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Price Discovery and Volatility Spillover Effect in Indian Commodity Market

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I

INTRODUCTION

Commodities are considered as separate asset class. To obtain economic exposure to commodity asset, commodity derivatives is a very useful tool. Commodity derivatives is a futures, forward, swap and option. Among these, futures contract helps to gain exposure to commodity price. A futures contract is a contract to buy or sell a pre-determined amount of certain standardised commodity at a pre-determined futures date at a pre-agreed price. Futures markets perform several economic functions. They include hedging, price discovery, financing, liquidity and price stabilisation.

The existence of price discovery and volatility spillover associated with spot and futures market has been important since the genesis of futures market. Price discovery is the process by which market attempts to reach equilibrium price. In a static sense price discovery implies the existence of equilibrium price. In a dynamic sense, the price discovery process describes how information is produced and transmitted across the market. Price discovery is a major function of commodity futures market. Information on price discovery is essential since these markets are widely used by firms engaged in the production, marketing and processing of commodities. It is generally argued that price discovery in commodity futures market is more efficient than that in spot market.

A well organised spot market also performs the price discovery function, but only in respect of the spot price. Futures prices provide an expression of the consensus of today's expectation about some point in the futures. The process of price discovery also facilitates the intertemporal inventory allocation function by which market participants are able to compare the current and futures prices and decide the optimal allocation of their stocks between immediate sale and storage for futures sale. Unlike the physical market a futures market facilitates offsetting the traders without exchanging physical goods until the expiry of a contract. As a result, futures market attracts hedgers for risk management and encourages considerable external competition from those who possess market information and price judgment to trade

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as traders in these commodities. While hedgers have long term perspective of the market, the traders or arbitragers prefer an immediate view of the market. However all these users participate in buying and selling of commodities based on various domestic and global parameters such as price, demand and supply, weather and market related information, these factors together result in efficient price discovery.

The studies of price discovery and volatility spillover are of two types. The first one is the price discovery and volatility spillover within the market and second one is the price discovery and volatility spillover across the market. In the first case price discovery and volatility spillover is studied in a futures market and its corresponding spot market. In the second case we study price discovery and volatility spillover by taking two futures markets for the same commodity, considering one futures market as spot market. Such a study would reveal which futures market dominates the other in terms of price discovery and volatility spillover. This study is focused on the first case, i.e., price discovery and volatility spillover within the market (futures-spot).

The issue of price discovery and the volatility spillover is of interest to traders, financial economists and analysts. Although futures and spot markets react to same information, the major question is which market reacts first and from which market volatility spills over to other markets. This paper many research studies on the price discovery and volatility spillover have been reviewed in the international and Indian context.

Garbade and Silber (1983) applied their framework to seven commodities (wheat, corn, oats, orange juice, copper, gold and silver). They specified and estimated a model which described the interrelationship between cash market prices and futures prices of storable commodities. They found that futures market dominated spot market, the spot market also played a role in price discovery. There was reverse information flow from spot to futures market as well. They also found that market size and liquidity played a positive role in the price discovery function.

Zapata and Fortenbery (1996) studied the temporal relationship between Chicago corn and soybean cash prices and nearby futures prices. For the purpose of analysis they used daily closing price for corn and soybean futures contract and cash prices and also they included U.S treasury bill rate. The study period covered from 1980 to 1989. They conducted cointegration test in two ways; the first test for contegration between the cash price, futures price and interest rate. Second cointegration is done on the basis of crop year's. Philips-Perron test suggested cash and futures prices are non-stationary of order one, the T-bill rate is non-stationary of order one at 5 per cent significance level for the aggregate crop period and in all individual crop years except three years: it is non-stationary at 10 per cent significance level. The cointegration test shows strong cointegration between corn and soybean cash prices, futures prices and T-bill rates. This suggests that interest rates are indeed critical in describing basic behaviour in both corn and soybean markets. They have used both bivariate and trivariate cointegration test for individual crop years. The bivariate test detected cointegration only for four years, not for other years. When there is bivariate cointegration in years it takes about two days for cash and futures to return back to equilibrium. This study showed the role of interest rate in determining dynamic relationship between cash and futures prices for storable commodities.

Yang *et al.* (2001) examined the price discovery for storable and non-storable commodities in the long run allowing for the compounding stochastic interest rate. The data for their study comprised cash and nearby futures prices for storable commodities, which included corn, oat, soybeans, three major types of wheat, cotton and pork bellies. Non-storable commodities included hog, live cattle and feeder cattle. The study period covered six and half years from January 1, 1992 to June 30,1998. Augmented Dickey Fuller Test and Philip-Perron test were used to examine the stationarity of the data. Both tests considered cases with trend and without trend. This study is contrary to the previous studies done by Fortenbery and Zapata (1993) and Covey and Bessler (1995), because this study shows that cointegration between cash and futures prices for non-storable commodities occurred as frequently as for storable commodities. That means asset storability does not affect the existence of cointegration. After the existence of cointegration was detected at 5 per cent levels, the likelihood ratio test were done. The result shows that futures prices are more likely to be an unbiased estimate of cash prices in the long run for most storable commodities than for most non-storable commodities. This study is a clear evidence of price discovery which may work to a certain extent on non-storable commodity futures markets in the long run, although not as well as on storable commodity futures markets. Moreover, the findings suggest that the forward pricing role may be moderately effective but may not serve the price discovery function of futures markets as well as the storage facilitation role. This study challenges the previous empirical results because this study shows that asset storability does not affect the existence of long run relationship between cash and futures prices. There is scope for further studies in this area since this study shows that price discovery performance for storable commodities is somewhat better than that for non-storable commodities.

Thomas and Karande (2001) analysed price discovery in India's castor seed markets such as Ahmedabad and Bombay. Their observations were based on daily closing futures and spot prices, which are covered from May 1985 to December 1999. To study price discovery across futures and spot market they have used Garbade and Silber (G.S) model. This model treats the futures and spot prices as a bivariate random walk. They also used G.S model using both de-trended basis and seemingly unrelated regression approach. The interpretation of G.S model relationship between the futures and spot market remained the same in both estimation approaches. They estimated the G.S model separately for March, June, September and December contract and also they estimated pooled data which combines the four contracts. Their estimated G.S return equation between the futures market in Ahmedabad and Bombay shows that out of four contracts three seasonal contracts of Bombay futures prices leads the Ahmedabad futures prices and only in the March contract does the Ahmedabad futures prices lead even though Bombay has much smaller volume, there is a clear dominance of the Bombay futures price over Ahmedabad price for all contracts except for the contract maturing at the time of harvest. The explanation given by authors is prices of castor seeds are largely driven by the export demand. Since the port is in Bombay, and the exporters are located in Bombay, traders on the Bombay market have a lead in getting information that drives prices in the June, September and December contracts. This study shows that markets that trade exactly the same asset, in the same time zone, do react differently to information and also small market may lead the large market.

Ashe and Guttormsen (2001) examined the relationship between spot and futures prices. The test was carried out in a multivariate framework like Johansen test. The data set consisted of monthly observation of futures prices for gas oil market International Petroleum Exchange. As a proxy for the futures price, the contract closest to delivery was used. Because if they assumed risk neutral and rational factors, the futures price close to delivery should represent the expected spot price when delivery actually happened. Futures contracts with one month to expiration, three months to expiration and six months to expiration were used in this analysis. Augmented Dickey Fuller test showed stationary at the first difference. The maximum eigen value test as well as the trace test suggested that there were three cointegration vectors in the system and only one stochastic trend. So there must be spot prices and futures prices with different time to expiration are cointegrated and hence there is a long run relationship between the prices. The bivariate tests indicated that all the prices were bilaterally cointegrated. The test for exogenity suggested that the futures contract with longest time to expiration is the driving factor in the price generating process and that it is this contract that binds the price series together in the long-run. The result shows that Johansen cointegration test is more suitable to find out the lead-lag relationship between spot and futures prices. The finding of this study was that the futures price leads the spot price and the futures contracts with longer time to expiration lead futures contracts with shorter time to expiration.

Buguk *et al.* (2003) examined the extent to which volatility in primary input market of soybean and corn spillover into fed and fed animal catfish markets. They analysed price volatility spillover in the U.S catfish supply chain are based on monthly price data from 1980 to 2000 for catfish food, its ingredients, and farm and wholesale level catfish. First volatility in each market is examined individually to establish baseline price behaviour. Then contemporaneous volatilities are used as exogenous variables to examine volatility spillover. The Exponential Generalised Autoregressive Conditional Heteroskedasticity (EGARCH) model was used to test univariate volatility spillovers for prices in the supply chain. Strong price volatility spillover from feeding material (corn, soybeans, and menhaden) catfish was detected.

Kumar and Sunil (2004) investigated the price discovery on six Indian commodity exchanges for five commodities. The daily futures and comparable ready price data for three contracts, each for five sample commodities (castor seed, gur, cotton, pepper and groundnut) have been used to undertake econometric study. The data has been collected from primary as well as secondary sources. Primary data was based on a visit to two exchanges at Hapur and Muzaffarnagar in June 2003.The data relating to other exchanges has been sourced from various publications of exchanges and Forward Markets Commission. The Study used Ordinary Least Squares (OLS) method for estimating regression equations. The problem of serial correlation was diagnosed using Durbin-Watson and Cochrane-Orcutt iterative procedure. The unit root test has been performed by using Augmented Dickey-Fuller (ADF) test to check for stationary of data and co-integration test has been done using Augmented Dickey-Fuller (ADF) test to examine cointegration of spot and futures rates to check for efficiency of futures markets. The ADF test showed that the data are integrated in the first difference. The cointegration result showed that some variables are cointegrated and others are not cointegrated. The results revealed inability of futures market to fully incorporate information and confirmed inefficiency of futures market. The authors concluded that the Indian agricultural commodities futures markets are not yet matured and efficient.

Based on the above studies the objective of this paper is to examine the price discovery in Indian commodity futures and spot market and to examine whether the volatility spills over from futures to spot market or vice versa. The remaining part of the present study been arranged as follows: Section two deals the profile of six commodities which are taken for the present study and the data and the third section discusses about the methodology. The empirical analysis and interpretation is discussed in the fourth section. The fifth section gives the conclusions.

II

DATA AND THE PROFILE OF THE SIX COMMODITIES

The data consists of futures and spot price for gold, silver, crude oil, castorseed, jeera and sugar. The futures and spot price of castor seed, jeera and sugar were obtained from NCDEX. The data on gold, silver and crude oil were obtained from MCX. The futures price is taken from the nearby contract. The sample period used in the analysis varies for each commodity based on the availability of the data. In order to make comparison,we take into account prices as on similar data for the entire commodity by smoothing the data after adjusting holidays and non-trading dates. In doing so, we obtained the following numbers of observations.

- Gold - 01-01-2004 to 30-06-2008 (1284 observations).
- Silver - 23-09-2004 to 06-09-2008 (1207 observations).
- Crude oil - 19-02-2005 to 06-09-2008 (1095 observations).
- Castor seed - 01-10-2004 to 22-07-2008 (983 observations).
- Jeera - 01-03-2005 to 20-05-2008 (916 observations).
- Sugar - 01-08-2005 to 18-01 2008 (713 observations).

The rationale for selecting these six commodities is as follows: the total turnover from the gold, silver, crude oil, jeera futures trading is increasing every year. Greater trading volume means high liquidity of the market. Sugar and its byproducts play a pivotal role in India's industrial economy and contribute around 2 per cent of gross domestic product (GDP). The statistics from NCDEX show the decreasing tendency in the sugar futures trading. In 2006 the trading volume was 8370 MT and trading value was 1670 crore rupees. But in 2007 it declined to 5400 MT and 812 crore rupees. India occupies first position in production and consumption of jeera in the world. It contributes about 80 per cent in the total world production. Exports as a percentage of production is also high close to 10 per cent. India exports nearly 80 per cent of castor seed production and is highly vulnerable to the world prices set by other trading countries. Hence, there is a need for futures contract to hedge their price risk. By the late 1990s, there were three exchanges - Ahmedabad, Bombay, Rajkot, which traded castor seeds and castor oil as the main commodity for forward contracts. This was very different from commodity markets all over the world, where there is a single exchange that typically pools the demand and supply for one commodity in one exchange; price discovery for the commodity is clearly centralised in one market. Now futures trading in castor seed is available in MCX, NCDEX and other commodity exchanges also. Trading volume and value are very important in the analysis of price discovery since the process of price discovery may be affected by low trading volume. For the better price discovery the information should be efficient. From this point of view we can go for the analysis of price discovery and volatility spillover.

III

METHODOLOGY

To test the process of price discovery and volatility spillover Augmented Dickey Fuller (ADF) test, Philip-Perron (PP) test, Johansen Cointegration test, Error Correction Model (ECM) and bivariate EGARCH model were used.

3.1 *The Test of Stationarity*

Various methods have been proposed in order to test for stationarity. These are based on the fact that a non-stationary series is characterised by unit root. The study has used Augmented Dickey and Fuller (1981) and Phillip and Perron (1988) tests. The result of unit root analysis proves that the spot and futures series are non-stationary at its level and stationary in its first difference. Therefore it can be concluded that the spot and futures prices follow I (1) process.

A test of stationarity is known as unit root test. A series Y_t is integrated of order one or contains a unit root, if Y_t is non-stationary, but ΔY_t is stationary. Dickey and Fuller (1981) devised a procedure to formally test for non-stationarity. The key insight of their test is that testing for non-stationarity which is equivalent to testing for the existence of a unit root. This is based on the following simple AR(1) model.

Here we need to examine whether φ is equal to one. So the null hypothesis is H0 = φ =1 and the alternative hypothesis is Ha = φ<1.

This can be obtained by more convenient version of the test by subtracting Δy_{t-1} from both sides of the equation (1)

$$Y_t - Y_{t-1} = \varphi Y_{t-1} - Y_{t-1} + e \quad \ldots.(1)$$
$$\Delta Y_{t-1} = \gamma Y_{t-1} + et \quad \ldots.(2)$$

Where γ =(φ-1).Then, null hypothesis is H0: γ=0 and the alternative hypothesis is Ha: γ<0 where if then Y_t follows random walk model.

3.2 *Augmented Dickey Fuller Test*

As the error term is unlikely to be white noise, Dickey and Fuller extended their test procedure suggesting an augmented version of the test which includes extra lagged terms of the dependent variable in order to eliminate autocorrelation. The lag length on these extra terms is either determined by Akaike Information Criterion (AIC) or Schartz Bayesian Criterion (SBC). The ADF equation can be written as

$$\Delta y_{t-1} = a0 + \gamma Y_{t-1} + \Sigma_{i=1}^{p} a1 \Delta y_{t-1} + ut \quad \ldots.(3)$$

This test assumes that there is at most one unit root and that the error term is a Gaussian white noise. The null hypothesis is that unit root exists. If the test statistics is smaller than the corresponding critical values, the null hypothesis may be rejected**.**

3.3 *Phillips – Perron Test*

Phillips and Perron (1988) developed a generalization of the ADF test procedure that allows for fairly mild assumption concerning the distribution of errors. The test of regression for the Philip-Perron test is AR(1) process.

$$\Delta y_{t-1} = \alpha_0 + \beta Yt - 1 + et \quad \ldots.(4)$$

The ADF test corrects for higher order serial correlation by adding lagged differenced terms on the right hand side, in PP test makes a correction to the t static of the coefficient γ from the AR (1) regression to account for the serial correlation in $e_{t.}$ In this test also the null hypothesis is that unit root exists. If the test statistics is smaller than the corresponding critical values, the null hypothesis may be rejected.

3.4 *Cointegration*

Before testing for cointegration, each individual price series should be examined for I (1) first. Augmented Dickey-Fuller (ADF) unit root tests are the common methods used here, i.e., the Augmented Dickey–Fuller (ADF) test constructs a parameter correction for higher- order correlation by assuming that the series follows an AR (P) process and adding lagged difference terms of the dependent variables to the right-hand side of the regression:

$$\Delta y_t = \alpha + \beta_t + (p-1)y_{t-1} + \theta_1 \Delta y_{t-1} + \theta_2 \Delta y_{t-2} + ... + \theta_{k-1} \Delta y_{t-k+1} + \omega_t \qquad ....(5)$$

Where Δ is the first difference, t a time trend variable, ω_t a white noise and k the lagged number.

If both the futures price and cash price is I (1), Johansen's cointegration test's can then be conducted.

Johansen (1988) suggested two test statistics to test the null hypothesis that there is at most r cointegrating vectors. The null hypothesis can be equivalently stated as the rank of the coefficient matrix: π, is at most r, for r=0,1,…..n-1.The two test statistics are based on trace and maximum eigen values, respectively.

$$\lambda_{trace} = -T\sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \qquad ....(6)$$

$$\lambda_{max} = T\ln(1-\hat{\lambda}_{r+1}) \qquad ....(7)$$

Where $\hat{\lambda}_i$ ….. $\hat{\lambda}_r$ are the r largest squared canonical correlations between the residuals obtained by regressing Δy_t and Δy_{t-1} on Δy_{t-1}, Δy_{t-2} ……. Δy_{t-k-1} and I respectively.

In our test for efficiency of futures market, $Y_t = (F_t, S_t)$, n=2, and the null hypothesis should be tested for r=0 and r=1.If r=0 cannot be rejected, we will conclude that there is no cointegration. On the other hand, if r=0 is rejected, and r=1 cannot be rejected, we will conclude that there is a cointegration relationship.

Inefficiency can be concluded if the futures price and the spot price are not cointegrated since cointegration is a necessary condition for market efficiency. If the futures price and spot market price are cointegrated, we can then test the restrictions on the parameter (1). Cointegration implies that there exist a cointegration vector β such that $\beta' Y_t^*$ is stationary, where in equation (1) $\beta' = (1,-b,-a)$ and $Y_t^* = (F_t, S_t, 1)$, so that $z_t = \beta' Y_t^*$,is stationary. Then, the hypothesis in market efficiency can be tested by imposing restrictions on the cointegrating vector β. We can then apply the standard likelihood ratio test in this case. Specifically, the test statistics can be expressed by the canonical correlations as (Johansen and Juselius, 1990):

$$LR = T\Sigma_{t=1}^{r}\left[\ln(1-\lambda_t^*) - \ln(1-\hat{\lambda_i})\right] \quad \text{….(8)}$$

Where $\lambda_1^*, \ldots\ldots \lambda_r^*$ are the r largest squared canonical correlations under the null hypothesis, the restricted model; and $\hat{\lambda_1} \ldots\ldots \hat{\lambda_i}$ are the r largest squared canonical correlations under the full or unrestricted model. The test statistics follows an asymptotic chi-square distribution with the degree of freedom equalling the number of restrictions imposed.

3.2 *Vector Error Correction Model (VECM)*

According to the cost-of-carry relationship, the (log) futures price F_t, the underlying spot price S_t, are cointegrated (that is, move together in the long run) with a common stochastic trend (Koutmos and Tucker, 1996), Hasbrouck (1995) describes this common stochastic trend as the common implicit efficient price in the cointegrating system. Hereafter, the futures price is described with F_t as the first variable and the spot price is described with S_t as the second variable in the system. The bivariate cointegrated series, $P_t = (F_t, S_t)$, is represented by a vector error correction model (VECM):

$$\Delta S_t = C_s + \sum_{i=1}^{k}\beta_{si}\Delta S_{t-i} + \sum_{i=1}^{k}\lambda_{si}F_{t-i} - \alpha_s Z_{t-1} + e_{stt} \quad \text{…. (9)}$$

$$\Delta F_t = C_f + \sum_{i=1}^{k}\beta_{ft}\Delta S_t + \sum \lambda_{ft}\Delta F_{t-i} - \alpha_f Z_{t-1} + e_{ft} \quad \text{.... (10)}$$

Where the co-efficient of α_s and α_f can be interpreted as speed of adjustment factors.

3.3 *Volatility Spillovers*

Substantial attention has been focused on how news from one market affects the volatility process of another market. Although the GARCH –type models are popular in modeling the volatility process in financial series, empirical results investigated provide evidence that EGARCH model can more accurately explain the volatility dynamics. Thus, we propose the following bivariate EGARCH (1,1) model to examine the volatility spillover mechanism.

$$\varepsilon_t = \begin{pmatrix} \varepsilon_{f,t} \\ \varepsilon_{s,t} \end{pmatrix} \Big| \Delta_{t-1} N(0, \Omega_t), \Omega_t = \{p_{ij} \sigma_{i,t} \sigma_{j,t}\} \qquad .... (11)$$

$$\ln\left(\sigma^2_{f,t}\right) = \omega_f + \varphi_f \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - \left| \sqrt{\frac{2}{\pi}} \right| + \tau_f \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \alpha_f \ln\left(\sigma^2_{2,t-1}\right) + \gamma_f \ln\left(\varepsilon^2_{s,t-1}\right) \qquad .... (12)$$

$$\ln\left(\sigma^2_{s,t}\right) \omega_f + \varphi_s \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - \left| \sqrt{\frac{2}{\pi}} \right| + \tau_s \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \alpha_s \ln\left(\sigma^2_{s,t-1}\right) + \gamma_s \ln\left(\varepsilon^2_{f,t-1}\right) \qquad ....(13)$$

The uncorrelated residuals, $\varepsilon_{f,t}$ and $\varepsilon_{s,t}$ in equation (7) are obtained from the VECM and Ω_{t-1} is the information set at t-1.

These two approaches are asymptotically equivalent to a joint estimation of the VECM and EGARCH models. Estimating these two models are simultaneously not practical because of the large number of parameters involved.

IV

EMPIRICAL ANALYSIS AND RESULTS

Using the above discussed tools we analysed the futures and spot price data of selected commodities. The results and interpretation are given below.

Each of the logarithmic price series were examined for I(1) in MCX and NCDEX commodity futures market. The ADF and PP test were performed to test the stationary of the data. The results of both the tests with trend and without trend

TABLE 1. THE STATISTICS OF ADF UNIT ROOT TEST

		Commodities					
		Gold	Silver	Crude Oil	Castor Seed	Jeera	Sugar
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
With intercept and Trend	S_t	-2.29071	-2.088520	-1.759590	-1.874169	-1.462662	-1.456289
	ΔS_t	-34.76791*	18.39985*	-32.83074*	-29.78691*	-11.89655*	-11.70627*
	Critical values of 1 per cent	-3.965220	-3.965693	-3.966466	-3.967440	-3.968155	-3.971067
	F_t	-2.251966	-1.923830	-2.034234	-2.370013	-1.976311	-1.710294
	ΔF_t	-35.22100*	-36.21389*	-25.06447*	-30.11400*	-22.34668*	17.39942*
	Critical values of 1 per cent	-3.965220	-3.965680	-3.966473	-3.967440	-3.968133	-3.971067
With intercept	S_t	0.284760	-1.502844	-1.145928	1.265924	-0.732395	-0.795233
	ΔS_t	-34.74736*	-18.39079*	-32.84587*	-29.49989*	-11.89885*	-11.71450*
	Critical values of 1 per cent	-3.435239	-3.435572	-3.436116	-3.436803	-3.437306	-3.439358
	F_t	0.325603	-1.482597	-1.158540	0.694040	-0.979680	-0.546288
	ΔF_t	-35.19701*	-36.21025*	-25.07600*	-29.92833*	-22.34653*	-17.40248*
	Critical values of 1 per cent	-3.435239	-3.435563	-3.436122	-3.436803	-3.437290	-3.439358

*indicates 1 per cent level of significance.

TABLE 2. THE STATISTICS OF PP UNIT ROOT TEST

		Commodities					
		Gold	Silver	Crude Oil	Castor Seed	Jeera	Sugar
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
With intercept and Trend	S_t	-2.363652	-1.964233	-1.742780	-1.711620	-1.264060	-1.333002
	ΔS_t	-34.77636*	-37.23330*	-32.83362*	-29.76581*	-25.83535*	-21.00271*
	Critical values of 1 per cent	-3.965220	-3.965680	-3.966466	-3.967440	-3.968122	-3.971012
	F_t	-2.332681	-1.881982	-1.932107	-2.378479	-1.939498	-2.014440
	ΔF_t	-35.24724*	36.19981*	-33.89373*	-30.09976*	-29.18915*	-28.17281*
	Critical values of 1 per cent	-3.965220	-3.965680	-3.966466	-3.967440	-3.968122	-3.971012
With intercept	S_t	0.231334	-1.493058	-1.132310	1.330869	-0.597831	-0.719876
	ΔS_t	-34.75723*	-37.23015*	-32.84908*	-29.48994*	-25.84552*	-21.01645*
	Critical values of 1 per cent	-3.435239	-3.435563	-3.436116	-3.436803	-3.437283	-3.439319
	F_t	0.258038	-1.498680	-1.289644	0.636177	-1.003265	-0.783177
	ΔF_t	-35.22540*	-36.19541*	-33.90976*	-29.92052*	-29.19440*	-28.18841*
	Critical values of 1 per cent	-3.435239	-3.435563	-3.436116	-3.436803	-3.437283	-3.439319

*indicates 1 per cent level of significance.

suggest the existence of unit root in each of the price series in Tables 1 and 2. Further tests indicate that all price series data are stationary in their first difference.

In the above two Tables (Table 1 and 2) F_t and S_t represents logarithmic spot and futures price at their level, ΔS_t and ΔF_t represents logarithmic spot and futures price at their first difference. In both the cases (with intercept and trend and intercept only) the test statistics are smaller than the corresponding critical value. So we rejected the null hypothesis. But further test indicate that all the price series data are stationary after the first order difference. Therefore we conclude that each of the logarithmic price series is I (1) in MCX and NCDEX commodity futures market.

The conformation that each series is I (1) allows us to proceed to Johansen cointegration test. In the Johansen cointegration test the issue of finding appropriate lag length is very important to know the Gaussian error terms. Setting the value of the lag length is affected by the omission of the variables that might affect only the short run behaviour of the model. This is due to the fact that the omitted variables instantly become part of the error term. Therefore a very careful inspection of the data and the functional relationship is necessary. Therefore we proceed with estimation in order to decide whether to include additional variables. We can use AIC and SBC criteria to select the optimum lag. The model that minimize AIC and SBC is selected as the one with the optimal lag length.

Here, according to Akaike information criterion (AIC) and Schwarz based criteria (SBC) the optimal lag for gold, silver and sugar is two and the optimal lag length for crude oil, castor seed and jeera is five. The results of Johansen's cointegration relationship between the logarithmic futures price and logarithmic spot price for Gold, silver, crude oil, castor seed, jeera and sugar are shown in Table 3 and 4.

TABLE 3. THE STATISTICS OF JOHANSEN'S COINTEGRATION TEST

Commodities (1)	(2)	t-statistics λ trace (3)	t-statistics λ max (4)	Critical values of 5 per cent λ trace (5)	Critical values of 5 per cent λ max (6)	Critical values of 1 per cent λ trace (7)	Critical values of 1 per cent λ max (8)
	H_0 :r=0	99.70440	92.39126	25.32	18.96	30.45	23.65
Gold	H_0 :r=1	7.313132	7.313132	12.25	12.25	16.26	16.26
	H_0 :r=0	107.8290	10306072	25.32	18.96	30.45	23.65
Silver	H_0 :r=1	4.221784	4.221784	12.25	12.25	16.26	16.26
	H_0 :r=0	84.43838	81.77962	25.32	18.96	30.45	23.65
Crude oil	H_0 :r=1	2.658755	2.658755	12.25	12.25	16.26	16.26

TABLE 4.THE STATISTICS OF JOHANSEN'S COINTEGRATION TEST

Commodities (1)	(2)	t-statistics λ trace (3)	t-statistics λ max (4)	Critical values of 5 per cent λ trace (5)	Critical values of 5 per cent λ max (6)	Critical values of 1 per cent λ trace (7)	Critical values of 1 per cent λ max (8)
	H_0 :r=0	60.36782	46.2090	25.32	18.96	30.45	23.65
Castor Seed	H_0 :r=1	14.16491	14.16491	12.25	12.25	16.26	16.26
	H_0 :r=0	35.52483	31.24143	25.32	18.96	30.45	23.65
Jeera	H_0 :r=1	4.283394	4.283394	12.25	12.25	16.26	16.26
	H_0 :r=0	17.88664	17.47693	15.41	14.07	20.04	18.63
Sugar	H_0 :r=1	0.409705	0.409705	3.76	3.76	6.65	6.65

The Johansen's test statistics of the null hypothesis is that there are at most (0≤r≤k) cointegrating vectors and thus (n-r) common stochastic trend. In the above results we reject the hypothesis H0:r=0 at 1 per cent and 5 per cent level for gold, silver, crude oil, castor seed and jeera. In case of sugar we rejected the hypothesis H0:r=0 at 5 per cent critical values and accept at 1 per cent significance level. Here in case of castor seed we reject the hypothesis H0: r=1 at 5 per cent significance level and accept at 1 per cent significance level. Here in case of gold, silver, crude oil and jeera, trace test and Max-eigen value test indicates there is 1 cointegrating equation at both 5 and 1 per cent level. In case of castor seed trace test and Max-eigen value test indicate that there are two cointegrating equation at both 5 per cent level and 1 cointegrating equation at 1 per cent level. In case of castor sugar trace test and Max-eigen value test indicate that there is 1 cointegrating equation at both 5 per cent level and no cointegrating equation at 1 per cent level. So this empirical result is clear evidence for cointegrating relationship in MCX and NCDEX spot futures market. That means there is price discovery process in the spot and futures market (cointegration of spot and futures price is necessary condition for price discovery).

Now we determine the number of cointegrating vector for each commodity, thus we can proceed with the estimation of Error Correction Model. To determine the appropriate lag length we performed ECM with different lag length (from ten to one).The optimum lag is two for gold, silver and sugar. The optimum lag length for other commodities is five.

TABLE 5. ECM RESULT FOR GOLD, SILVER AND SUGAR

	Gold		Silver		Sugar	
	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t
(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta\alpha_i$ i = S, F	0.000490	0.000289	0.000327	0.000529	-0.000432	-0.000162
	(1.90027)	(1.48234)	(0.97800)	(1.06729)	(-0.83645)	(-0.80788)
ΔF_{t-1}	-0.003197	0.678985	-0.291800	-0.007812	-0.026977	0.017122
	(-0.07604)	(21.3173)	(-8.80709)	(-0.15892)	(-0.71882)	(1.17426)
ΔF_{t-2}	-0.124580	0.128690	-0.037985	0.118588	-0.106096	-0.006844
	(-2.75074)	(3.75012)	(-1.70008)	(3.57750)	(-2.84058)	(-0.47162)
ΔS_{t-1}	0.137592	-0.255055	0.528146	-0.042738	0.202068	0.225787
	(2.94042)	-(7.19364)	(17.4960)	(-0.95429)	(2.08883)	(6.00734)
ΔS_{t-2}	0.098376	-0.046518	0.175964	-0.050566	-0.050858	0.113560)
	(3.09469)	(-1.93129)	(5.79613)	(-1.12267)	(-0.52417)	(3.01244
$\Delta\alpha_i$ i = S, F	0.182253	-0.073974	0.250576	-0.232185	0.007841	0.045814
	(6.81950)	(-2.09730)	(2.03096)	(-8.75234)	(1.67293)	(3.79784)

Note: Figures in parentheses show t statistics.

TABLE 6. ECM STATISTICS FOR CRUDE OIL, CASTOR SEED AND JEERA

	Crude oil		Castor seed		Jeera	
	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔF_{t-5}	0.29601	-0.022030	-0.003446	0.025771	-0.052449	0.008713
	(1.48510)	(-0.77447)	(-0.07948)	(0.76632)	(-1.27915)	(0.50193)
ΔS_{t-1}	0.668311	0.001116	0.076393	-0.192984	0.178653	-0.015663
	(17.8246)	(0.02085)	(1.38353)	(-4.50558)	(1.95452)	(-0.40476)
ΔS_{t-2}	0.219025	-0.065127	-0.005748	-0.089489	0.143256	0.063141
	(5.19493)	(-1.08244)	(-0.10156)	(-2.03833)	(1.56891)	(1.63334)
ΔS_{t-3}	0.060127	-0.060537	0.073511	0.0200099	0.264177	0.100582
	(1.43987)	(-1.01585)	(1.29555)	(0.45663)	(2.90893)	(2.61602)
ΔS_{t-4}	0.009185	-0.002201	0.038256	0.017320	0.184182	0.023017
	(0.22867)	(-0.03839)	(0.681321)	(0.39764)	(2.02221)	0.59691)
ΔS_{t-5}	0.005699	-0.058976	-0.011960	0.014106	0.050752	-0.022175
	(0.15667)	(-1.13615)	(-0.23543)	(0.35794)	(0.59886)	(-0.61805)
$\Delta\alpha_i$ i = S, F	0.280440	-0.002326	0.111046	-0.014274	0.035821	-0.023514
	(8.79808)	(-0.05114)	(4.69400)	(-0.77780)	(2.00551)	(-3.28003)

Note: Figures in parentheses show t statistics.

The above Tables 5 and 6 explain the parameter α is the speed of adjustment coefficient. The ECM indicate that there exist a feedback effect between the cash and futures markets but that the lead of the futures market on the spot market is much stronger than the reverse. But in case of sugar, spot market leads the futures market. Inspection of the estimates of the adjustment factor coefficients, the element of the vector, indicates that each market adjusts to the new equilibrium price following a price discrepancy, with a clear dominance of the spot market. The information is first aggregated in the futures price than disseminating to the spot market, except in sugar.

The empirical evidence suggests that although the two markets contribute to the price discovery, the major part of the price discovery is achieved in the spot market in case of sugar. The arrival and aggregation of new information into price is achieved primarily through futures trading and the spot market adjusts quickly to the new equilibrium price. In short, when the cost of carry relationship is perturbed the futures market will lead the spot market in the price discovery process.

In case of sugar, the spot market plays an important role. The possible explanation for this can be low trading volume in the futures market. Compared to other commodities the total trading volume in the sugar market is very low. The volume of contracts traded on the NCDEX varies by the commodity. The trading volume of the sugar contract is very low. For example in 2006 the total volume in jeera futures market was 3751380 at the same time the total volume in sugar futures market is only 8370.It is usually assumed that low trading volume market are inefficient. Low trading volume implies a relatively small amount of information. This poor flow of information might affect the price discovery function.

4.1 *Volatility Spillover*

The literature on volatility spillover indicate that the study of volatility spillover can be of two types. The first one is the study of volatility spillover on return series, or errors from modeling return series, and how return is related within market. The second one is directly to examine volatility. This study used the second method; we are not taking return series. That means we examined directly the volatility spillover between futures and spot market for six commodities in Indian commodity market. From the ECM it was noted that futures market plays an important role in price discovery. The volatility spillover is examined by applying EGARCH model.

TABLE 7. THE EGARCH RESULT FOR GOLD, SILVER AND CRUDE OIL

	Commodities					
	Gold		Silver		Crude Oil	
	Futures	Spot	Futures	Spot	Futures	Spot
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ω_i	2.232859	-2.188478	-3.213416	-3.649309	3.402943	3.191344
	4.437792	-4.365493	-4.557984	-4.846492	4.386211	4.334240
ψ_i	0.340755	0.340881	0.532620	0.544684	0.399374	0.394816
	9.896736	9.992797	12.82787	12.32001	6.991940	7.011796
τ_i	-0.024208	0.021690	0.033126	0.034251	-0.031174	0.030658
	-1.491873	1.352823	1.471068	1.460294	-1.051779	1.049928
α_i	0.912586	0.913988	0.859784	0.845362	0.673765	0.683918
	49.45095	49.76590	33.41260	31.23024	10.96208	11.40523
γ_i	0.1222408	0.125833	0.168402	0.200569	0.044516	0.060946
	2.922604	3.019579	2.925983	3.272076	0.688447	0.915268

Note: The symbols of the Bivariate EGARCH model is explained in equation 12 and 13 of the text.

TABLE 8. THE EGARCH RESULT FOR CASTOR SEED, JEERA AND SUGAR

	Commodities					
	Castor Seed		Jeera		Sugar	
	Futures	Spot	Futures	Spot	Futures	Spot
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ω_i	2.099883	1.323003	-4.261627	-4.053619	2.227796	0.480030
	3.051452	1.803960	-2.909069	-2.976835	0.888872	0.269593
ψ_i	0.826588	0.941644	1.294217	1.200429	1.476880	1.475737
	8.915494	10.30001	9.536536	10.14408	16.30693	22.20430
τ_i	0.125167	0.121748	0.051011	0.081958	0.140632	0.021086
	2.672818	2.464470	0.685798	1.282245	2.922578	0.421181
α_i	0.799446	0.751855	0.797878	0.831671	0.846976	0.837231
	23.31065	24.43313	18.52568	22.50050	35.43750	34.06511
γ_i	0.057258	0.273248	0.192738	0.200589	0.413135	0.033233
	0.492561	2.074517	1.337545	1.387935	1.656251	0.097595

Note: The symbols of the Bivariate EGARCH model is explained in equation 12 and 13 of the text.

In the bivariate EGARCH (1, 1) results the coefficients γ_s and γ_f are very important. The coefficients γ_s and γ_f describe the volatility spillover from the spot to futures or futures to spot. This result supports the price discovery result, here volatility spillover from futures to spot except in the case of sugar. In case of sugar, the volatility spillover from spot to futures. In the above tables (Tables 8 and 9) the corresponding volatility spillover coefficient are all significant, because γ_s is larger than the γ_f in any futures market. Moreover the futures market plays more important role in price discovery, except for sugar. For sugar spot market plays a more important role in the process of price discovery and also volatility spillover from spot to futures. The bivariate EGARCH model indicates that past innovation in futures significantly influence spot volatility, except in sugar, volatility spillover spot to futures are much weaker. In arbitrage free economy, volatility of prices is directly related to the flow of information. If futures market increases the flow of information, volatility in the underlying spot market will rise. The variance of price change is equal to the rate or variance. The implication is that volatility of the asset price will rise as the rate of information flow increases. It follows therefore that if futures market increases the flow of information, volatility of the spot price must change. Our result proves this theory, except in the sugar futures trading. The sugar futures trading does not follow this theory, perhaps due to low trading volume and also our sugar observation is very low (713 observations).

In brief, the finding of the study is futures market plays a crucial role in the price discovery. In the process of price discovery futures market leads the spot market. But in the case of sugar, spot market leads the futures market. This may be due to low level of trading volume in the sugar futures market. So the authorities should take suitable action to solve this problem. Secondly volatility spillover from futures to spot. This result supports the price discovery result. Only in the sugar contract the volatility spillover from spot to futures.

V

CONCLUSIONS

The existence of price discovery and volatility spillover associated with spot and futures market has been an important topic since the genesis of futures market. Price discovery is the process by which markets attempt to reach equilibrium price. Price discovery is a major function of commodity futures market. Information on price discovery is essential since these markets are widely used by firms engaged in the production, marketing and processing of commodities. Production and consumption decision depends on efficient price signal from the market. It is generally argued that price discovery in commodity futures market is more efficient than that in cash market. Futures market is able to perform the price discovery function for two reasons. Firstly, futures price are collective expectation of market agents about prospective demand and supply of commodities at maturity of futures contract. Traders make decisions to buy or sell futures contract on the basis of difference in expectation about futures demand and supply conditions at maturity. Secondly, futures trading is paper trading; therefore prices tend to be very sensitive to new information, the transaction cost of futures trading is low and also it provides greater liquidity. The study of volatility interdependence provides useful insights into how information is transmitted and disseminated between futures and spot market. In arbitrage free economy, volatility of prices is directly related to the flow of information. If futures market increase the flow of information, volatility in the underlying spot market will rise. The variance of price changes is equal to the rate of variance. The implication is that volatility of asset price will rise as the rate of information flow increases. It follows therefore that if futures market increases the flow of information, volatility of spot price must change. Our results prove this theory, except in the sugar futures trading. The sugar futures trading do not follow this theory, perhaps due to low trading volume. It is usually assumed that low trading volume markets are inefficient. Low trading volume implies a relatively small amount of information. This poor flow of information might affect the price discovery function and volatility spillover of sugar futures market.

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