefficients (standard error in parentheses)

LOGFP	LOGSP
1.000000	-0.919571
	(0.01093)

Adjustment coefficients (standard error in parentheses)

D(LOGFP)	-0.119970
	(0.01601)
D(LOGSP)	-0.045722
	(0.02095)

JOHANSAN CO-INTEGRATION TEST OF NATURAL GAS

Date: 07/28/17 Time: 21:10

Sample (adjusted): 6 1459

Included observations: 1436 after adjustments

Trend assumption: Linear deterministic trend

Series: LOG_FUTURE LOG_SPOT

Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.094536	147.5392	15.49471	0.0001
At most 1 *	0.003429	4.933030	3.841466	0.0263

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.094536	142.6061	14.26460	0.0001
At most 1 *	0.003429	4.933030	3.841466	0.0263

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG_FUTURE	LOG_SPOT
-47.57572	44.29027
9.283026	1.018937

Unrestricted Adjustment Coefficients (alpha):

D(LOG_FUTURE)		0.000626	-0.000598
D(LOG_SPOT)	-0.011432	-0.001011	

1 Cointegrating Equation(s): Log likelihood 7178.257

Normalized cointegrating coefficients (standard error in parentheses)

LOG_FUTURE	LOG_SPOT
1.000000	-0.930943
	(0.01633)

Adjustment coefficients (standard error in parentheses)

D(LOG_FUTURE)		-0.029781
		(0.01310)
D(LOG_SPOT)	0.543864	
		(0.04960)

Results of Granger Causality Test:

We have performed Granger causality test in between Spot and Future price for both Crude oil and Natural gas. For crude oil both the null hypothesises that LOGSP does not Granger Cause LOGFP and LOGFP does not Granger Cause LOGSP have been rejected because of very low p-value. Hence there is two-way Granger Causality in between log spot price and log future price for the crude oil. Similarly Granger Causality test result shows there is two way Granger Causality in between log of Spot price and log of future price for the natural gas.

Results of GANGER CASUALITY TEST OF CRUDE OIL

Pairwise Granger Causality Tests

Date: 08/04/17 Time: 21:12

Sample: 1 1459

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGSP does not Granger Cause LOGFP	1448	152.917	6.E-61
LOGFP does not Granger Cause LOGSP		14.5695	5.E-07

GANGER CASUALITY TEST OF NATURAL GAS

Pairwise Granger Causality Tests

Date: 08/04/17 Time: 21:07

Sample: 1 1459
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG_SPOT does not Granger Cause LOG_FUTURE	1448	21.3149	8.E-10
LOG_FUTURE does not Granger Cause LOG_SPOT		167.925	3.E-66

Results of Vector Error Correction Model Estimation:

For VECM on Crude oil data, we find that 3 lags are found to be appropriate. The error correction term, also called the speed of adjustment given in the following table is significant in both the equations implying that a bi directional error correction. This indicates that when the co integrated series are in disequilibrium in the short run then both the series, spot price and future price adjust themselves

in order to re-establish the equilibrium. In the equation with future return as the dependent variable, all the 3 lag values of spot and future price are significant. Similarly for Natural Gas, we find that4 lags are found to be appropriate. The error correction term is significant in both the equations implying that a bi directional error correction. In the equation with future return as the dependent variable, all the 4 lag values of spot and future price are significant.

Results of VECM estimation for CRUDE OIL

Vector Error Correction Estimates
Date: 08/01/17 Time: 23:12
Sample (adjusted): 5 1459
Included observations: 1440 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LOGFP(-1)	1.000000	
LOGSP(-1)	-0.919571	
	(0.01093)	
	[-84.1022]	
C	-0.306522	
Error Correction:	**D(LOGFP)**	**D(LOGSP)**
CointEq1	-0.119970	-0.045722
	(0.01601)	(0.02095)
	[-7.49503]	[-2.18261]
D(LOGFP(-1))	-0.173463	0.266856
	(0.03160)	(0.04135)
	[-5.48956]	[6.45298]
D(LOGFP(-2))	-0.085908	0.092292
	(0.03152)	(0.04125)
	[-2.72576]	[2.23753]

D(LOGFP(-3))	-0.022442	0.038403
	(0.02694)	(0.03526)
	[-0.83301]	[1.08921]
D(LOGSP(-1))	0.297220	-0.264124
	(0.02702)	(0.03536)
	[10.9990]	[-7.46858]
D(LOGSP(-2))	0.156838	-0.141073
	(0.02897)	(0.03791)
	[5.41415]	[-3.72113]
D(LOGSP(-3))	0.051801	-0.022423
	(0.02615)	(0.03423)
	[1.98054]	[-0.65508]
C	0.000127	0.000182
	(0.00018)	(0.00024)
	[0.69760]	[0.76323]
R-squared	0.195363	0.046894
Adj. R-squared	0.191429	0.042235
Sum sq. resids	0.068279	0.116945
S.E. equation	0.006905	0.009037
F-statistic	49.66909	10.06519
Log likelihood	5125.445	4738.012
Akaike AIC	-7.107562	-6.569461
Schwarz SC	-7.078271	-6.540170
Mean dependent	0.000167	0.000174
S.D. dependent	0.007679	0.009234
Determinant resid covariance (dof adj.)		2.84E-09
Determinant resid covariance		2.81E-09
Log likelihood		10090.48
Akaike information criterion		-13.98955
Schwarz criterion		-13.92365

ESTIMATES (INCLUDING P-VALUE)

System: UNTITLED

Estimation Method: Least Squares

Date: 08/01/17 Time: 23:13

Sample: 5 1459

Included observations: 1441

Total system (unbalanced) observations 2881

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.120779	0.016010	-7.543845	0.0000
C(2)	-0.172412	0.031614	-5.453720	0.0000
C(3)	-0.084533	0.031528	-2.681225	0.0074
C(4)	-0.021645	0.026954	-0.803028	0.4220
C(5)	0.296607	0.027038	10.97006	0.0000
C(6)	0.156977	0.028987	5.415381	0.0000
C(7)	0.051749	0.026172	1.977254	0.0481
C(8)	0.000135	0.000182	0.739819	0.4595
C(9)	-0.045722	0.020948	-2.182606	0.0291
C(10)	0.266856	0.041354	6.452976	0.0000
C(11)	0.092292	0.041247	2.237534	0.0253
C(12)	0.038403	0.035257	1.089209	0.2762
C(13)	-0.264124	0.035365	-7.468577	0.0000
C(14)	-0.141073	0.037911	-3.721125	0.0002
C(15)	-0.022423	0.034229	-0.655083	0.5125
C(16)	0.000182	0.000238	0.763226	0.4454

Determinant residual covariance 2.82E-09

Equation: D(LOGFP) = C(1)*(LOGFP(-1) - 0.919571255537*LOGSP(-1) - 0.306521532633) + C(2)*D(LOGFP(-1)) + C(3)*D(LOGFP(-2)) + C(4) *D(LOGFP(-3)) + C(5)*D(LOGSP(-1)) + C(6)*D(LOGSP(-2)) + C(7) *D(LOGSP(-3)) + C(8)

Observations: 1441

R-squared	0.195682	Mean dependent var	
Adjusted R-squared	0.191753	S.D. dependent var	
S.E. of regression	0.006910	Sum squared resid	
Durbin-Watson stat	1.992609		

Equation: D(LOGSP) = C(9)*(LOGFP(-1) - 0.919571255537*LOGSP(-1) - 0.306521532633) + C(10)*D(LOGFP(-1)) + C(11)*D(LOGFP(-2)) + C(12)*D(LOGFP(-3)) + C(13)*D(LOGSP(-1)) + C(14)*D(LOGSP(-2)) + C(15)*D(LOGSP(-3)) + C(16)

Observations: 1440

R-squared	0.046894	Mean dependent var	0.000174
Adjusted R-squared	0.042235	S.D. dependent var	0.009234
S.E. of regression	0.009037	Sum squared resid	0.116945
Durbin-Watson stat	2.002044		

VECM OF NATURAL GAS

Vector Error Correction Estimates
Date: 08/01/17 Time: 22:40
Sample (adjusted): 6 1459
Included observations: 1436 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG_FUTURE(-1)	1.000000
LOG_SPOT(-1)	-0.930943
	(0.01633)
	[-56.9938]
C	-0.170470

Error Correction:	D(LOG_FUTURE)	D(LOG_SPOT)
CointEq1	-0.029781	0.543864
	(0.01310)	(0.04960)
	[-2.27273]	[10.9651]

D(LOG_FUTURE(-1))	-0.004415	0.216940
	(0.02854)	(0.10801)
	[-0.15470]	[2.00846]
D(LOG_FUTURE(-2))	0.025035	0.144757
	(0.02808)	(0.10630)
	[0.89145]	[1.36175]
D(LOG_FUTURE(-3))	-0.014916	0.107856
	(0.02704)	(0.10234)
	[-0.55167]	[1.05387]
D(LOG_FUTURE(-4))	0.018518	-0.172118
	(0.02607)	(0.09867)
	[0.71039]	[-1.74439]
D(LOG_SPOT(-1))	0.021366	-0.325604
	(0.01186)	(0.04490)
	[1.80099]	[-7.25095]
D(LOG_SPOT(-2))	0.015470	-0.228212
	(0.01106)	(0.04186)
	[1.39890]	[-5.45176]
D(LOG_SPOT(-3))	-0.000264	-0.156538
	(0.00969)	(0.03667)
	[-0.02724]	[-4.26855]
D(LOG_SPOT(-4))	0.002992	-0.080397
	(0.00732)	(0.02771)
	[0.40869]	[-2.90153]
C	-2.99E-05	-2.65E-05
	(0.00028)	(0.00104)
	[-0.10850]	[-0.02540]

R-squared	0.034972	0.396236
Adj. R-squared	0.028882	0.392426
Sum sq. resids	0.155342	2.225674
S.E. equation	0.010437	0.039507
F-statistic	5.741953	103.9835
Log likelihood	4518.996	2607.546
Akaike AIC	-6.279939	-3.617752
Schwarz SC	-6.243242	-3.581056
Mean dependent	-3.15E-05	-1.13E-05
S.D. dependent	0.010591	0.050684

Determinant resid covariance (dof adj.)	1.58E-07
Determinant resid covariance	1.56E-07
Log likelihood	7178.257
Akaike information criterion	-9.966931
Schwarz criterion	-9.886199

ESTIMATE (INCLUDING P-VALUE)

System: UNTITLED

Estimation Method: Least Squares

Date: 08/01/17 Time: 22:54

Sample: 6 1459
Included observations: 1437

Total system (unbalanced) observations 2873

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.029517	0.013092	-2.254624	0.0242
C(2)	-0.004137	0.028524	-0.145032	0.8847
C(3)	0.025421	0.028068	0.905674	0.3652
C(4)	-0.014774	0.027030	-0.546581	0.5847
C(5)	0.018539	0.026061	0.711384	0.4769
C(6)	0.021587	0.011854	1.821155	0.0687
C(7)	0.015624	0.011053	1.413573	0.1576
C(8)	-0.000183	0.009685	-0.018857	0.9850

	Coefficient	Std. Error	t-Statistic	Prob.
C(9)	0.003028	0.007318	0.413826	0.6790
C(10)	-2.58E-05	0.000275	-0.093893	0.9252
C(11)	0.543864	0.049600	10.96507	0.0000
C(12)	0.216940	0.108013	2.008456	0.0447
C(13)	0.144757	0.106302	1.361751	0.1734
C(14)	0.107856	0.102342	1.053874	0.2920
C(15)	-0.172118	0.098669	-1.744391	0.0812
C(16)	-0.325604	0.044905	-7.250945	0.0000
C(17)	-0.228212	0.041860	-5.451764	0.0000
C(18)	-0.156538	0.036672	-4.268545	0.0000
C(19)	-0.080397	0.027708	-2.901531	0.0037
C(20)	-2.65E-05	0.001043	-0.025401	0.9797
Determinant residual covariance		1.56E-07		

Equation: D(LOG_FUTURE) = C(1)*(LOG_FUTURE(-1) - 0.930942625224 *LOG_SPOT(-1) - 0.170470288291) + C(2)*D(LOG_FUTURE(-1)) + C(3)*D(LOG_FUTURE(-2)) + C(4)*D(LOG_FUTURE(-3)) + C(5) *D(LOG_FUTURE(-4)) + C(6)*D(LOG_SPOT(-1)) + C(7)*D(LOG_SPOT(-2)) + C(8)*D(LOG_SPOT(-3)) + C(9)*D(LOG_SPOT(-4)) + C(10)

Observations: 1437

R-squared	0.034979	Mean dependent var	-2.74E-05
Adjusted R-squared	0.028892	S.D. dependent var	0.010589
S.E. of regression	0.010435	Sum squared resid	0.155375
Durbin-Watson stat	1.954345		

Equation: D(LOG_SPOT) = C(11)*(LOG_FUTURE(-1) - 0.930942625224 *LOG_SPOT(-1) - 0.170470288291) + C(12)*D(LOG_FUTURE(-1)) + C(13)*D(LOG_FUTURE(-2)) + C(14)*D(LOG_FUTURE(-3)) + C(15) *D(LOG_FUTURE(-4)) + C(16)*D(LOG_SPOT(-1)) + C(17) *D(LOG_SPOT(-2)) + C(18)*D(LOG_SPOT(-3)) + C(19)*D(LOG_SPOT(– 4)) + C(20)

Observations: 1436

R-squared	0.396236	Mean dependent var	-1.13E-05
Adjusted R-squared	0.392426	S.D. dependent var	0.050684
S.E. of regression	0.039507	Sum squared resid	2.225674
Durbin-Watson stat	2.007725		

Conclusion

Our econometric analysis reveals the long run relationship between spot and future prices of the crude oil and natural gas in the commodity future market. We find that spot and future return i.e., log of spot and future prices of both crude oil and nature gas exhibit the presence of unit root at the level but first difference form of the variables, show the presence of stationarity. Our Johanson Trace test reveals that there is one co integrating relationship in between log of spot price and log of future price and Johanson Eigen Value test reveals that there is two co integrating relation among log spot price and log future price. Granger causality test reveals that there is two-way Granger Causality in between log spot price and log future price for the crude oil. Similarly there is also the presence of two way Granger causality in between log of Spot price and log of future price for the natural gas. Estimation of our error correction model indicates that for both the energy products, speed of adjustment coefficient is significant. There is bi directional error correction in for the series of log value of spot and future prices for both the energy products. This indicates that for the energy products, crude oil and natural gas when the co integrated series are in disequilibrium in the short run then both the series, spot price and future price adjust them in order to re-establish the equilibrium.

References

- Bhatia, S. (2007). Do the S&P CNX Nifty Index and Nifty futures really lead/lag? Error correction model: a co-integration approach. www.nseindia.com/content/research/comppaper183.pdf.
- Brooks, C. (2014). Introductory econometrics for finance. Cambridge University Press, New York.
- Chaihetphon, P. and Pavabutr, P. (2010). Price discovery in Indian gold futures market. J Econ Financ 34(4): 455-467
- Chan, K. (1992). A further analysis of the lead-lag relationship between the cash market and stock index futures market. Rev Financ Stud 5(1) : 123-152
- Figuerola-Ferretti, I. and Gonzalo, J. (2006). Price discovery in commodity markets: the case of metals. http://ssrn.com/abstract=891030.
- Garbade, K. D. and Silber, W.L. (1983). Price movements and price discovery in futures and cash markets. The Review of Economics and Statistics, 65: 289-297.
- Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross- Spectral Methods. Econometrica. 37(3): 424-438.

- Gupta, K. and Singh, B. (2007). An examination of price discovery and hedging efficiency of Indian equity futures market. In: 10th Indian Institute of Capital Markets conference paper. http://www.ssrn.com/abstract=962002
- Johansen, S. (1995). Likelihood Inference in Co integrated vector Autoregressive Models, Oxford University Press, New York.
- Karande, K. (2006). Astudy of castor seed futures market in India. Unpublished Doctoral Dissertation, Indira Gandhi Institute of development Research, Mumbai, India. http://www.ssrn.com/abstract=983342
- Karmakar, M. (2009). Price discoveries and Volatility spillovers in the S&P CNX Nifty future and its underlying index CNX Nifty. Vikalpa 34(2) : 41-56.
- Koontz, S. R., Garcia, P. and Hudson, M. A. (1990). Dominant-satellite relationship between live cattle cash and futures markets. J Futures Mark 10(20) : 123-136.
- Kumar, N. and Arora, S. (2011). Price discovery in precious metals market : a study of gold. Int J Finac Manag 1(1) : 49-58.
- Oellermann, M. C. and Farris, P. L. (1985). Futures or cash: Which market leads live beef cattle prices? J Futures Mark 5(4): 529-538.
- Quan, J. (1992). Two-step testing procedure for price discovery role of futures prices. J Futures Mark 12(2) :139-149.
- Raju, M .T. and Karande, K. (2003). Price discovery and Volatility on NSE futures market. Securities and Exchange Board of India Working Paper Series No.7. http://www.sebi.gov.in/cms/sebi_data/attachdocs/1293096997650.pdf.
- Wahab, M. and Lashgari, M. (1993). Price dynamics and error correction in stock index and stock index futures markets: a co-integration approach. J Futures Mark 13(7): 711-742.