I J A B E R, Vol. 14, No. 6, (2016): 4573-4586

PRICE DISCOVERY AND SPILL-OVER IMPACT IN THE INDIAN COMMODITY FUTURES MARKET: AN EMPIRICAL INVESTIGATION INTO METAL FUTURES

Chinmaya Behera*

Abstract: *Price discovery and risk management are two major important economic functions of futures market. Price discovery gives competitive reference (futures) price from which spot price can be derived. The study examines price discovery and spill-over impact in the Indian futures market using metal and energy futures. Sample data consist of daily futures and spot closing price from 1st June, 2005 to 29th January 2016 for gold, silver and copper. Using co-integration and error correction mechanism, the study finds the fair price discovery in the futures market. The study also finds that price discovery takes place first in the futures market then transgresses to spot market. Ratio of standard deviation is used to check the market efficiency in the futures market and it is found that gold market is not efficient as it fails to incorporate all the information available in the market. Using BEKK model volatility spill-over impact is observed to be statistically significant in all the commodity spot and futures returns. Bi-directional shocks transmission can be observed across the commodities like gold, silver and copper which means shocks in the futures market do have impact on spot market volatility for gold, silver and copper.*

Keywords: *Futures pricing, efficient market, long memory.*

JEL Classification: G13.

A. INTRODUCTION

Price discovery is one of the important economic functions of futures market and it is widely accepted that price discovery takes place first in the futures market then transfers to the spot market due to inherent leverage, low transaction cost, and lack of short sell restrictions (Tse, 1999). The essence of price discovery is to establish a competitive reference (futures) price from which the spot price can be derived. It depends on whether information is reflected first in changed futures price or in changed spot price. Quan (1992) finds that price discovery takes place

* Assistant Professor, Economics and Finance, GITAM School of International Business, Visakhapatnam-530045 (AP). *E-mail: chinmayaeco@gmail.com*

in spot market and gets transmitted to futures market. In contrast Garbade and Silber (1983) conclude that futures market plays a major role in the price discovery and spot market has role in price discovery too. The dearth of conclusive statement on price discovery creates scope for the further examination.

Efficient futures market needs to incorporate all the information available in the market during price determination. Day-to-day variations in spot and futures prices are purely a result of new information that is arriving in the market. The extent of variation in both spot and futures markets should be similar for the storable commodities. If the spot market is efficient, the relative magnitude of variation in prices can help assess whether the futures market is able to incorporate information efficiently. The behaviour of investors causes failure to efficient market hypotheses. The study examines market efficiency in the context of Indian market.

Commodity futures market is prone to risk as speculative activities and macroeconomic imbalances distort price determination process. Moreover, dynamism in futures market is a matter of concern for the investors and policy makers. The degree of risk or volatility varies over time and tends to cluster in periods of large volatility and dampen in periods of tranquillity which behaviour results in heteroskedasticity. The possible factors of high volatility may be due to supply and demand conditions, speculative trade, weather events, international price pressure, regulatory practices and the government policy changes. Higher volatility may induce investors to increase trading in futures because futures contracts constitute a convenient means to adjust their investment positions (Chen, Cuny and Haugen, 1995). It is widely acknowledged that the futures markets are more volatile than spot markets, providing additional concern to market regulators for potential transmission of volatility from the futures to spot market. The futures market volatility can be used as a leading indicator of spot market volatility. This suggests that futures market volatility can be used to forecast changes in spot market volatility based on readily available low-cost historical information (Bhattacharya, Ramjee and Balasubramani, 1986).

It is widely accepted that volatilities move together more or less closely over time across the assets or markets. Even there has been evidence that shocks in one market affect other markets also which is called the spill-over effect. In that case, uni-variate analysis may not be useful for the investors as well as policy makers. Baillie and Mayers (1991) examine six different commodities using daily data over two futures contract and they find spill-over effect among the commodities. This study makes an attempt to examine the Indian commodity futures market dynamics in the context of metal and energy in India. Specifically, the study examines spill-over effect of these markets on their spot markets.

Tse (1999) examines volatility spill-over between the DJIA index and the index futures. Using bi-variate EGARCH model, he finds a significant bi-directional information flow *i.e.*, innovations in one market can predict the future volatility in another market, but the futures market volatility spillovers to the spot market is more than vice versa. Both markets also exhibit asymmetric volatility effects, with bad news having a greater impact on volatility than good news of similar magnitude. Baillie and Mayers (1991) study six different commodities using daily data over two futures contract. They use Bi-variate GARCH models of spot and futures prices of commodities. The optimal hedge ratio (OHR) is then calculated as ratio of the conditional covariance between spot and futures to the conditional variance of futures. From the OHR results, they find that standard assumption of time- invariant OHR is inappropriate. For each commodity the estimated OHR path appears non-stationary, which has important implications for hedging strategies.

B. DATA AND METHODOLOGY

Secondary data are collected from Multi Commodity Exchange (MCX), Mumbai for the analysis. The exchange is chosen on the basis of highest trading volume of metal futures. Daily spot and futures closing prices of gold, silver and copper are collected from MCX website. Closing price of the commodities is taken into analysis as it is believed that closing price incorporates all the information during the trading day. The commodities are chosen based on MCX's world ranking in terms of number of futures contracts traded in 2016, where silver stood 1^{st} followed by gold and copper. The future series of the aforesaid commodities are constructed by taking into account the nearby futures contract (*i.e.* contract with the nearest active trading delivery month to the day of trading).

The nearby futures contract is used because it is highly liquid and the most active. Daily futures and spot closing prices are taken from 1^{st} June, 2005 to 29 January, 2016 for gold, silver and silver based on availability. All the observations are reported excluding Sundays and holidays. Furthermore, we have created data series in such a way that both spot and futures data are available in a given date. The data matching has been done for all the series taking into account of availability of the data both for futures and the spot in any given day. The non-availability of data either on spot or futures for any given day has been deleted from both the series.

C. EMPIRICAL ANALYSIS

All price series are found to be non-stationary with no tendency to revert back to an underlying trend value as they typically exhibit 'random walk' properties, *i.e.*, today's prices cannot be used to predict future prices. However, differencing the data runs the disadvantage of losing information about underlying long run relationships between prices. Thus, the relationship and co-movement between the prices is examined in a co-integration framework in which linear combinations of non stationary variables could be identified.

ADF and PP test results for gold, silver and copper are reported in the table 1 (see Appendix). The results of both ADF and PP test show that the null hypothesis (that all the series for gold, silver and copper are non-stationary H-0 : 0) cannot be rejected either at 1 percent significance level. Therefore, the spot and futures prices are non-stationary in the levels model. This non-stationarity raises the possibility of spurious regressions in the levels model and requires a test for stationarity at the difference level. The results of applied ADF and PP tests to the first-order difference of the sample spot and futures series of gold, silver, copper, crude oil and natural gas are also reported thereof in the table 1. All the first differences of return series are stationary at 1 percent level of significance. Thus, all the prices are integrated of the first order; *I*(1). This implies that the levels of all the five spot price and futures prices series show similar temporal properties. However, whether the levels of the spot price and futures prices are statistically linked over the long run has to be examined by the cointegration test.

D. ENGLE-GRANGER COINTEGRATION

Engle-Granger cointegration technique is applied to examine price discovery process in the metal and energy market. Price discovery can be accessed by close relationship between spot and futures in the long run. Cointegration technique is used to check long run equilibrium relationship between spot and futures. Once the long run relationship is established then it can be concluded that price discovery does exist in the respective futures market.

Table 1
Stationary Test for Commodities

	ADF		*PP*	
Variable	*Level*	*1st Difference*	*Level*	*1st Difference*
Gold Futures	–1.35	50.16*	1.35	50.22*
Gold Spot	–1.32	–55.17*	–1.32	55.23*
Silver Futures	–1.59	–51.06*	–0.688	–57.36*
Silver Spot	–1.62	–57.41*	–1.62	–44.85*
Copper Futures	–2.021	–44.74*	–2.006	–44.74*
Copper Spot	–2.209	–8.916*	–2.329	–10.13*

Note: * indicates 1 percent level of significance

Initially, regression technique is used to calculate residual values. As it is already mentioned that all the variables are non-stationary in the level, therefore regression results are likely to be spurious in nature. However, the major objective of the study is to check stationarity of residual values drawn from the regression so as to know whether futures and spot are cointegrated. ADF and PP tests are applied to the residual values for stationary. These results are reported in the table 2 (see Appendix) and it is observed that residual values for gold, silver, copper, crude oil and natural gas are stationary in the level which indicates futures and spot are cointegrated in all those respective commodities. Whether price discovery takes place first in the futures or spot can be examined from the error correction mechanism.

Error correction results for gold, silver, copper, crude oil and natural gas are reported in the table 3 (see Appendix) where t-statistic values are reported in the parenthesis. For the diagnostic checking, the study has used Ljung Box Q statistics for first order serial correlation. The empirical results say Ljung Box Q statistics

Table 2
Stationary Test Results for the Residual

Variable	*ADF*	*PP*
	Level	*Level*
Gold	–6.08*(0.00)	8.84*(0.00)
Silver	–5.39*(0.00)	–30.45*(0.00)
Copper	–5.57*(0.00)	–43.33*(0.00)

Note: * indicates 1% level of significance and Probability values in parenthesis.

Table 3
Error Correction Results for the Commodities

Equations	*Coefficients*	*Gold*	*Silver*	*Copper*
Futures	5.99* (1.67)	7.05(0.61)	0.131(1.05)	
	–0.03 (–4.91)	–0.04*(–3.65)	0.01(0.86)	
	0.06 (3.18)	–0.03(–1.48)	0.00(0.01)	
	0.06 (2.96)	0.07(0.801)	–0.02(–0.79)	
Ljung Box Q	Q(1)	0.003	0.008	0.0002
Spot		5.5 (1.65)	5.73 (0.56)	0.11(0.35)
		0.01* (2.02)	0.07*(6.83)	–0.967*(–30.7)
		0.4* (21.02)	0.53*(27.10)	–0.061(–0.906)
		–0.19* (–10.1)	–0.28*(–15.36)	–0.01(–0.506)
Ljung Box Q	Q(1)	0.27	1.001	0.0003

Note: Figure in parenthesis is *t*-statistic values, and * and ** indicate 1 percent and 5 percent level of significance respectively.

are significant at the 5 percent level of significance as it is well below its critical value of 3.84. The results for the error correction model are consistent with and support the results for cointegration. At least one error correction coefficient is significant in all cases where Engle-Granger technique indicates the presence of a cointegration vector. If coefficient α_s is always significant indicating that causality exists from futures to spot for all the commodities. In other words, price discovery occurs first in the futures market than transgress to spot market. Price discovery occurs additionally in the spot market if β_f is significant. The magnitude of β_s is at least twice that of indicating stronger feedback from futures to spot market for all commodities. The error correction results indicate that there is unidirectional causality from futures to spot. Price discovery occurs in the futures market then transgress to spot market for all commodities.

E. MARKET EFFICIENCY

In an efficient market, day-to-day variations in spot and futures prices are purely a result of new information that is arriving in the market. For storable commodities, in the efficient market, the extent of variation in both spot and futures markets should be similar. If the spot market is efficient, the relative magnitude of variation in prices can help assess whether the futures market is able to incorporate information efficiently. The study has analysed the ratio of standard deviations of futures and spot prices on a monthly basis to assess the futures market's performance. Assuming cost of carry in the month is negligible, a ratio of standard deviation of future and spot prices that is closer to one indicates that futures market is efficient, *viz.*, markets are incorporating all the information efficiently, a ratio greater than one close to the maturity period indicates speculative activities. Conversely, a ratio less than one shows that markets are not able to incorporate the information fully and efficiently. For the sake of interpretation, a cut-off has been assumed at 0.7 and 1.3 as the lower and upper levels to provide indication of extent of variability in the spot and futures markets. This assumption is on the same lines as adopted in the previous study (Naik and Jain, 2002).

In case of gold, silver and copper, the ratios are close to one which indicates that all the three markets are efficient. It indicates that gold, silver and copper futures prices are able to incorporate information efficiently. standard deviation of futures to spot is reported in the table 1.

Heteroskedasticity Effect

The study tests for the heteroskedasticity effect of the commodities futures and spots under consideration. Deploying the ARCH-LM test for the purpose, the study affirms the presence of heteroskedasticity effect in gold, silver and copper.

F. SPILL-OVER EFFECT IN COMMODITY FUTURES MARKET

There are evidences that spot and futures tend together over the period, and any changes in the futures market affects spot and any changes in spot market affects futures. Therefore, the study uses multi-variate GARCH (BEKK) model to check futures and spot trend as well as spill-over impact.

It is widely accepted that volatilities move together more or less closely over time across the assets or markets. To show the spill-over impact between futures and spot, multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) model in vector autoregressive (VAR) framework is employed where the conditional mean and variance are estimated simultaneously. The MGARCH model is used to study the mean and volatility spill-over between futures and spot market with the BEKK parameterization of MGARCH developed by Engle and Kroner (1995). The BEKK model doesn't impose restriction of constant correlation among variables over time. Furthermore, the model incorporates quadratic forms in such a way that ensures the positive semi-definite feature of the covariance matrix. Bi-variate GARCH model is used to study the volatility transmission among two markets simultaneously.

Multivariate GARCH (BEKK Model) results on commodity series are reported in Table 5. The covariance GARCH parameters and, which account for the conditional covariance between spot and futures returns, are all positive and statistically significant, implying strong interactions between spot and futures prices. It seems important to let the conditional covariance be time-dependent rather than restricting it to be a constant. In addition, there appears to be substantial efficiency gains in modelling the spot and futures prices jointly as opposed to a univariate analysis (Baillie, 2001). As the coefficients and are statistically significant indicating that future volatility in all spot and futures are influenced by the shocks and volatilities in their own market for gold, silver and copper. Bi-directional shocks transmission can be observed from significant coefficient and for the aforesaid series. The coefficient is significant for the commodities of gold, silver and crude oil which mean shocks in the futures market do have impact on spot market volatility. On the other hand, coefficient is statistically significant for gold and silver implying that shocks in the spot market do affect futures market volatility. However, coefficient is statistically insignificant for copper, indicating that shocks in the copper spot market do not have any impact on copper futures market volatility. Coefficients and are statistically significant in case of gold and silver, indicating that volatility spills over from futures market to spot market and *vice versa*. For the diagnostic checking, the study has used Ljung-Box Q statistics at the lag (10). Ljung-Box Q (LB) test is applied with 10 lags considering it as the optimal lag length and LBQ test statistics results are reported in the table 4.

Table 4
Multivariate GARCH Results for Commodity

		Gold	*Copper*	*Silver*
VAR 1	C	0.41(3.29)	0.03(1.44)	0.03(1.70)
	AR	0.037(1.84)	0.03(2.1)	–0.03 (–1.51)
VAR 2	C	0.05(3.95)	0.04(0.68)	0.04(1.92)
	AR	–0.59(34.48)	1.15(139.34)	0.57(33.75)
	$\hat{c}_{11}$	0.11(9.17)	0.14(8.81)	0.45(9.9)
	$\hat{c}_{21}$	0.00(0.06)	–0.17(–0.8)	–0.07(–2.02)
	$\hat{c}_{22}$	0.06(3.37)	0.3(2.19)	0.14(3.31)
	$\hat{a}_{11}$	0.17(8.45)	0.2(17.33)	0.36(12.08)
	$\hat{a}_{12}$	–0.16(–6.65)	–0.14(–9.17)	–0.1(–3.59)
	$\hat{a}_{21}$	0.08(3.78)	0.05(3.34)	–0.16(–5.54)
	$\hat{a}_{22}$	0.32(17.09)	2.29(52.47)	0.37(12.25)
	$\hat{b}_{11}$	0.97(187.37)	0.97(323.26)	0.86(39.77)
	$\hat{b}_{12}$	0.04(5.89)	0.1(3.91)	0.07(3.86)
	$\hat{b}_{21}$	–0.02(–3.42)	–0.02(–2.58)	0.08(5.15)
	$\hat{b}_{22}$	0.93(123.85)	–20.22(–20.22)	0.9(56.06)
Log–Liklihood		–1849.23	–6833.66	–8088.31
$Q(10)$		62	520.27	544
$Q^2(10)$		15	130.07	69

Note: *t*–statistics values are in parentheses

G. POLICY SUGGESTIONS

Market determined prices in the futures market create confidence among participants for the investment but this is not case always as speculative trading distorts the market fundamentals. Therefore, the role of policymakers in futures market is desirable so as to stabilize the market by ensuring smooth run of price discovery process. Moreover, futures markets need to incorporate all the available information while setting up the prices of futures.It is widely believed that higher the risk higher the return.

However, higher risk does not ensure higher return always. Investor may lose huge money in one instance or may gain huge in another. The study finds that future volatility in all spot and futures are influenced by the shocks and volatilities in their own market for gold, silver and copper. Bi-directional shocks transmission are observed in commodities like gold, silver and copper which mean shocks in the futures market do have impact on spot market volatility. But, shocks in the spot market do affect futures market volatility only in case of gold, silver and copper. Volatility spill-over is observed from futures market to spot market and vice versa in case of gold, silver and copper. Therefore, sophisticated policy tools and continuous surveillance on gold and silver market may reduce volatility spill-over effect.

H. CONCLUSION

Using a novel and comprehensive dataset of MCX India daily data, this study provides systematic study of price discovery process in the spot and future commodities market of India. This study further investigated whether spot and futures commodities price are cointegrated or not. The daily closing price series of the commodities under the study are cointegrated and therefore both futures and spot series exhibit a stable long-run equilibrium relationship. The error correction results indicate the futures and spot are cointegrated which support long run relationship. This evidence appears to suggest that more information flows from the futures to the spot market. In other words, price discovery takes place in the futures market first and transgress into the spot market in the commodities under study. In examining market efficiency, gold silver and copper are incorporated information efficiently. Examination of dynamics of commodity futures market has focused on issues on spill-over effects relating to the commodities chosen for the study. Volatility spill-over impact is observed to be statistically significant in all the respective spot and futures commodities under the study. Bi-directional shocks observed across the commodities such as gold, silver and crude oil. But, shocks in the futures market have impact on spot market volatility for gold, silver and copper.

APPENDIX

Generally, price change in one market transgress into the other market. The price change may occur first at futures market and in turn influences the spot market and vice versa. This price change may continue to persist for a longer period of time, which could be due to other fundamental factors associated with the futures and spot market. To capture the long run equilibrium between futures and spot market the following equation can be written as a regression framework:

$$F_t = \alpha + \beta S_t + \alpha_t \quad (1)$$

Where F_t and S_t are spot and futures price at time t. α and β are the intercept and coefficient terms. Equation (3.5.2) can be expressed in the residual as:

$$F_t - \alpha - \beta S_t = \hat{\varepsilon}_t \quad (2)$$

Where $\hat{\varepsilon}_t$ is the estimated white noise disturbance term. Ordinary least squares (OLS) inappropriate if F_t and S_t are non-stationary because standard errors are not consistent. If F_t and S_t are non-stationary but the estimated disturbance term $(\hat{\varepsilon}_t)$ is stationary then F_t and S_t are said to be cointegrated. That means they have a long run relationship or price discovery takes place in the market. If each series (F_t and S_t) is non-stationary in the level but the first difference (ΔF_t and ΔF_t) and deviation $(\hat{\varepsilon}_t)$ are stationary, the series are said to be cointegrated of the order (1, 1) with as a cointegrating parameter.

The study mentioned that if each series (F_t and S_t) is non-stationary at the level but the deviation $\hat{\varepsilon}_t$ is stationary then and are said to be cointegrated or they have long run equilibrium. But, in the short run there may be disequilibrium. Therefore, we can treat error term $(\hat{\varepsilon}_t)$ as the equilibrium error. The error correction mechanism (ECM) states that if two variables F_t and S_t are cointegrated then the relationship can be expressed as ECM which includes last period's equilibrium error as well as lagged values of first difference of each variable. Therefore, temporal causality can be assessed by examining the statistical significance and relative magnitude of the error correction parameter and parameter of lagged variables. The error correction model is (Pizzi, Economopoulos and O'Neill, 1998; Wahab and Lashgari, 1993):

$$\Delta F_t = \delta_s + \alpha_s \hat{\varepsilon}_{t-1} + \beta_s \Delta S_{t-1} + \gamma_s \Delta F_{t-1} + e_{s,t} \tag{3}$$

$$\Delta S_t = \delta_f + \alpha_f \hat{\varepsilon}_{t-1} + \beta_f \Delta F_{t-1} + \gamma_f \Delta S_{t-1} + e_{f,t} \tag{4}$$

In the above two equations, the first part $(\hat{\varepsilon}_{t-1})$ is the equilibrium error. This measures how the left hand side variable adjusts to the previous period's deviation from long run equilibrium. The remaining portion of the equation is lagged first difference which represents the short run effect of previous period's change in the price on current period' s deviation. The parameter of the equilibrium error, α_s and α_f is the speed of the adjustment parameter and have important implication in an error correction model. At least one speed of adjustment parameter must be non-zero for the model to be ECM. The parameter serves the role of identifying the direction of causal relation and shows the speed at which departure is corrected.

(a) Multivariate GARCH model (BEKK Model):

There are two major equations in the BEKK are mean equation and variance equation. The mean equation in the VAR-MGARCH model can be specified as;

$$R_{i,t} = \mu_i + \alpha R_{i,t-1} + \varepsilon_{it} \tag{5}$$

and it can also be stated as:

$$\begin{bmatrix} R_{1,t} \\ R_{2,t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} R_{1,t-1} \\ R_{2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \tag{6}$$

where is returns at time *t*; is the drift coefficient; and is the error term for the return of i[th] market,

Let $\varepsilon_t \mid \varphi_{t-1} \sim N(0, H_t)$; is a 2 × 2 corresponding variance covariance matrix, is an information set at time *t* – 1. The parameter represents the mean spill-over effect from market *j* to market i whereas the measure their own lagged response.

The BEKK parameterization for the variance equation can be written as:

$$H_t = C'C + A'\varepsilon_t \varepsilon'_{t-1} A + B' H_{t-1} B \tag{7}$$

The individual elements of *A*, *B* and **C** are:

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

$$B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

$$C = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

A is 2 × 2 a matrix of parameters and shows how conditional variances are correlated with past squared errors. The elements a_{ij} measure the effects of shocks spill-over from the market *j* to volatility in market *i* and a_{ii} measure the magnitude of impacts of shocks in market of its own volatility. *B* is 2 × 2 square matrix of parameters and show how past conditional variances affect current levels of conditional variances. Thus, b_{ij} implies the volatility spill-over from market *j* to market *i* and b_{ii} indicates persistence of volatility within the same market.

To have better understanding about the effect of shocks and volatility on the conditional variance equation, it can be expanded for the bi-variate GARCH(1,1) as :

$$h_{11} = c_{11} + a_{11}^2 \varepsilon_1^2 + 2a_{11}a_{21}\varepsilon_1\varepsilon_2 + a_{21}^2 \varepsilon_2^2 \tag{8}$$

$$h_{12} = c_{12} + a_{11}a_{12}\varepsilon_1^2 + a_{21}a_{12}\varepsilon_1\varepsilon_2 + a_{11}a_{22}\varepsilon_1\varepsilon_2 + a_{21}a_{22}\varepsilon_2^2 \tag{9}$$

$$h_{22} = c_{13} + a_{11}^2 \varepsilon_1^2 + 2a_{12}a_{22}\varepsilon_1\varepsilon_2 + a_{22}^2 \varepsilon_2^2 \tag{10}$$

Equations (8), (9) and (10) show how shocks and volatility are transmitted across markets and over time. Since two futures and spot markets are used, the transmission mechanism is examined by estimating bi-variate GARCH models.

The BEKK-MGARCH model is estimated using the maximum likelihood method. The log-likehood can be written as:

$$l(\theta) = -Tln(2\pi) - \frac{1}{2}\sum \ln|H_t| + \varepsilon_1' H_t^{-1} \varepsilon_t$$

where *T* is the number of observations and θ represents the parameter vector to be estimated. To obtain the estimates of the parameters, a combination of the standard gradient-search algorithm Broyden-Fletcher-Goldfarb-Shanno (BFGS) and simplex algorithm are used.

References

Asche F. and Guttormsen (2002), 'Lead Lag Relationship between Futures and Spot Prices', *Working Paper,* No.2/02, Institute for Research in Economics and Business Administration, Bergen.

Bhatacharya, H. (2007), 'Commodity Derivatives Market in India', *Economic and Political Weekly,* Vol. XLII, pp. 1151-1162.

Bhattacharya, A.K., Ramjee, A. and Ramjee, B. (1986), 'The Causal Relationship between Futures Price Volatility and the Cash Price Volatility of GNMA Securities' *The Journal of Futures Markets*, Vol. 6, pp. 29-39.

Booth, G.G., So, R.W. and Tse, Y. (1999), 'Price Discovery in the German Equity Index Derivatives Markets', *The Journal of Futures Markets,* Vol. 19, pp. 619-643.

Brorsen, B.W., Oellermann, C.M. and Farris, P. L. (1989), 'The Live Cattle Futures Marketand Daily Cash Price Movements', *The Journal of Futures Markets*, Vol. 9, pp. 273-282.

Engle, R.F. and Granger, C.W. (1987), 'Co-integration and Error Correction: Representation, Estimation and Testing', *Econometrica,* vol. 55, pp. 251-256.

Fama, E. (May, 1970), 'Efficient Capital Markets: A Review of Theory and Empirical Work', *The Journal of Finance*, Vol. 25, pp. 383-417.

Foster, J.A. (1996), 'Price Discovery in Oil Markets: A Time Varying Analysis of the 1990-91 Gulf Confilct' *Energy Economics,* Vol. 18 pp. 231-246.

Garbade, K.D. and Silber, W.L. (1983), 'Price Movements and Price Discovery in Futures and Cash Markets', *The Review of Financial and Economic Studies,* Vol. 65, pp. 421-440.

Genman H. (2005): 'Commodities and Commodity Derivatives' John Wiley and Sons, ltd.

Gorton, G. and Rouwenhorst, K.G. (February 2005), 'Facts and Fantasies about Commodity Futures', *Yale ICF Working Paper* No. 04-20 pp. 1-40.

Granger, C.W.J. (August, 1969), 'Investigating Causal Relations by Econometric Models and Cross-spectral Methods', *Econometrica*' Vol. 37, pp. 424-438.

Herbst, A.F., McCormack, J. P. and West, E. N. (1987), 'Investigation of a Lead-Lag Relationship between Spot Stock Indices and Their Futures Contracts' *The Journal of Futures Markets*, Vol. 7, No. 4, pp. 373-381.

Jones, F.J. (1981), 'The Interaction of the Cash and a Futures Markets for Treasury Securities' *The Journal of Futures Markets*, Vol. 1, pp.33-57.

Kamara, A. (1982), 'Issues in Futures Markets: A Survey', *The Journal of Futures Markets,* Vol. 2, pp. 261-294.

Kabra, K. N. (2007), 'Commodity futures in India', *Economic and Political Weekly*, March 31, 2007, pp. 1163-1170.

Karende, K.(2006), 'A Study of Castorseed Futures Market in India' *PhD thesis* submitted to the Indira Gandhi Institute of Development and Research (IGIDR).

Kaminsky, G. and Kumar, M.S. (1989), 'Efficiency in Commodity Futures Markets' *Working papers,* International Monetary Fund.

Lokare, S.M. (Monsoon, 2007), 'Commodity Derivatives and Price Risk Management: An Empirical Ancedote From India' *Reserve Bank of India Occasional Papers,* Vol. 48, No. 2, pp. 27-77.

Lingareddy, T. (2008), 'Exert Committee on Commodity Futures: Agreements and Disagreements', *Economic and Political Weekly*, Vol. XLIII, pp35-42.

Moosa, I.M. (2002), Economic Note by Banca Monte dei Paschi di Siena SpA, Vol. 31, pp. 155-165.

Oellermann, C.M. and Farris P.L. (1985), 'Futures or Cash: Which Market Leads Live Beef Cattle Prices', *The Journal of Futures Market,* Vol. 5, pp. 529-538.

Ollermann C.M. and B. Wade Brorsen and P.L. Farris (1989), 'Price Discovery for Feeder Cattle', *The Journal of Futures Markets,* Vol. 9, pp. 113-121.

Quan, J. (1992), 'Two-step Testing Procedure for Price Discovery Role of Futures Prices' *The Journal of Futures Markets*, Vol. 12, pp.139-149.

Schwarz, T.V. and Szakmary, A.C. (1994), 'Price Discovery in Petroleum Markets: Arbitrage, Cointegration, and the Time Interval', *The Journal of Futures Market*, Vol. 14, pp. 147-167.

Silvapulle, P. and Moosa, I.M. (1999): 'The Relationship between Spot and Futures Prices: Evidence from the Crude Oil Market' *The Journal of Futures Markets*, Vol. 19, pp 175-193.

Schroeder, T.C. and Goodwin, Goodwin B. K. (1991): 'Price Discovery and Cointegration for Live Hogs', *The Journal of Futures Markets*, Vol. 11, pp.685-696.

Tse, Y. (1999), 'Price Discovery and Volatility Spillovers in the DJIA Index and Futures Markets', *The Journal of Futures Markets*, Vol. 19, pp.911–930.

Tse, Y., Xiang, J, and Fung, K.W.J. (2006), 'Price Discovery in the Foreign Exchange Futures Market', *The Journal of Futures Markets,* Vol. 26, pp. 1131-1143.

Wahab, M and Lashgari, M. (1993), ' Price Dynamics and Error Correction in Stock Index and Stock Index Futures Markets: A Cointegration Approach', *The Journal of Futures Markets*, Vol. 13, pp. 711-42.

Withperpoon, J. T. (1993), 'How Price Discovery by Futures Impact the Cash Market,' *Jorunal of Futures Markets*, Vol. 13, pp. 469-496.

Baillie, R.T. and Myers, R.J. (1991): 'Bivariate Garch Estimation of Opitmal Futures Hedged', Journal of Applied Econometrics, Vol. 6, pp. 109-124.

Engle, R.F. and Kroner, K.F. (1995), 'Multivariate Simultaneous Generalized Arch', *Econometric Theory,* Vol.11, pp. 122-150.

Ferretti, F.I. and Gilbert, L.C. (2008), 'Commonality in the LME Aluminum and Copper Volatility Processes Through A FIGARCH Lens' *The Journal of Futures Markets,* Vol. 28, pp. 935-962.

Figlewski, S. (1981), 'Futures Trading and Volatility in the GNMA Market', *The Journal of Finance*. Vol. 36, pp. 445-56.

Khalia, A.A.A., Miao, H. and Ramchander, S. (2011), 'Measuring and Forecasting Volatility in the Metal Futures Markets', *The Journal of Futures Markets*, Vol 48, pp. 27-77.

Liew, K.Y. and Brooks, R.D. (1998), 'Returns and Volatility in the Kuala Lumpur Crude Palm Oil Futures Market', *The Journal of Futures Markets,* Vol. 18, pp. 985-999.

Peters, T. (2008), 'Forecasting Covariance Matrix with DCC GARCH Model', *Project* at Stockholm University.

Tse, Y. (1999), 'Price Discovery and Volatility Spillovers in the DJIA Index and Futures Markets', *The Journal of Futures Markets*, Vol. 19, pp.911–930.

Yang, S. R. and Brorsen, B.W. (1993), 'Nonlinear Dynamics of Daily Futures Prices: Conditional Heteroskedasticity or Chaos?' *The Journal of Futures Markets*, Vol. 13, pp. 175-191.