Is Really Future Price and Spot Price of Crude Oil Co-integrated? An Empirical Evidence from India

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Abstract:

In current scenario, it is very important to understand how future price of crude oil behaving. Specially, in emerging market higher weight of inflation data was dependent on price of crude oil on spot market. This is due to economy is run on weak infrastructure facility that encounter huge cost to economy leads to affecting inflation. However, if there is some way for predicting future price or spot price tomorrow one can able to hedge the risk associate with price fluctuation in crude oil price. In past, there were studies that talk about relationship between spot price and future price of crude price and even many other commodities. However, in emerging market price of crude oil price not affected only by the its own fluctuation but also affected by the fluctuation in currency. Thus, here is first attempt to check co-integration between spot and future price of crude oil in rupee term in Indian context. Result found significant co-integration between spot and future price. So, final error correction model is proposed for prediction of future and spot price in rupee term and concluded.

Keywords: Spot Price, Future Price, Crude Oil Price, Emerging Market

1. Introduction:

In current scenario, it is very important to understand how future price of crude oil behaving. Specially, in emerging market higher weight of inflation data was dependent on price of crude oil on spot market. This is due to economy is run on weak infrastructure facility that encounter huge cost to economy leads to affecting inflation. However, if there is some way for predicting future price or spot price tomorrow one can able to hedge the risk associate with price fluctuation in crude oil price. In past, there were studies that talk about relationship between spot price and future price of crude price and even many other commodities. However, in emerging market price of crude oil not affected by its own fluctuation only but also affected by the fluctuation in the currency. Crude oil price in global market is more represented in dollar term rather than any other local currency. Hence, in emerging market price behaviour of crude oil should be different from the price behaviour in develop countries.

In same context, current study is trying for finding possible co integration between spot price and future price of crude oil in Indian context. In fact, current study also develop model for prediction of future price of crude oil in Indian rupee term that helps business firms to hedge their exposure to crude oil.

2. Literature Review:

The role of futures markets in providing an efficient price discovery mechanism has been an area of extensive empirical research. Several studies have dealt with the lead–lag relationships between spot and futures prices of commodities with the objective of investigating the issue of market efficiency.

Garbade and Silber (1983) first presented a model to examine the price discovery role of futures prices and the effect of arbitrage on price changes in spot and futures markets of commodities.

The Garbade–Silber model was applied to the feeder cattle market by Oellermann et al. (1989) and to the live hog commodity market by Schroeder and Goodwin (1991), while a similar study by Silvapulle and Moosa (1999) examined the oil market. Bopp and Sitzer (1987) tested the hypothesis that futures prices are good predictors of spot prices in the heating oil market, while, Serletis and Banack (1990), Cologni and Manera (2008)and Chen and Lin (2004)tested for market efficiency using cointegration analysis. Crowder and Hamed (1993)and Sadorsky (2000)also used cointegration to test the simple efficiency hypothesis and the arbitrage condition for crude oil futures. Finally, Schwarz and Szakmary (1994) examined the price discovery process in the markets of crude and heating oil.

Recent work has revealed that nonlinear structure indeed exists in spot and futures returns. So, in current study instead of restricting relationship in unidirectional both model showing impact of spot on future and impact of future on spot price of crude oil. Again, most of the study took dollar term pricing for crude oil for analysis, which may not work out in domestic context. Thus, this study is first attempt to create model of prediction for future and spot price in rupee term in Indian context.

3. Research Methodology:

3.1 Sample Frame and Sample Size

3.1.1 Exchange Selected:

This study considered Indian crude oil price from most efficient commodity exchange Multi Commodity Exchange of India Ltd (MCX) was selected for this study. MCX (BSE: 534091) is an independent commodity exchange based in India. It was established in 2003 and is based in Mumbai. The turnover of the exchange for the fiscal year 2014 was more than US$ 1.24 trillion, and in terms of contracts traded, it was in 2009 the world's sixth largest commodity exchange. MCX offers futures trading in bullion, ferrous and non-ferrous metals, energy, and a number of agricultural commodities (mentha oil, cardamom, potatoes, palm oil and others). In 2012, MCX has taken the third spot among the global commodity bourses in terms of the number of futures contracts traded. Based on the latest data from Futures Industry Association (FIA), during the period between January and June this year, about 127.8 million futures contracts were traded on MCX. MCX also organize many types of awareness program.

3.1.2Timeline Selected:

Now as discuses in earlier section, price of crude oil form MCX based on daily future and respective spot price were collected for 2 years of time span from 1st April, 2013 to 19th March, 2015. There are two main reasons for selection of two years in research analysis. One, this time line cover complete two financial year that helps to understand short term trend and behaviour of spot price and future price properly. Secondly, size of commodity future was seems stable since 2010 in Indian context specifically on MCX platform. Thus, it is appropriate to take last 2 years data to understand relationship between future and spot price commodities. At the same time, this time line provide enough observation data that can help for concluding co integration between future and spot price and also can be generalize. With these 2 years data line future price was taken for analysis and whenever spot price of commodity traded for more than one location, data of Mumbai spot price was considered. Mumbai is considered as hub for business and trading in India that's why spot price of Mumbai can be considered as representing of Indian spot price.

3.2 Data Analysis

For the purpose of data analysis collected data used to perform different statistical tests to answer the research problem. Now, for confirm relationship between spot and future price of crude oil author first checked whether data is stationary or not and if it found non-stationary it is transform in stationary data by nth integration I(n) of the series. These stationary series used to check co integration and model development. Thus, author performs following tests on data for analysis:

- ➢ Unit Root Test using ADF test (Augmented Dickey-Fuller test)
- ➢ Engle - Granger Co-integration Test
- ➢ Develop Spurious model using time-series data in OLS (Ordinary Least Square) Method that for calculation residual of relation (uhat)
- ➢ Develop final Error correction model for represent prediction model

4. Data Analysis, Interpretation and Implications:

As discussed in research methodology section, four steps are followed here for the data analysis using gretl trial version and interpretation of the same explained simultaneously.

4.1 Augmented Dickey-Fuller (ADF) test

Unit root is check for both future and spot price using greet trial version for the check that whether data were stationary or not. Here, null hypothesis and its interpretations were reported.

For the future price of crude oil unit root check as follow:

$(1-L)\ F_t = b0 + (a-1){*}y\ (-1) + \ldots + e$

Where, for check unit root of future price,

$H_0\ (1){:}\ a = 1$

Similarly, for spot price

For the spot price of crude oil unit root check as follow:

$(1-L)\ S_t = c0 + (d-1){*}y(-1) + \ldots + e$

Where, for check unit root of spot price,

$H_0\ (2){:}\ d = 1$

Result of ADF shows non-significant $p = 0.9901$ that confirms that future price data where non-stationary. Similar test done for spot price of crude oil and that also found non-significant $p = 0.9842$ that confirms that even spot price also non-stationary.

4.2 Engle-Granger Co-integration Test

As both data are shown non-stationary data set, relation through OLS method possibly creates spurious relationship. Thus, to avoid spurious relationship Engle-Granger Co-integration test run between spot and future price that allow to check unit root of data with their first lag, second lag and till it converts to stationary data. Then, data correlations were checked to understand co-integration between given data set. Here, at first lag model develop as follow:

$\Delta F_t = \alpha 1 + \beta 1 \Delta S_t + u_t 1$...(4.1)

$\Delta S_t = \alpha 2 + \beta 2 \Delta S_t + u_t 2$...(4.2)

This ΔS_t and ΔF_t now representing stationary data as well $\beta 1$ and $\beta 2$ are also shows significant result. That even confirms by Engle-Granger Co-integration test with $p < 0.01$. Thus, this co-integration relationship further leads to development correction model that adjust short-term change for the long-term model representation.

4.3 Calculation for residual term

We can rewrite equation given by 4.1 and 4.2 to understand residual as follow:

$$u_t 1 = \Delta F_t - (\alpha 1 + \beta 1 \Delta S_t) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4.3)$$

$$u_t 2 = \Delta S_t - (\alpha 2 + \beta 2 \Delta S_t) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4.4)$$

Using gretl equation 4.1 and 4.2 were solved with OLS methodology and then from analysis residual calculation is save as new variable $u_t 1$ and $u_t 2$ for preparation of error correction model (ECM) as shown in next section.

4.4 Error Correction Model (ECM)

It is clearly shown in co-integration test that future and spot price of crude oil are co-integrated and based on that long-term model developed as equation 4.1 and 4.2. However, short-term prediction required correction. Thus, residual of long-term capture relationship of variable for the short-term prediction as follow:

$$\Delta F_t = \gamma_{01} + \gamma_{11} \Delta S_t + \gamma_{21} u_{t-1} 1 + \varepsilon_1 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4.5)$$

$$\Delta S_t = \gamma_{02} + \gamma_{12} \Delta F_t + \gamma_{22} u_{t-1} 2 + \varepsilon_2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(4.6)$$

Table 4.1: Result of Error Correction Model for Future Price of Crude Oil

Value of Coefficient	t-statics	p-value
γ_{01} = -3.87	-1.10	0.2730
γ_{11} = 0.22	3.88	0.0001
γ_{21} = -0.24	-4.00	0.0000
R-squared		0.0335
Adj. R-square		0.0298
F-value		9.0717
p-value for F-statics		0.0001

Table 4.1 is indicating strong relationship between future price and spot price. In fact, result shows impact of first difference of spot price and lag residual significantly ($p<0.01$). This result can be used for prediction of future price where it is clearly shown 1 unit change in change of spot price leads to 0.22 point change in change of future price. In addition, 1 unit of residual in prediction of future leads to decrease change of future by 0.24 units.

Table 4.2: Result of Error Correction Model for Spot Price of Crude Oil

Value of Coefficient	t-statics	p-value
γ_{02} = -4.44	-1.19	0.2357
γ_{12} = 0.07	1.57	0.1162
γ_{22} = -0.14	-3.258	0.0012
R-squared		0.0238
Adj. R-square		0.0200
F-value		6.3809
p-value for F-statics		0.0018

Table 4.2 is indicating no impact of spot price on future price. In fact, result shows impact of first difference of spot price and lag residuals are non-significant (p>0.05). This result can be easily interpretable as future price is derived from spot price, future price is depending upon spot price but spot price is not depend upon future. Hence, equation 4.5 can be use for prediction of future price but equation 4.6 is meaningless for understanding spot price behaviour pattern.

5. Conclusion:

This study can be concluded with future price of crude oil price in Indian context depends on spot price of crude oil. In fact, interestingly with increase in change spot price, change in future price is also increase and with decrease in spot price, change in future price decreases. However, this clear-cut relationship is remaining unchanged even in long run. Therefore, for correction in short run error of prediction in previous period was adjusted by introducing lag variable of error term. Final ECM proposed in study helps for prediction of future price based on spot price in market and hence help business firm to hedge their risk associated with crude oil in India.

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