INDONESIAN
CAPITAL MARKET REVIEW

Role of Indian Commodity Derivatives Market in Hedging Price Risk: Estimation of Constant and Dynamic Hedge Ratio, and Hedging Effectiveness

Brajesh Kumar* and Ajay Pandey**

This paper examines hedging effectiveness of four agricultural (soybean, corn, castor seed and guar seed) and seven non-agricultural (gold, silver, aluminium, copper, zinc, crude oil and, natural gas) futures contracts traded in India, using VECM and CCC-MGARCH model to estimate constant hedge ratio and dynamic hedge ratios, respectively. We find that agricultural futures contracts provide higher hedging effectiveness (30-70%) as compared to non-agricultural futures (20%). In the more recent period, the hedging effectiveness of Indian futures markets has increased. When hedging effectiveness of non-agricultural Indian futures contracts with the world spot markets (NYMEX and LME) is analyzed, hedging effectiveness increases dramatically which indicates the fact that Indian futures contracts are more effective for hedging exposures to global prices. Other reasons of lower hedging effectiveness of Indian futures contracts may be low awareness of futures markets among participants, high transaction costs in the futures markets, policy restrictions, inadequate contract design, or high transaction costs in the spot market. These are, of course, expected birth pays for a nascent futures markets in an emerging economy.

Keywords: *CCC-MGARCH, commodity futures, hedging effectiveness, dynamic hedge ratio*

Introduction

Risk management and price discovery are the two main functions of futures market. Futures markets perform risk allocation function, and can be used to hedge the prices. One of the determinants of success of futures market is its hedging effectiveness (Pennings and Meulenberg, 1997). Role of hedging using futures market for minimizing the risk of spot market fluctuation has attracted considerable attention. According to the portfolio theory, hedging with futures can be considered as a portfolio selection problem in which futures can be used as one of the assets in the portfolio to minimize the overall risk or to maximize utility function. Hedging in futures market involves purchase/sale of futures in combination with another commitment, usually with the expectation of favorable change in relative prices of

*Brajesh Kumar, Jindal Global Business School, O.P. Jindal Global University, Sonipat, Haryana-131001, India, Email: bkumar@jgu.edu.in
**Ajay Pandey, Indian Institute of Management Ahmedabad, India, Email: apandey@iimahd.ernet.in

spot and futures market (Castelino, 1992). The basic idea of hedging through futures market is to compensate profit/loss in spot market by profit/loss in futures markets.

The emerging markets, where derivatives markets are of relatively recent origin, have somewhat different characteristics as compared to the developed markets. According to Bakaert and Harvey (1997) and Antoniou and Ergul (1997), emerging markets are characterized by low liquidity, thin trading, offer small sample size for research and consequentially returns exhibit higher sample average, low correlations with developed market returns, non-normality, better predictability, higher volatility. It is usually assumed that emerging market exhibit higher price variability and poor information processing (Tomek, 1980; Carter, 1989). Poor flow of information might affect the price discovery process and risk management in emerging markets. Unfortunately, relatively little empirical work has been done to investigate the hedging role of emerging commodity futures markets. The understanding of how effective is the hedge provided by futures in the emerging markets is important to recognize the functioning of these markets. Most of the studies in commodity derivatives markets and specially related to its hedging role are limited to U.S. and other developed markets and are mostly related to contracts on non-agricultural commodities.

This study investigates optimal hedge ratio (constant and dynamic) and hedging effectiveness in Indian commodity derivatives markets. The commodities considered for analysis consists of agricultural commodities (soybean, corn, castor seed, and guar seed), industrial metals (aluminium, copper, and zinc), precious metals (gold and silver), and energy commodities (crude oil and natural gas) traded on national commodity exchanges (National Commodity and Derivatives Exchange (NCDEX), and Multi Commodity Exchange (MCX)). The data period considered in the analysis is from the year 2004 to year 2008. We apply vector autoregressive model to estimate constant hedge ratio and multivariate GARCH with constant conditional correlation model to estimate dynamic hedge ratio.

Commodity derivatives markets in India

Commodities futures as financial instruments have seen exceptional growth in the recent years in India. Organized commodity derivatives in India started as early as 1875, barely about a decade after they started in Chicago. The regulation and development of futures market in India is done by the Central Government under the Forward Contracts Regulation Act (FCRA) and Forward Market Commission (FMC) is the statutory body under the FCRA. Before 2003, futures' trading was allowed for select commodities, including cotton, jute, potatoes, spices, etc. Under the essential commodity act (1955), free trade in many commodities was restricted and futures contracts were limited to specific commodities listed under FCRA. A major step was taken in 2003, when the central government realized the importance of commodity futures and agreed to remove the ban on futures trading for all commodities. In the same year three national level multi commodity exchanges National Multi Commodity Exchange (NMCE), Multi Commodity Exchange (MCX) and National Commodities and Derivatives Exchange (NCDEX) were setup. Currently, commodity futures are traded on three national level multi commodity exchanges, namely NMCE, MCX and NCDEX besides 20 other regional exchanges. There are around 103 commodities traded on these exchanges.

Indian commodity futures market has been going through many ups and downs after inception of national exchanges came in to being. Despite phenomenal growth, futures trading has been banned and revived many times particularly in agricultural commodities. Recently, after the ban on wheat futures in year 2007, there has been a considerable policy debate on the alleged effect of futures trading on commodity prices. High growth in Indian commodity futures markets has been accompanied by higher volatility in prices which requires a systematic investigation of hedging effectiveness provided by these markets. Such an investigation will also help in designing better hedging strategy and diversified portfolio. In India, very few studies have tried to understand commodity futures price behavior and its price discovery and hedging roles. Most of the studies on Indian commodity derivatives markets have been on to policy issues related to growth of derivatives market. Some of the major issues identified and investigated in this context are: the role of spot markets integration and friction (high transaction cost) in these markets, proper contract design, identification of delivery location, importance of warehousing facilities and policy issues like restriction on cross-border movement of commodities, different kind of taxes, etc (Thomas, 2003; Kolamkar, 2004; and Nair, 2004). Role of commodity futures market in price discovery and integration with spot market has been looked up by various authors (Naik and Jain, 1999; Thomas, 2003; and Sahadevan, 2002). Market efficiency and hedging effectiveness of commodity market have also been explored using data from national exchanges (Roy and Kumar, 2007; Kumar et al., 2008). These studies are limited in many ways. Most of the work used regional exchanges data, which were existed before national exchanges came into being. The regional exchanges have open outcry format, limited access to the participants and have poor liquidity. Methodology used in these studies did not consider the specific properties of time series data including conditional returns and volatility, volatility clustering, time varying covariance structure of spot and futures prices, persistence in return and volatility.

In order to fill this research gap, this study investigates the hedging effectiveness of Indian commodity futures market. We apply VECM model, which factors in the long-run cointegration between spot and futures prices, to estimate the constant hedge ratio. The dynamic hedge ratios are estimated using VECM-MGARCH model with constant correlation which considers joint distribution of conditional spot and futures returns and models autoregressive properties of conditional volatility. This paper is organized as follows. Section 2 presents a brief review of issues related to estimation of hedge ratio and hedging effectiveness, and models used to estimate the hedging effectiveness and hedge ratio in this study. In Section 3, description of the data used for the study is presented. Section 4 discusses the results and the final section concludes.

Literature Review

Measuring hedging effectiveness and hedge ratio

Optimal hedge ratio and hedging effectiveness provided by futures contract has been extensively researched. Various estimation techniques have been developed to estimate constant as well as dynamic hedge ratio, which is based on conditional distribution of covariance of spot and futures returns and conditional variances. The hedge ratio is defined as the ratio of the size of position taken in the futures market to the size of the position in spot market. There has been long-standing debate about the optimal hedge ratio. Traditionally, the hedge ratio was considered to be '-1', i.e., taking a position in futures market which is equal in magnitude and opposite in sign to spot market. If the movement of changes in spot prices and futures prices is same, then such a strategy eliminates the price risk. Such a perfect correlation between spot and futures prices is rarely observed in markets and hence there was a need felt for a better approach. Johnson (1960) came up with an approach called 'minimum variance hedge ratio (MVHR)'. The main objective of minimizing the risk was kept intact but the concept of utility maximization (mean) was also brought. Risk was defined as the variance of return on a two-asset hedged position.

The MVHR (Benninga et al., 1983) has been suggested as slope coefficient of the OLS regression, for changes in spot prices on changes in futures prices. The optimal hedge ratio for any unbiased futures market can be given by ratio of covariance of spot prices with futures prices and variance of futures prices. In other words, MVHR is the regression coefficient of the regression model (changes in spot prices over changes in futures prices). The R-squared of this model indicates the hedging effectiveness.

Many authors defined hedging effectiveness as the reduction in variances and considered utility function as risk minimization problem (Johnson, 1960; Ederington, 1979). However, Rolfo (1980) and Anderson and Danthine (1981) calculated optimal hedge ratio by maximizing traders' expected utility, which is determined by both expected return and variance of portfolio. Due to the nature of relationship (trade off) between risk and return, they advocate that optimal hedge ratio must be estimated in mean-variance frame work.

Hedge ratio that minimizes risk is optimal when the futures market is unbiased i.e. the expected return from the futures contracts are zero (Benninga et al., 1984). In case of biased futures market, minimum-variance hedge ratio has to be adjusted according to expected futures and cash prices, and the resultant basis.

The use of regression for calculating the hedge ratio and hedging effectiveness has been criticized on mainly two grounds. First, it is based on unconditional second moments, whereas the covariance and variance should be conditional because hedging decision made by any trader is based on all the information available at that time. Second, the estimates based on OLS regression is time invariant but the joint distribution of spot and futures prices may be time variant. In most of the markets, spot and futures prices are cointegrated in long-run (which is a necessary condition of market efficiency), application of vector autoregressive model (VAR) is also not appropriate. Estimation of constant hedge ratio through vector error correction model (VECM) model, which considers the long run cointegration between spot and futures, is therefore widely used.

Recent advancements in the time series modeling techniques try to remove the deficiencies of earlier methods used to estimate constant hedge ratio. A multivariate GARCH (Bollerslev et al., 1988) model is used to estimate time varying hedge ratio. Many relatively recent works on the hedging effectiveness calculate time varying hedge ratios (Park and Switzer, 1995; Holmes, 1995). Park and Switzer (1995a and 1995b) applied MGARCH approach to calculate hedging effectiveness of three types of stock index futures: S&P 500, MMI futures and Toronto 35 index futures and found that Bivariate GARCH estimation improves the hedging performance. Lypny and Powella (1998) used VECM-MGARCH (1,1) model to examine the hedging effectiveness of German stock Index DAX futures and found that the dynamic model is superior as compared to constant hedge ratio model.

In this study, VECM model is employed to estimate time invariant optimal hedge ratio where as time varying optimal hedge ratio is calculated using bivariate GARCH model (Bollerslev et al., 1988).

Hedge ratio and hedging effectiveness

The optimal hedge ratio is defined as the ratio of the size of position taken in the futures market to the size of the cash position which minimizes the total risk of portfolio. The return on an unhedged and a hedged portfolio can be written as:

$$R_U = S_{t+1} - S_t$$
$$R_H = (S_{t+1} - S_t) - H(F_{t+1} - F_t) \qquad (1)$$

Variances of an unhedged and a hedged portfolio are:

$$Var(U) = \sigma_S^2$$
$$Var(H) = \sigma_S^2 + H^2\sigma_F^2 - 2H\sigma_{S,F} \qquad (2)$$

where, S_t and F_t are natural logarithm of spot and futures prices, H is the hedge ratio, R_H and R_U are returns from unhedged and hedged portfolio, σ_S and σ_F are standard deviation of the spot and futures returns and $\sigma_{S,F}$ is the covariance.

Hedging effectiveness is defined as the ratio of the variance of the unhedged position minus variance of hedged position over the variance of unhedged position:

$$Effectiveness(E) = \frac{(Var(U) - Var(H))}{Var(U)} \qquad (3)$$

Methodology

Models for estimating hedging effectiveness and hedge ratio

Several models are used to estimate constant and dynamic hedge ratio and hedging effectiveness. In case of cointegration between spot and futures prices, VECM model is used and otherwise VAR model is applied to estimate constant hedge ratio. The dynamic hedge ratio is estimated through VECM/VAR-Multivariate GARCH model.

Vector Error Correction Model

When futures and spot prices are cointegrated, return dynamics of the both prices can be modeled through vector error correction model. VECM model specifications allow a long-run equilibrium error correction in prices in the conditional mean equations (Engle and Granger, 1987). Similar approach has been used to model short run relationship of cointegrated variables (Harris et al. 1995; Cheung and Fung, 1997; Ghosh et al., 1999). If the futures and spot series are co-integrated of the order one, then VECM of the return series is given as:

$$R_{S,t} = C_S + \chi_{S,EC}P_{S,t-1} + \gamma_{F,EC}P_{F,t-1} + \sum_{i=2}^{k}\chi_{S,i}R_{S,t-i} + \sum_{j=2}^{l}\gamma_{F,j}R_{F,t-j} + \varepsilon_{S,t}$$

$$R_{F,t} = C_F + \chi_{F,EC}P_{F,t-1} + \gamma_{S,EC}P_{S,t-1} + \sum_{i=2}^{k}\chi_{F,i}R_{F,t-i} + \sum_{j=2}^{l}\gamma_{S,j}R_{S,t-j} + \varepsilon_{F,t} \qquad (4)$$

where, $P_{S,t}$ is the log spot price and $P_{F,t}$ is the log futures prices. The error correction term $\chi_{F,EC}P_{F,t-1}+\gamma_{S,EC}P_{S,t-1}$ or $\chi_{F,EC}P_{S,t-1}+\gamma_{S,EC}P_{F,t-1}$ ($\Pi = \alpha\beta'$ representation) represents the speed of adjustment towards long run equilibrium. The short run parameter estimates χ_F, χ_S, γ_F and γ_S measure the short run integration or return spillover. The error terms in the equations, $\varepsilon_{S,t}$, and $\varepsilon_{F,t}$ are independently identically distributed (IID) random vector. The minimum variance hedge ratio are calculated as:

$$H = \frac{\sigma_{sf}}{\sigma_f}$$
where,
$$Var(\varepsilon_{St}) = \sigma_s$$
$$Var(\varepsilon_{Ft}) = \sigma_f$$
$$Cov(\varepsilon_{St}, \varepsilon_{Ft}) = \sigma_{sf} \qquad (5)$$

VECM-MGARCH Model

Generally, time series data possesses time varying heteroscedastic volatility structure (ARCH-effect). Because of ARCH effect in the return of spot and futures prices and their time varying joint distribution, the estimation of constant hedge ratio and hedging effectiveness may be inappropriate. Cecchetti et al. (1988) used ARCH model to represent time variation in the conditional covariance matrix of treasury bond returns and bond futures to estimate time-varying optimal hedge ratios and found substantial variation in optimal hedge ratios. The VECM-MGARCH model considers the ARCH effect in the time series and calculate time varying hedge ratio. We use constant conditional correlation (CCC) model to estimate the time varying hedge ratio. First, errors from the VECM model are obtained and then each error is modeled as univariate GARCH model and covariance is calculated as follows:

$$h_{ss,t} = \omega_s + \alpha_{s,1}\varepsilon^2_{s,t-1} + \beta_{s,1}h_{ss,t-1}$$
$$h_{ff,t} = \omega_f + \alpha_{f,1}\varepsilon^2_{f,t-1} + \beta_{f,1}h_{ff,t-1}$$
$$h_{sf,t} = \rho\left(h_{ss,t} \times h_{ff,t}\right)^{1/2} \quad (6)$$

where, $h_{ss,t}$ is the conditional spot variance at time t, $h_{ff,t}$ is conditional futures variance, $h_{sf,t}$ is covariance and ρ is the constant conditional correlation. The parameters are estimated through the MLE developed by Bollerslev et al. (1990).

Time varying hedge ratio is calculated as follows:

$$H_t = \frac{h_{sft}}{h_{fft}} \quad (7)$$

The Indian commodity futures: some characteristics

The objective of this study is to estimate the hedge ratio and hedging effectiveness of Indian commodity futures markets. For our analysis, four agricultural commodities: soybean, maize, castor seed, and guar seed, three industrial metals: aluminum, copper, and zinc, two precious metals: gold and silver, and two energy commodities: crude oil and natural gas have been considered. The premise for selecting such a wide group is that it would be is interesting to see and compare the risk management role of futures in case of agricultural commodities, which are less tradable and less susceptible to global information as compared to non-agricultural commodities which face less transaction costs and are more sensitive to global information from all over the world. We analyze the near month contracts and next to near month contracts where trading volume is high. We prepare the near month futures series and next to near month futures series on rolling basis, i.e. when the near month contract approaches maturity, we select data from the next contract. We also remove the maturity week data from the near month futures series to remove the maturity bias. For agricultural commodities (soybean, maize, castor seed, and guar seed), futures contracts from NCDEX and for non-agricultural commodities MCX are used. The selection of exchange for selecting the futures contract is based on trading volume of the commodity futures contracts at different exchanges. We choose the exchange for a commodity where the trading volume was highest. These exchanges also report the data of spot prices of a particular delivery center (Table 1), which has been used as data for spot prices.

The data period considered in the analysis is from year 2004 to year 2008 (Table 1). Since the national exchanges in India started only in year 2004, the sample chosen was largest feasible at the time of this study. We also divide the data into two non-overlapping sub-periods of almost two years each. The first sub-period from year 2004 to 2006 represents the early phase of the national commodity exchanges and

Table 1. Details of commodity, data period, and source

Commodities		Data-Periods	Futures Market	Reference Spot Market for Settlement or Delivery
Agricultural	Soy Bean	09/01/2004 to 10/20/2008	NCDEX	Indore
	Maize	01/05/2005 to 10/20/2008	NCDEX	Nizamabad
	Castor Seed	09/21/2004 to 10/20/2008	NCDEX	Disa
	Guar Seed	04/12/2004 to 09/19/2008	NCDEX	Jodhapur
Bullion	Gold	05/02/2005 to 09/30/2008	MCX	Ahmedabad
	Silver	05/02/2005 to 09/30/2008	MCX	Ahmedabad
Metals	Aluminium	02/01/2006 to 09/30/2008	MCX	LME Cash Price
	Copper	07/04/2005 to 11/20/2008	MCX	LME Cash Price
	Zinc	04/03/2006 to 09/30/2008	MCX	LME Cash Price
Energy	Crude Oil	05/02/2005 to 09/30/2008	MCX	NYMEX Cash Price
	Natural Gas	07/21/2006 to 09/30/2008	MCX	NYMEX Cash Price

is characterized by low futures trading volume and market depths and the second sub-period from year 2007 to 2008 is from a period when futures trading volume and depth were relatively high.

Test of unit root and cointegration

The price series of spot and futures prices of each commodity is tested for stationarity and cointegration[1]. Stationarity of the prices and their first difference are tested using ADF test statistics and cointegration between spot and futures prices are tested using Johansen co-integration tests (both Eigen value and Trace test). It is found that for all commodities, spot price, near and next to near month futures price series have unit root and return series are stationary in the entire period and in the both sub-periods. The results of cointegration test indicate that both near month and next to near month futures prices are cointegrated with spot prices except next to near month futures of natural gas futures. In case of near month futures in the both sub-periods, the futures and spot prices are cointegrated except for guar seed in second sub-period. In case of next to near month futures in the first sub-period, maize, aluminium, copper, and natural gas spot and futures prices, are not cointegrated, and in the second sub-period, castor, crude and natural gas spot and futures, are not cointegrated. To estimate the constant hedge ratio we apply VECM model where spot and futures prices are cointegrated otherwise we use VAR model.

Result and Discussion

Hedge ratio and hedging effectiveness of eleven commodity futures traded on Indian commodity derivatives markets are estimated through VECM and multivariate GARCH model with constant conditional correlation models as described in section 3. We estimate constant and dynamic hedge ratio for all commodities. Hedge ratio and hedging effectiveness are calculated for both near month and next to near month futures.

Constant hedge ratio using VECM estimates

To calculate the hedge ratio and hedging effectiveness, the parameters of VECM/VAR models are estimated and residuals are obtained. We used residuals from these models to calculate hedge ratio and hedging effectiveness (equation (5)). The parameter

[1] The results of unit root and cointegration test are not reported here. These results can be obtained from authors on request.

estimates of the VECM/VAR model of the spot and future returns equations are given in Appendix. It is found that both spot and futures prices respond to the long run deviation in the prices and the parameter estimates of error correction term in the VECM model are significant at 1% level in the mean spot return equation of all agricultural commodities, silver, aluminium and zinc. The parameters of lagged spot and futures returns are also significant. In the recent period, futures returns are self autoregressive and do not depend on spot returns. These results are also verified by the weak exogeneity test (not reported here) for both spot and futures.

The optimal hedge ratio and hedge effectiveness for near month futures are presented in Table 2. Table 2(a), 2(b), and 2(c) present the hedge ratio and hedging effectiveness for the entire period, the first sub-period (year 2004 to 2006) and the second sub-period (year 2007 to 2008) respectively. Table 3(a), 3(b) and 3(c) represent the same for next to near month futures.

In case of near month futures of agricultural commodities, where local spot prices are used, optimal hedge ratios are in the range of 0.45 to 0.75 with lowest hedge ratio of 0.32 maize futures. These contracts provide around 20%-70% of hedging effectiveness [soybean (70%), maize (23%), castor seed (50%), and guar seed (44%)]. All other non-agricultural commodities have less hedge ratios (less than 0.4) and lower hedging effectiveness (less than 25%). In case of precious metals, where Ahmedabad spot prices are used, gold contract provides hedging effectiveness of around 23% and silver around 15%. In case of crude oil and natural gas where NYMEX spot price converted into Indian currency are used, hedging effectiveness is low (19%). In case of industrial metals futures where LME cash prices are used, hedging effectiveness is low for aluminium, copper and zinc and futures contracts are providing only 10%, 3% and 20% of hedging effectiveness respectively. In both the sub-periods, agricultural near month futures have similar hedging effectiveness except for maize futures. In the early periods it provides only 18% of hedging effectiveness which improves to 35% in the recent period. The near month futures of precious metals, industrial metals and energy commodities provide similar hedging effectiveness in both the sub-periods.

We also analyze the next to near month futures and estimate the hedge ratio and hedging effectiveness. It is found that next to near month futures of agricultural commodities provide similar effectiveness as provided by near month futures except for soybean where hedging effectiveness reduces to 30%. For silver, industrial metals and natural gas, the hedging effectiveness of next to near month futures is less than near month futures. For natural gas the hedging effectiveness reduces from 20% provided by near month futures to 2% in next to near month futures. There are major differences in hedging effectiveness of next to near month futures for industrial metals, maize, and silver in the two sub periods because of less trading volume in the next to near month contracts in the first sub-period. The hedging effectiveness improved in the recent period of these commodities. However, for castor seed and crude, hedging effectiveness has decreased in the recent sub-period. The reason would be less trading volume in the castor futures whereas crude oil and copper prices have shown very high volatility and dramatic price movements in the recent period.

To sum up, we find that the agricultural commodities and precious metals, where local spot market prices are used, futures contracts provide higher hedge ratio and hedging effectiveness as compared to other non-agricultural commodities, where international spot prices converted into

Table 2(a). Estimation of hedge ratio and hedging effectiveness for near month futures for the entire period (2004-2008)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000216	0.000078	0.000093	0.000218	0.000040	0.000085	0.000073	0.000038	0.000195	0.000112	0.000484
Variance (ε_F)	0.000291	0.000246	0.000160	0.000456	0.000128	0.000364	0.000276	0.000386	0.000659	0.000319	0.001182
Hedge Ratio	0.739833	0.317607	0.584379	0.477391	0.316849	0.232021	0.262816	0.097611	0.295546	0.349902	0.409389
Variance (ε_S)	0.000230	0.000105	0.000112	0.000237	0.000054	0.000133	0.000165	0.000131	0.000295	0.000208	0.001063
Variance(H)	0.000070	0.000081	0.000058	0.000133	0.000041	0.000114	0.000145	0.000128	0.000238	0.000169	0.000865
Variance(U)	0.000229	0.000106	0.000112	0.000237	0.000054	0.000133	0.000161	0.000131	0.000296	0.000208	0.001066
Hedging Effectiveness, E	0.692946	0.237123	0.486313	0.437719	0.236243	0.146975	0.096287	0.027994	0.197039	0.189441	0.189156

Table 2(b). Estimation of hedge ratio and hedging effectiveness for near month futures for the first sub-period (2004-2006)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000178	0.000066	0.000081	0.000291	0.000039	0.000101	0.000064	0.000038	0.000146	0.000129	0.001088
Variance (ε_F)	0.000244	0.000198	0.000157	0.000586	0.000120	0.000427	0.000391	0.000340	0.000725	0.000298	0.002735
Hedge Ratio	0.731624	0.333731	0.516682	0.496459	0.325280	0.237217	0.162500	0.111726	0.200687	0.432523	0.397671
Variance (ε_S)	0.000186	0.000121	0.000105	0.000318	0.000056	0.000174	0.000225	0.000173	0.000317	0.000238	0.002000
Variance(H)	0.000055	0.000099	0.000063	0.000173	0.000044	0.000150	0.000215	0.000169	0.000288	0.000182	0.001568
Variance(U)	0.000186	0.000121	0.000105	0.000318	0.000056	0.000174	0.000225	0.000173	0.000317	0.000238	0.002017
Hedging Effectiveness, E	0.702977	0.183017	0.398208	0.454555	0.225757	0.138000	0.045788	0.024454	0.092126	0.234767	0.222604

Table 2(c). Estimation of hedge ratio and hedging effectiveness for near month futures for the second sub-period (2007-2008)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000265	0.000093	0.000108	0.000101	0.000041	0.000068	0.000075	0.000046	0.000214	0.000093	0.000323
Variance (ε_F)	0.000361	0.000293	0.000162	0.000254	0.000130	0.000279	0.000198	0.000407	0.000620	0.000335	0.000778
Hedge Ratio	0.735484	0.315907	0.670206	0.395943	0.313358	0.242272	0.380850	0.114104	0.344876	0.276419	0.414326
Variance (ε_S)	0.000283	0.000087	0.000122	0.000100	0.000051	0.000091	0.000123	0.000087	0.000273	0.000173	0.000686
Variance(H)	0.000088	0.000058	0.000049	0.000060	0.000038	0.000075	0.000094	0.000081	0.000199	0.000147	0.000553
Variance(U)	0.000283	0.000088	0.000122	0.000100	0.000051	0.000091	0.000121	0.000087	0.000273	0.000168	0.000690
Hedging Effectiveness, E	0.689706	0.338375	0.598378	0.398083	0.249660	0.180167	0.225528	0.061162	0.270389	0.122934	0.198484

Indian currency are used, in Indian futures market. Hedging effectiveness provided by the near month futures is higher than the next to near month futures for most of the commodities. These results are consistent with the notion that time-to-expiration is important to hedging effectiveness, and generally consistent with "Samuelson hypothesis", which states that the volatility of futures contracts is inversely related to time to maturity and hence near month futures should provide higher hedging effectiveness than next to near month futures. Another important reason may be less trading activity in the next to near month contracts of non-agricultural commodities, where trading activity is 5-8 times lesser than near month futures. This is the reason why we find that out of 11 commodities, cointegration relationship between futures and spot prices are not found in six commodities. Further, we find that for most

Table 3(a). Estimation of hedge ratio and hedging effectiveness for next to near month futures for the entire period (2004-2008)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000122	0.000059	0.000089	0.000220	0.000042	0.000083	0.000070	0.000042	0.000179	0.000105	0.000287
Variance (ε_F)	0.000211	0.000242	0.000164	0.000501	0.000122	0.000339	0.000258	0.000349	0.000598	0.000277	0.000810
Hedge Ratio	0.577326	0.242724	0.542966	0.438871	0.342242	0.245991	0.273305	0.120029	0.299099	0.379611	0.354383
Variance (ε_S)	0.000224	0.000107	0.000107	0.000224	0.000058	0.000137	0.000179	0.000154	0.000313	0.000217	0.001224
Variance(H)	0.000154	0.000093	0.000059	0.000128	0.000044	0.000116	0.000159	0.000149	0.000260	0.000177	0.001122
Variance(U)	0.000224	0.000107	0.000107	0.000224	0.000058	0.000137	0.000175	0.000154	0.000313	0.000218	0.001224
Hedging Effectiveness, E	0.311315	0.133362	0.452535	0.430664	0.246231	0.150156	0.091710	0.032746	0.170797	0.185514	0.083070

Table 3(b). Estimation of hedge ratio and hedging effectiveness for next to near month futures for the first sub-period (2004-2006)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000094	0.000024	0.000073	0.000289	0.000044	0.000099	0.000007	0.000029	0.000108	0.000119	0.000022
Variance (ε_F)	0.000136	0.000105	0.000147	0.000639	0.000116	0.000404	0.000354	0.000286	0.000647	0.000245	0.000782
Hedge Ratio	0.694536	0.233463	0.496621	0.452964	0.375518	0.244549	0.018660	0.102194	0.167391	0.487260	0.028244
Variance (ε_S)	0.000167	0.000092	0.000098	0.000296	0.000064	0.000175	0.000240	0.000187	0.000332	0.000252	0.000946
Variance(H)	0.000101	0.000086	0.000062	0.000165	0.000048	0.000151	0.000239	0.000184	0.000314	0.000193	0.000945
Variance(U)	0.000167	0.000092	0.000098	0.000296	0.000064	0.000175	0.000240	0.000187	0.000332	0.000252	0.000957
Hedging Effectiveness, E	0.393548	0.062189	0.370665	0.443269	0.256074	0.137873	0.000515	0.016025	0.054529	0.231297	0.012088

Table 3(c). Estimation of hedge ratio and hedging effectiveness for next to near month futures for the second sub-period (2007-2008)

	Agricultural				Bullion		Metals			Energy	
	Soybean	Maize	Castor Seed	Guar Seed	Gold	Silver	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.000151	0.000086	0.000026	0.000079	0.000033	0.000069	0.000080	0.000042	0.000206	0.000041	0.000086
Variance (ε_F)	0.000305	0.000301	0.000096	0.000240	0.000099	0.000254	0.000185	0.000364	0.000563	0.000255	0.000401
Hedge Ratio	0.496836	0.286811	0.271338	0.327935	0.333604	0.269838	0.434189	0.116117	0.365703	0.161897	0.213480
Variance (ε_S)	0.000281	0.000087	0.000074	0.000081	0.000046	0.000094	0.000139	0.000090	0.000282	0.000146	0.000785
Variance(H)	0.000206	0.000062	0.000067	0.000055	0.000035	0.000075	0.000104	0.000085	0.000207	0.000140	0.000767
Variance(U)	0.000281	0.000088	0.000075	0.000081	0.000046	0.000094	0.000138	0.000090	0.000282	0.000136	0.000789
Hedging Effectiveness, E	0.267845	0.287731	0.096645	0.317890	0.240686	0.197570	0.245160	0.054520	0.266877	-0.024979	0.027981

of the commodities hedging effectiveness has improved in the recent sub-period. The estimation of constant hedge ratio does not take into account the autoregressive nature of spot and futures volatility. Therefore, we also estimate the time varying hedge ratio by VECM-MGARCH model with constant correlation where spot and futures volatilities are modeled as a GARCH process. These results are discussed next.

Dynamic hedge ratio using VECM-MGARCH estimates

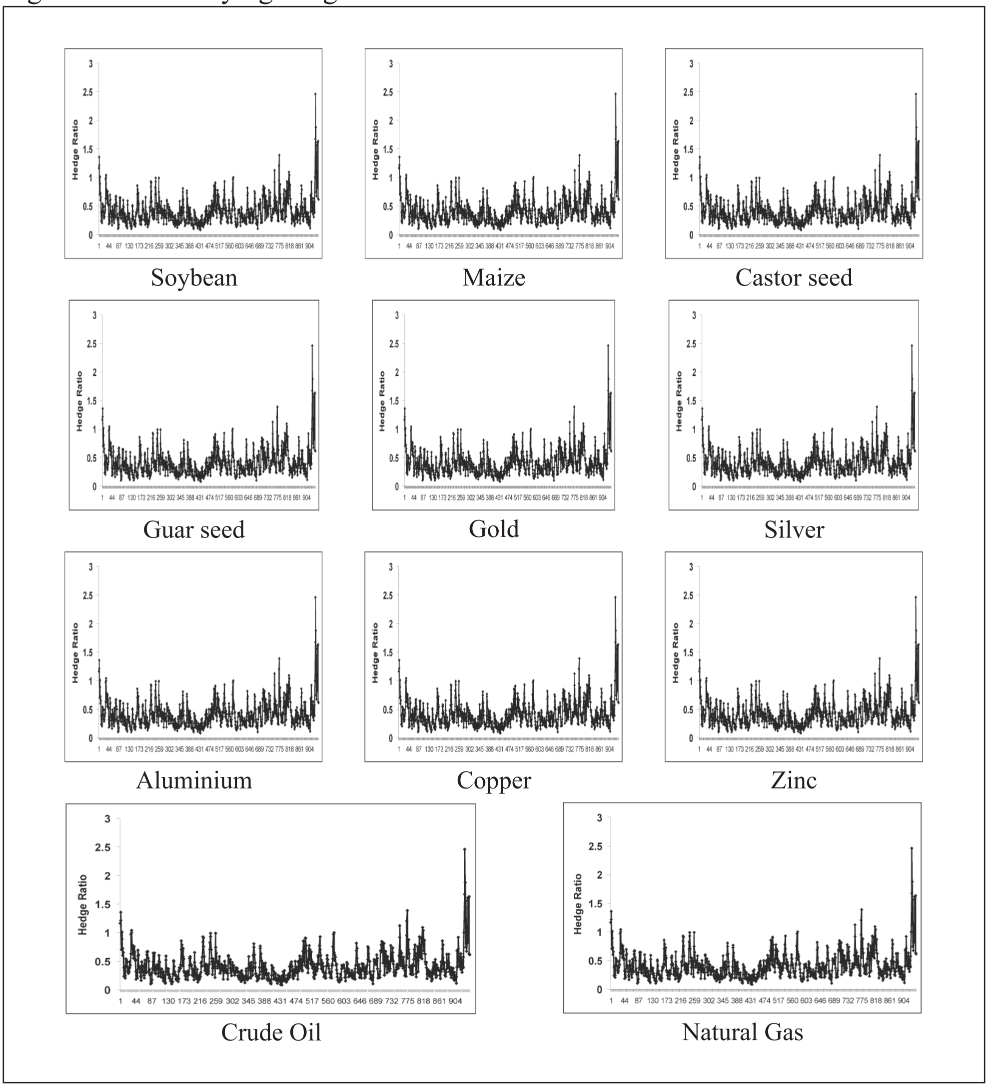
We test the residuals from the VECM/VAR model for ARCH effect and find that for most of the cases both spot and futures residuals obtained from VECM/VAR exhibit ARCH effect.[2] The ARCH effect present in residuals confirms the necessity of multivariate GARCH (M-GARCH)

[2] Results of ARCH LM test on spot and futures residuals are not reported here. Results can be obtained from authors on request.

Table 4. Estimation of dynamic hedge ratio and hedging effectiveness for near month future and next to near month futures for the entire period

Commodity	Hedge Ratio	Hedging Effectiveness, E	Hedge Ratio	Hedging Effectiveness, E
	Near Month Futures		Next to Near Months Futures	
Soybean	0.4276	0.6335	0.4521	0.4707
Maize	0.8920	0.2418	0.4046	0.1514
Castor Seed	0.7126	0.4917	0.5329	0.4577
Guar Seed	0.5022	0.4367	0.4063	0.4316
Gold	0.2723	0.2407	0.2698	0.2492
Silver	0.2681	0.1385	0.2290	0.1459
Aluminium	0.5048	0.1481	0.4518	0.1449
Copper	0.1072	0.0402	0.1103	0.0468
Zinc	0.2795	0.1972	0.3630	0.1780
Crude Oil	0.3951	0.1978	0.3869	0.1920
Natural Gas	0.3849	0.2486	0.4472	0.1446

Figure 1. Time varying hedge ratios of near month futures



modeling to estimate the conditional variance, covariance and time varying hedge ratios. As discussed in the section 2, we use constant conditional correlation M-GARCH (1,1) model to estimate conditional covariance and variance of the spot and futures residuals obtained from VECM/VAR model. The estimates of the parameter are given in the Appendix. As conditional covariance is time varying, the dynamic hedge ratios are estimated using equation (7). Average hedge ratios and hedging effectiveness estimated from CCC-MGARCH (1,1) model are presented in Table 4. Table 4 and Figure 1 report the estimated hedge ratios and hedging effectiveness of near month futures and for next to near month futures. The average hedge ratios and hedging effectiveness estimated from CCC-GARCH model are not very different from the constant hedge ratios calculated from VECM/VAR model. However, we find some improvement in hedging effectiveness for non-agricultural commodities where spot and futures residual series show ARCH effect. In most of the agricultural commodities, except guar seed, spot and futures residual series do not exhibit ARCH effect. The average hedge ratio and hedging effectiveness estimated from CCC-MGARCH model of agricultural futures remain higher than non-agricultural commodities. The dynamic hedge ratios and hedging effectiveness estimated in different sub-periods (not reported here) are similar to constant hedge ratios results.

We further investigate the reasons for low hedging effectiveness for non-agricultural commodities. In commodity futures markets, the spot and futures prices are related with cost of carry model and their co-movement is determined by cost of storage or convenience yield (Working, 1949, 1958). The low correlation between spot and futures markets (hedging effectiveness) may be because of volatile convenience yield. The notion of convenience yield is derived from no arbitrage relationship between spot and futures prices. If the futures markets are too speculative and inefficient, they will move apart from the spot markets and will provide low hedging effectiveness.

On the other hand, if spot markets have high friction in terms of high transaction cost and other restriction, it becomes difficult to perform arbitrage and comovement of futures and spot prices is restricted. Another reason for the low hedging effectiveness of futures contracts may be the regional restriction on movement of commodities and low number of delivery centers. Brinkmann and Rabinovich (1995) investigated the limitations in the transportation system for the natural gas market in the United States and found that hedging effectiveness varies with delivery centers. It is possible that the futures markets of industrial metals and energy commodities may aggregate global price information from LME/NYMEX futures markets than spot prices. Also most of the futures contracts of non-agricultural commodities are cash settled contracts rather than contracts for actual delivery. Hence, we find lower hedging effectiveness of Indian futures in cases where LME/NYMEX spot prices converted into Indian currency are used. It is plausible that the LME/NYMEX futures also provide similar hedging effectiveness with their spot prices and as Indian futures are linked with LME/NYMEX futures, it also provides lesser hedging effectiveness. Also, if Indian markets are linked with LME/NYMEX futures, they may provide higher effectiveness with LME/NYMEX futures than respective spot prices.

To diagnose these possibilities further, we try to find out the hedging effectiveness of Indian futures contracts with LME/NYMEX futures and LME/NYMEX futures with their respective spot prices.

Table 5. Estimation of hedge ratio and hedging effectiveness for Indian futures with LME/NYMEX futures prices

	Industrial Metals			Energy	
	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.00012	0.00017	0.00026	0.00032	0.00118
Variance (ε_F)	0.00022	0.00031	0.00039	0.00039	0.00149
Hedge Ratio	0.55200	0.56684	0.64848	0.81525	0.79289
Variance (ε_S)	0.00022	0.00023	0.00032	0.00057	0.00190
Variance(H)	0.00016	0.00014	0.00015	0.00032	0.00097
Variance(U)	0.00022	0.00023	0.00032	0.00057	0.00342
Hedging Effectiveness, E	0.29829	0.41952	0.51193	0.45000	0.71676

Table 6. Estimation of hedge ratio and hedging effectiveness LME/NYMEX futures prices with spot prices

	Metals			Energy	
	Aluminium	Copper	Zinc	Crude Oil	Natural Gas
Covariance(ε_F, ε_S)	0.00017	0.00033	0.00046	0.00025	0.00100
Variance (ε_F)	0.00028	0.00048	0.00073	0.00072	0.00229
Hedge Ratio	0.60376	0.68964	0.62216	0.34978	0.43591
Variance (ε_S)	0.00018	0.00043	0.00045	0.00044	0.00173
Variance(H)	0.00008	0.00020	0.00017	0.00035	0.00129
Variance(U)	0.00018	0.00047	0.00045	0.00044	0.00173
Hedging Effectiveness, E	0.54981	0.56625	0.63114	0.19862	0.25234

The selection of exchanges is once again based on trading volume.

First, the LME/NYMEX futures prices are tested for stationarity. It is found that prices have unit root and return series are stationary. Then, Johansen cointegration test is performed to test the cointegration between Indian futures prices and LME/NYMEX futures prices and LME/NMEX futures prices and spot prices. It was found that all series are cointegrated[3].

As explained earlier, after finding the cointegration between Indian futures and the LME/NYMEX futures prices and LME/NYMEX futures prices and spot prices, VECM models are estimated and residuals are obtained. Results of VECM model are given in the Appendix. It is found that Indian futures returns of industrial metals and energy commodities respond to the long run deviation in the LME/NYMEX futures prices and the parameter estimates of error correction term in the VECM model are significant at 5% level for Indian futures returns. In case of LME/NYMEX futures and spot prices, futures prices are exogenous and spot prices adjust to restore long-run equilibrium. Hedge ratio and hedging effectiveness are estimated from residuals obtained from VECM errors. The optimal hedge ratio and hedge effectiveness for Indian futures with LME/NYMEX futures are presented in Table 5 and Table 6 gives the hedge ratio and hedging effectiveness of LME/NYMEX futures and spot prices.

It is interesting to note that the hedge ratio and hedging effectiveness of Indian futures contracts with LME/NYMEX futures increased dramatically for industrial metals and energy commodities. In case of crude oil and natural gas, hedge ratio is around 0.80 and hedging effectiveness of crude oil and natural gas are 45% and 72%

[3] Results of unit root test and cointegration test is not reported here. Results can be obtained from authors on request.

respectively. We also see improvement in the hedging effectiveness of industrial metals. Aluminium, copper, and zinc futures provide around 30%, 42% and 52% of hedging effectiveness respectively. The results of hedging effectiveness of Indian futures markets with LME/NYMEX spot prices clearly indicate that the Indian futures markets process global information and are more strongly linked with the LME/NYMEX futures markets rather than the LME/NYMEX spot markets especially for precious metals and energy commodities. We also find that the LME futures provide good hedging effectiveness with spot prices for industrial metals. The NYMEX futures are not providing better hedging effectiveness as compared to Indian futures contracts. Combining the results of hedging effectiveness of Indian futures with LME/NYMEX futures and LME/NYMEX futures with spot prices, it can be inferred that the Indian commodities futures markets are providing good hedging effectiveness vis-à-vis LME/NYMEX futures rather than with their spot prices.

Conclusion

This paper investigates risk minimizing hedge ratio and hedging effectiveness of Indian commodity futures markets for eleven commodities. Commodities considered for the analysis consist of four agricultural commodities and seven non-agricultural commodities including industrial metals, precious metals and energy commodities. The constant and dynamic hedge ratios are estimated using VECM/VAR and VECM-MGARCH with constant correlation model respectively. The findings point out the great differences between agricultural and non-agricultural commodities with regard to the hedging performance of futures contracts traded in India. In case of agricultural commodities, Indian commodity futures markets provide higher hedging effectiveness (30-70%) as compared to industrial metals and energy commodities (less than 20%) when LME/NYMEX cash prices are used. The results are similar for whether hedging is done using constant hedge ratio or dynamic hedge ratios. It is found that the near month futures provide higher hedging effectiveness than next to near month futures. We also find that the hedging role of Indian commodity futures markets has increased in the recent period with increased activity in the market.

We explored the possibility of stronger linkages of Indian commodity futures markets with the international futures market for industrial metals and energy commodities. It is found that for these commodities, Indian futures markets assimilate the global information from international futures market strongly. Therefore, when hedging effectiveness of Indian commodity futures markets with the LME/NYMEX futures prices is analyzed, we find that hedging effectiveness of Indian futures contracts increases dramatically. It is also found that the LME futures are providing good hedging effectiveness with spot prices whereas Indian futures markets are providing very low hedging effectiveness with spot prices for industrial metals. These findings help in improving the understanding of the linkages of the Indian commodity futures markets with the world markets for non-agricultural commodities.

The findings also carry some implications for users of futures markets for both agricultural and non-agricultural commodities. It is evident that in non-agricultural commodities, hedgers may not use futures markets to hedge exposure in spot market as compared to the agricultural futures markets. This is supported by the observed speculation ratio (ratio of volume to open interest) given in the Appendix. In case of agricultural commodities, this ratio (approx 0.5-0.9) is much lower than the non-agricultural commodities (approx 3.0).

While our analysis suggests that Indian futures contracts are more effective for hedging exposures to global futures prices, there may be other reasons of lower hedging effectiveness of Indian futures contracts. Some of these may be low awareness of futures markets among participants, low participation of hedgers, high transaction costs in the futures markets, policy restrictions, lower number of delivery centers, inadequate contract design or high transaction costs in the spot market. These are, of course, expected birth pays for a nascent futures markets in an emerging economy.

References

Anderson, R.W. and Danthine, J.P. (1981), Cross Hedging, *Journal of Political Economy*, 81, 1182-1196.

Antonious, A. and Ergul, N. (1997), Market Efficiency, Thin Trading and Non-linear Behaviour: Evidence from an Emerging Market, *European Financial Management*, 3, 175–90.

Bakaert, G. and Harvey, C.R. (1997), Emerging Equity Market Volatility, *Journal of Financial Economics*, 43, 29–77.

Benninga, S., Eldor, R., and Zilcha, I. (1983), Optimal Hedging in the Futures Market Under Price Uncertainty, *Economics Letters*, 13, 141–145.

Benninga, S., Eldor, R., and Zilcha, I. (1984), The Optimal Hedge Ratio in Unbiased Futures Market, *Journal of Futures Market*, 4, 155-159.

Bollerslev, T., Engle, R., and Wooldridge, J.M. (1988), A Capital Asset Pricing Model with Time Varying Covariances, *Journal of Political Economy*, 96, 116-131.

Bollerslev, T. (1990), Modeling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Approach, *Review of Economics and Statistics*, 72, 498-505.

Brinkmann, E.J. and Rabinovich, R. (1995), Regional Limitations on the Hedging Effectiveness of Natural Gas Futures, *Energy Journal*, 16, 3.

Carter, C.A. (1989), Arbitrage Opportunities between Thin and Liquid Futures Markets, *Journal of Futures Markets*, 9, 347-353.

Castelino, M.G. (1992), Hedge Effectiveness Basis Risk and Minimum Variance Hedging, *Journal of Futures Markets*, 20, 1, 89-103 (2000), Originally published in 1992.

Cecchetti, S.G., Cumby, R.E., and Figlewski, S. (1988), Estimation of Optimal Futures Hedge. *Review of Economics and Statistics*, 70, 623-630.

Cheung, Y.W. and. Fung, H.G. (1997), Information Flows between Eurodollar Spot and Futures Markets, *Multinational Finance Journal*, 1, 255–271

Ederington, L.H. (1979), The Hedging Performance of the New Futures Markets, *Journal of Finance*, 36, 157-170.

Engel R.F. and Granger, C. (1987), Cointegration and Error Correction: Representation, Estimation and Testing, *Econometrica*, 55, 251-276.

Ghosh, A., Saidi, R. and Johnson, K.H. (1999), Who Moves the Asia-Pacific Stock Markets-U.S. or Japan? Empirical Evidence Based on the Theory of Cointegration, *Financial Review*, 34, 159–170.

Harris, F.H., McInish, T.H., Shoesmith, G.L., and Wood, R.A. (1995), Cointegration, Error Correction, and Price Discovery on Informationally Linked Security Markets, *Journal of Financial and Quantitative Analysis*, 30,563–579.

Holmes, P. (1995), Ex-ante Hedge Ratios and the Hedging Effectiveness of the FTSE-100 Stock Index Futures Contract, *Applied Economics Letters*, 2, 56-59.

Johnson, L. (1960), The Theory of Hedging and Speculation in Commodity Futures, *Review of Economic Studies*, 27, 139-151.

Kolamkar, D.S. (2003), Regulation and Policy Issues for Commodity Derivatives in India, *http://www.igidr.ac.in/~susant/DERBOOK/PAPERS/dsk_draft1.pdf*, accessed on 20, January, 2009.

Kumar, B., Singh, P., and Pandey, A. (2008), Hedging Effectiveness and Optimal Hedge Ratio in Indian Stock and Commodity Derivatives Markets, *IIMA Working Paper Series,* 2008-04-04, Indian Institute of Management, Ahmedabad, India.

Lypny, G., and Powalla, M. (1998), The Hedging Effectiveness of DAX Futures, *European Journal of Finance*, 4, 345-355.

Naik, G. and Jain, S.K. (2002), Indian Agricultural Commodity Futures Markets: A Performance Survey, *Economic and Political Weekly*, XXXVII (30).

Nair, C.K.G. (2004), Commodity Futures Markets in India: Ready for "Take-Off"?, *NSE News,* July.

Park, T.H. and Switzer, L.N. (1995a). Bivariate GARCH Estimation of the Optimal Hedge Ratios for Stock Index Futures: A Note, *Journal of Futures Markets*, 15, 61–67.

Park, T.H. and Switzer, L.N. (1995b), Time-varying Distributions and the Optimal Hedge Ratios for Stock Index Futures, *Applied Financial Economics*, 5, 131-137.

Pennings, J.M.E., and Meulenberg, M.T.G. (1997), Hedging Efficiency: A Futures Exchange Management Approach, *Journal of Futures Markets*, 17, 599-615.

Rolfo, J. (1980), Optimal Hedging under Price and Quantity Uncertainty: The Case of a Cocoa Producer, *Journal of Political Economy*, 88, 100-116.

Roy, A. and Kumar, B. (2007), A Comprehensive Assessment of Wheat Futures Market: Myths and Reality, Paper presented at *International Conference on Agribusiness and Food Industry in Developing Countries: Opportunities and Challenges*, held at IIM Lucknow, August 10-12, 2007.

Sahadevan, K.G. (2002), Sagging Agricultural Commodity Exchanges: Growth Constraints and Revival Policy Options, *Economic and Political Weekly*, XXXVII (30).

Samuelson, P.A. (1965), Proof that Properly Anticipated Prices Fluctuate Randomly, *Industrial Management Review*, 6, 41–63.

Thomas, S. (2003), Agricultural Commodity Markets in India: Policy Issues for Growth, Mimeo, *Indira Gandhi Institute for Development Research*, Mumbai, India.

Thomas, S. and Karande, K. (2002), Price Discovery Across Multiple Spot and Futures Markets, *http://www.igidr.ac.in/~susant/PDFDOCS/ThomasKarande2001_pricediscovery_castor.pdf*

Tomek, W.G. (1980), Price Behavior on a Declining Terminal Market, *American Journal of Agricultural Economics*, 62, 434-445.

Working (1948), Theory of the Inverse Carrying Charge in Futures Markets, *Journal of Farm Economics*, 30(2), 1-28.

Working (1949), The Theory of the Price of Storage, *American Economic Review*, 39(12), 1254-62.

Appendix

Appendix 1(a). Estimates of VECM model: Near month futures for the entire period (2004-2008)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.064*	-0.299*	0.307*	-0.085	0.010	-0.063	-0.029	0.152*	-0.040	-0.025	0.028
Maize	0.005*	-0.042*	0.041*	0.148*	0.038	0.136*	--	0.058#	0.043	0.009	--
Castor Seed	-0.002*	-0.074*	0.074*	-0.350*	-0.043	--	--	0.454*	0.067	--	--
Guar Seed	-0.015	-0.032	0.034	-0.520*	-0.203*	-0.008	--	0.668*	0.214*	0.044	--
Gold	0.011*	-0.191*	0.190*	-0.577*	-0.259*	-0.112#	-0.083 *	0.806*	0.472*	0.235*	0.105#
Silver	0.026*	-0.177*	0.175*	-0.481*	-0.239*	-0.105*	-0.097 *	0.685*	0.331*	0.195*	0.098*
Aluminium	-0.008*	-0.142*	0.143*	-0.329*	-0.145*	-0.091*	--	0.545*	0.223*	0.068	--
Copper	0.016*	-0.177*	0.174*	-0.618*	-0.362*	-0.159*	0.011	0.78*	0.545*	0.283*	0.126*
Zinc	-0.013*	-0.464*	0.466*	-0.297*	-0.137*	-0.060#	--	0.418*	0.282*	0.126*	--
Crude Oil	-0.032*	-0.354*	0.358*	-0.228*	-0.052	--	--	0.589*	0.221*	--	--
Natural Gas	-0.038*	-0.515*	0.522*	-0.140*	--	--	--	0.240*		--	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	C_F	$\chi_{F,EC}$	$\gamma_{S,EC}$	$\chi_{F,1}$	$\chi_{F,2}$	$\chi_{F,3}$	$\chi_{F,4}$	$\gamma_{S,1}$	$\gamma_{S,2}$	$\gamma_{S,3}$	$\gamma_{S,4}$
Soybean	-0.027*	-0.125*	0.129*	-0.164*	-0.180*	-0.127#	-0.032	0.168 *	0.153 #	0.077	0.089
Maize	0.001	-0.008	0.008	-0.007	-0.039	0.050	--	0.089	0.078	0.025	--
Castor Seed	0.002#	0.047	-0.048	0.166*	0.098	--	--	-0.148#	0.019	--	--
Guar Seed	0.052*	0.108*	-0.115*	0.132*	-0.033	-0.033	--	-0.034	-0.013	0.131*	--
Gold	-0.003	0.075	-0.075	0.085	0.002	0.047	0.015	-0.012	0.004	0.072	-0.047
Silver	-0.021#	0.148*	-0.146*	0.060	0.016	0.149*	-0.011	-0.060	0.016	0.023	-0.068
Aluminium	0.006#	0.098#	-0.099#	0.058	-0.118#	-0.061	--	0.114	0.098	0.096	--
Copper	-0.007	0.079	-0.078	0.054	0.173#	0.116	0.195*	-0.196*	-0.111	-0.118	-0.023
Zinc	-0.002	-0.050	0.050	-0.044	-0.046	-0.054	--	0.049	0.041	0.033	--
Crude Oil	0.001	0.001	-0.001	-0.071	-0.060	--	--	0.077	-0.015	--	--
Natural Gas	-0.027*	-0.125*	0.129*	-0.164*	-0.180*	-0.127#	-0.032	0.168 *	0.153 #	0.077	0.089

*(#) denotes significance of estimates at 1% (5%) level

Appendix 1(b). Estimates of VECM model: Near month futures for the first sub-period (2004-2006)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.245*	-0.344*	0.378*	-0.046	-0.100	-0.185*	-0.006	0.059	0.028	0.027	0.058
Maize	0.028*	-0.050*	0.046*	0.140*	0.015	0.186*	--	0.075	0.064	-0.019	--
Castor Seed	-0.028*	-0.052*	0.057*	-0.321*	--	--	--	0.482*	--	--	--
Guar Seed	-0.017	-0.062	0.064	-0.546*	-0.237*	-0.017	--	0.719*	0.243*	0.076	--
Gold	0.067*	-0.290*	0.282*	-0.441*	-0.165*	0.005	--	0.686*	0.386*	0.145#	--
Silver	0.033*	-0.184*	0.180*	-0.431*	-0.247*	-0.174*	-0.105*	0.696*	0.334*	0.243*	0.167*
Aluminium	-0.045	-0.075#	0.084#	-0.250*	-0.129	-0.099	--	0.482*	0.151#	0.044	--
Copper	0.057*	-0.242*	0.232*	-0.631*	-0.342*	-0.115*	--	0.796*	0.667*	0.280*	--
Zinc	-0.088*	-0.345*	0.362*	-0.259*	-0.115	-0.161*	--	0.492*	0.178	0.153	--
Crude Oil	-0.006*	-0.325*	0.325*	-0.180*	-0.103*	--	--	0.542*	0.210*	--	--
Natural Gas	-0.427*	-0.404*	0.477*	--	--	--	--		--	--	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	C_F	$\chi_{F,EC}$	$\gamma_{S,EC}$	$\chi_{F,1}$	$\chi_{F,2}$	$\chi_{F,3}$	$\chi_{F,4}$	$\gamma_{S,1}$	$\gamma_{S,2}$	$\gamma_{S,3}$	$\gamma_{S,4}$
Soybean	-0.068	-0.095	0.104	-0.111	-0.030	-0.020	0.025	0.086	0.014	-0.025	0.089
Maize	0.013	-0.021	0.020	-0.009	-0.053	0.022	--	0.137#	0.123	0.072	--
Castor Seed	0.026#	0.049#	-0.053#	0.174*	--	--	--	-0.069	--	--	--
Guar Seed	0.043*	0.146*	-0.151*	0.207*	0.027	0.005	--	-0.118	-0.067	0.114	--
Gold	-0.001	0.007	-0.007	-0.087	-0.135	-0.067	--	0.160	0.171	0.163*	--
Silver	-0.05*	0.293*	-0.288*	0.082	0.048	0.241#	0.042	-0.151	-0.022	-0.034	-0.075
Aluminium	0.075#	0.122#	-0.137#	0.046	-0.103	-0.142	--	0.159	0.209#	0.265*	--
Copper	0.020	-0.079	0.076	-0.144	-0.052	-0.032	--	0.052	0.080	0.090#	--
Zinc	0.024	0.085	-0.089	0.083	-0.068	0.024	--	0.019	0.033	0.141	--
Crude Oil	0.000	-0.019	0.019	-0.159#	-0.130	--	--	0.130	-0.006	--	--
Natural Gas	0.1214	0.1154	-0.136	--	--	--	--	--	--	--	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 1(c). Estimates of VECM model: Near month futures for the second sub-period (2007-2008)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.018*	-0.249	0.252*	-0.164#	--	--	--	0.261*	--	--	--
Maize	-0.003	-0.066	0.067	-0.321*	--	--	--	0.400*	--	--	--
Castor Seed	-0.005	-0.007	0.008	-0.445*	-0.111#	--	--	0.465*	0.135*	--	--
Guar Seed	-0.139*	-0.073*	0.094*	0.184*	--	--	--	-0.002	--	--	--
Gold	-0.045*	-0.279*	0.284*	-0.548*	-0.179#	-0.059	-0.102*	0.745*	0.386*	0.158#	0.049
Silver	-0.007*	-0.197*	0.198*	-0.571*	-0.224*	0.019	-0.076#	0.672*	0.336*	0.127#	-0.008
Aluminium	-0.034*	-0.299*	0.306*	-0.427*	-0.257*	-0.156#	-0.014	0.583*	0.355*	0.189#	0.078
Copper	-0.152*	-0.501*	0.527*	-0.257*	-0.122#	-0.008	0.010	0.522*	0.275*	0.151#	0.050
Zinc	-0.007*	-0.687*	0.688*	-0.170*	-0.055	--	--	0.235*	0.203*	--	--
Crude Oil	-0.018*	-0.436*	0.438*	-0.237*	-0.001	--	--	0.571*	0.212*	--	--
Natural Gas	0.041*	-1.005*	0.998*	--	--	--	--	--	--	--	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	C_F	$\chi_{F,EC}$	$\gamma_{S,EC}$	$\chi_{F,1}$	$\chi_{F,2}$	$\chi_{F,3}$	$\chi_{F,4}$	$\gamma_{S,1}$	$\gamma_{S,2}$	$\gamma_{S,3}$	$\gamma_{S,4}$
Soybean	-0.001	0.026	-0.026	-0.038	--	--	--	0.070	--	--	--
Maize	0.055	-0.037	0.029	0.010	--	--	--	0.060	--	--	--
Castor Seed	0.008	-0.099	0.098	0.120	--	--	--	-0.151	--	--	--
Guar Seed	0.053#	-0.079#	0.072#	-0.035	-0.110	--	--	0.182	0.009	--	--
Gold	0.021	-0.123	0.121	0.225#	0.095	0.114	-0.027	-0.165	-0.101	0.054	-0.075
Silver	0.001	-0.027	0.027	0.127	0.049	0.042	-0.044	-0.068	-0.049	0.086	-0.057
Aluminium	0.026#	-0.231#	0.226#	0.222#	0.026	0.214#	0.065	-0.080	-0.165	-0.149	-0.034
Copper	0.070	-0.245	0.233	0.240	0.402*	0.156	0.294*	-0.459*	-0.172	-0.251#	0.002
Zinc	-0.003	0.069	-0.068	-0.050	0.040	--	--	0.000	-0.040	--	--
Crude Oil	0.001	0.000	0.000	-0.023	-0.005	--	--	0.038	-0.018	--	--
Natural Gas	0.003	0.049	-0.050	--	--	--	--	--	--	--	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 2(a). Estimates of VECM model: Next to near month futures for the entire period (2004-2008)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.064*	-0.088*	0.097*	-0.083#	--	--	--	0.286*	--	--	--
Maize	0.007*	-0.022*	0.021*	0.173*	0.055	0.135*	--	0.050	0.029	0.029	--
Castor Seed	-0.019*	-0.039*	0.043	-0.403*	-0.058	--	--	0.508*	0.101#	--	--
Guar Seed	0.001*	--	--	-0.514*	-0.238*	-0.034	--	0.720*	0.255*	0.116*	--
Gold	0.001#	-0.053#	0.053#	-0.686*	-0.341*	-0.161*	-0.097*	0.947*	0.563*	0.301*	0.138*
Silver	0.020*	-0.090*	0.088*	-0.550*	-0.279*	-0.114*	-0.096*	0.797*	0.397*	0.228*	0.101*
Aluminium	-0.019*	-0.063*	0.067*	-0.368*	-0.135*	-0.070#	--	0.601*	0.229*	0.038	--
Copper	0.006*	-0.056*	0.055*	-0.645*	-0.389*	-0.177*	-0.006	1.016*	0.677*	0.393*	0.168*
Zinc	-0.025*	-0.241*	0.246*	-0.430*	-0.202*	-0.080*	--	0.648*	0.410*	0.172*	--
Crude Oil	-0.025*	-0.102*	0.105*	-0.446*	-0.284*	-0.163*	-0.076*	0.897*	0.477*	0.280*	0.126*
Natural Gas	0.003#	--	--	-0.432*	-0.219*	-0.081#	--	0.990*	0.442*	0.329*	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	C_F	$\chi_{F,EC}$	$\gamma_{S,EC}$	$\chi_{F,1}$	$\chi_{F,2}$	$\chi_{F,3}$	$\chi_{F,4}$	$\gamma_{S,1}$	$\gamma_{S,2}$	$\gamma_{S,3}$	$\gamma_{S,4}$
Soybean	-0.021*	-0.029*	0.031*	-0.014	--	--	--	0.000	--	--	--
Maize	0.004	-0.011	0.010	-0.036	-0.054	0.071	--	0.098	0.025	-0.056	--
Castor Seed	-0.004	-0.008	0.009	0.115#	0.064	--	--	-0.134#	0.039		--
Guar Seed	0.000#	--	--	0.036	-0.043	-0.018	--	0.020	0.003	0.134*	--
Gold	0.000	0.056	-0.056	0.076	-0.021	0.051	0.034	0.007	0.005	0.054	-0.057
Silver	-0.021#	0.103#	-0.101#	0.027	-0.006	0.159#	-0.013	-0.032	0.011	0.014	-0.068
Aluminium	0.015#	0.050#	-0.052#	0.080	-0.039	-0.060	--	0.051	0.052	0.083#	--
Copper	-0.005	0.044	-0.043	0.027	0.104	0.077	0.173*	-0.124	-0.071	-0.085	-0.021
Zinc	-0.006	-0.047	0.048	-0.022	-0.005	-0.033	--	0.022	0.017	0.028	--
Crude Oil	0.009	0.035	-0.036	-0.029	-0.011	0.080	0.036	0.038	-0.063	-0.048	0.031
Natural Gas	-0.001	--	--	0.000	-0.011	-0.050	--	0.050	0.018	-0.027	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 2(b). Estimates of VECM model: Next to near month futures for the first sub-period (2004-2006)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.035*	-0.142*	0.146*	-0.181*	-0.146*	-0.211*	-0.006	0.398*	0.159#	0.115	0.142#
Maize	0.000	--	--	0.064	0.064	0.161*	0.122#	0.263*	0.054	0.056	-0.081
Castor Seed	-0.039#	-0.031#	0.038#	-0.442*	-0.103	0.005	-0.107#	0.568*	0.174*	0.021	0.039
Guar Seed	-0.005	-0.013	0.014	-0.631*	-0.304*	-0.058	--	0.765*	0.307*	0.127*	--
Gold	0.055*	-0.128*	0.122*	-0.564*	-0.251*	-0.025	--	0.836*	0.473*	0.196*	--
Silver	0.053#	-0.114#	0.108#	-0.484*	-0.279*	-0.181*	-0.104	0.791*	0.386*	0.273*	0.167*
Aluminium	0.000	--	--	-0.123#	--	--	--	0.503*	--	--	--
Copper	-0.001	--	--	-0.527*	-0.170*	0.003	0.040	1.051*	0.511*	0.112	-0.102
Zinc	-0.101*	-0.138*	0.158*	-0.346*	-0.151#	-0.166*	--	0.719*	0.246*	0.172	--
Crude Oil	0.033*	-0.188*	0.183*	-0.251*	-0.138*		--	0.731*	0.288*	--	--
Natural Gas	0.005	--	--	-0.105	-0.062	-0.060	--	1.044*	0.143	0.176	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	C_F	$\chi_{F,EC}$	$\gamma_{S,EC}$	$\chi_{F,1}$	$\chi_{F,2}$	$\chi_{F,3}$	$\chi_{F,4}$	$\gamma_{S,1}$	$\gamma_{S,2}$	$\gamma_{S,3}$	$\gamma_{S,4}$
Soybean	-0.012*	0.050*	-0.049*	0.057	-0.002	-0.029	0.014	-0.035	-0.008	0.014	0.020
Maize	0.000	--	--	0.136*	-0.069	0.110#	0.110#	0.103	0.097	-0.064	-0.133#
Castor Seed	0.001	-0.001	0.001	0.179*	0.097	-0.097	0.045	-0.155#	0.048	0.115	-0.111
Guar Seed	0.038*	-0.091*	0.086*	0.176*	0.012	0.002	--	-0.103	-0.040	0.128#	--
Gold	-0.013	-0.030	0.032	-0.055	-0.129	-0.048	--	0.145	0.148	0.154*	--
Silver	-0.091*	-0.191*	0.201*	-0.003	-0.028	0.208	0.029	-0.075	0.017	-0.022	-0.069
Aluminium	-0.001	--	--	0.095	--	--	--	0.148#	-	--	--
Copper	0.001	--	--	-0.060	0.009	0.130	0.219*	-0.016	-0.079	-0.082	-0.066
Zinc	0.057	-0.085	0.074	0.129	-0.009	0.086	--	-0.013	-0.027	0.136	--
Crude Oil	0.003	0.015	-0.016	-0.158#	-0.129	--	--	0.128#	0.007	--	--
Natural Gas	-0.005	--	--	0.029	-0.276#	0.062	--	0.263*	-0.010	-0.091	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 2(c). Estimates of VECM model: Next to near month futures for the second sub-period 1 (2007-2008)

i. Spot prices

	C_S	$\chi_{S,EC}$	$\gamma_{F,EC}$	$\chi_{S,1}$	$\chi_{S,2}$	$\chi_{S,3}$	$\chi_{S,4}$	$\gamma_{F,1}$	$\gamma_{F,2}$	$\gamma_{F,3}$	$\gamma_{F,4}$
Soybean	-0.039*	-0.079*	0.085*	-0.060	--	--	--	0.232*	--	--	--
Maize	-0.146*	-0.038*	0.060*	0.164*	--	--	--	0.020	--	--	--
Castor Seed	0.001#	--	--	-0.133*	--	--	--	0.612*	--	--	--
Guar Seed	-0.016	-0.016	0.018	-0.457*	-0.116#	--	--	0.445*	0.128*	--	--
Gold	-0.052#	-0.102#	0.108#	-0.682*	-0.278*	-0.129#	-0.119*	0.930*	0.513*	0.251*	0.112
Silver	-0.098*	-0.160*	0.169*	-0.613*	-0.240*	0.031	-0.069#	0.745*	0.374*	0.126#	-0.021
Aluminium	-0.030	-0.081	0.087	-0.587*	-0.308*	-0.185*	-0.034	0.775*	0.463*	0.215*	0.138#
Copper	-0.236*	-0.368*	0.408*	-0.333*	-0.195*	-0.058	-0.002	0.695*	0.367*	0.247*	0.101
Zinc	-0.026*	-0.505*	0.508*	-0.325*	-0.176*	-0.015	--	0.437*	0.373*	0.128#	--
Crude Oil	0.000	--	--	-0.423*	-0.161*	-0.125#	-0.073#	1.010*	0.404*	0.160#	0.148#
Natural Gas	0.002	--	--	-0.559*	-0.332*	-0.132*	--	0.978*	0.560*	0.440*	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

	CS	χF,EC	γS,EC	χF,1	χF,2	χF,3	χF,4	γS,1	γS,2	γS,3	γS,4
Soybean	-0.017	0.038	-0.036	-0.067	--	--	--	0.020	--	--	--
Maize	0.015	-0.006	0.004	-0.060	--	--	--	0.096	--	--	--
Castor Seed	0.000	--	--	0.142#	--	--	--	-0.006	--	--	--
Guar Seed	0.065#	-0.074#	0.065#	-0.025	-0.110	--	--	0.193	0.003	--	--
Gold	0.056	-0.113	0.107	0.213*	0.058	0.097	-0.022	-0.134	-0.078	0.050	-0.076
Silver	0.049	-0.084	0.079	0.198*	0.119	0.099	-0.045	-0.127	-0.112	0.070	-0.047
Aluminium	0.058*	-0.168*	0.156*	0.204*	0.064	0.061	-0.017	-0.125	-0.091	-0.058	-0.015
Copper	0.087	-0.151	0.136	0.148	0.284#	0.078	0.258#	-0.333*	-0.087	-0.199#	0.007
Zinc	-0.010	0.158	-0.157	-0.139	-0.031	-0.064	--	0.078	0.031	-0.033	--
Crude Oil	0.001	--	--	-0.024	0.014	0.009	0.114	0.022	-0.046	-0.033	0.061
Natural Gas	0.000	--	--	-0.005	0.043	-0.103	--	0.009	0.020	-0.004	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 3. Parameter estimates of VECM

i. Indian futures prices

Commodity	CIN	$\gamma_{WF,EC}$	$\chi_{IN,EC}$	$\gamma_{WF,1}$	$\gamma_{WF,2}$	$\gamma_{WF,3}$	$\chi_{WF,4}$	$\chi_{IN,1}$	$\chi_{IN,2}$	$\chi_{IN,3}$	$\chi_{IN,4}$
Gold	$0.035^{\#}$	$0.189^{\#}$	$-0.191^{\#}$	0.535^{*}	0.284	-0.137	--	-0.56^{*}	-0.306	0.203	--
Silver	$0.045^{\#}$	$0.119^{\#}$	$-0.123^{\#}$	$0.277^{\#}$	0.251	--	--	$-0.299^{\#}$	$-0.35^{\#}$	--	--
Aluminium	0.3530	0.299^{*}	-0.37^{*}	-0.110	-0.039	-0.040	0.0469	$0.220^{\#}$	0.055	0.040	-0.061
Copper	-0.023	0.093	-0.089	-0.035	-0.162	-0.088	--	0.034	0.079	$0.254^{\#}$	--
Zinc	0.067	0.3076	-0.320	-0.345	$-0.36^{\#}$	$-0.26^{\#}$	--	$0.525^{\#}$	0.205	$0.380^{\#}$	--
Crude Oil	-0.015	$0.0646^{\#}$	$-0.062^{\#}$	-0.026	-0.081	--	--	-0.013	0.059	--	--
Natural Gas	0.001	-0.006	0.006	-0.0167	-0.007	--	--	0.055	$-0.13^{\#}$	--	--

*(#) denotes significance of estimates at 1% (5%) level

ii. Futures prices

Commodity	C_{WF}	$\chi_{WF,EC}$	$\gamma_{IN,EC}$	$\chi_{WF,1}$	$\chi_{WF,2}$	$\chi_{WF,3}$	$\chi_{WF,4}$	$\gamma_{IN,1}$	$\gamma_{IN,2}$	$\gamma_{IN,3}$	$\gamma_{IN,4}$
Gold	0.018	0.094	-0.096	0.123	0.096	-0.253	-0.125	-0.107	0.293	--	--
Silver	0.030	0.075	-0.077	-0.110	0.143	--	0.089	-0.241		--	--
Aluminium	0.032	0.027	-0.034	-0.33^{*}	$-0.227^{\#}$	-0.0934	0.387^{*}	0.144	0.06	0.036	$-0.13^{\#}$
Copper	0.031	-0.111	0.106	-0.630^{*}	-0.44^{*}	-0.198^{*}	0.688^{*}	0.508^{*}	0.396^{*}	--	--
Zinc	$-0.095^{\#}$	$-0.431^{\#}$	$0.449^{\#}$	-0.517^{*}	-0.41^{*}	-0.302^{*}	0.790^{*}	$0.364^{\#}$	0.499^{*}	--	--
Crude Oil	0.0192	-0.0675	0.0652	-0.492^{*}	-0.31^{*}	--	0.366^{*}	0.219^{*}	--	--	--
Natural Gas	0.060^{*}	-0.45^{*}	0.438^{*}	-0.654^{*}	-0.34^{*}	--	0.328	0.344	--	--	--

*(#) denotes significance of estimates at 1% (5%) level

Appendix 4. Parameter estimates of the VECM-MGARCH (1,1) model with constant conditional correlation

i. Near month futures for the entire period (2004-2008)

Parameters	Soybean	Corn	Castor seed	Guar seed	Gold	Silver	Aluminium	Copper	Zinc	Crude	Natural gas
ω_S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α_S	0.43	0.6	0.14	0.10	0.18	0.15^{*}	0.38	$0.26^{\#}$	0.13	$0.26^{\#}$	0.45
β_S	$0.57^{\#}$	0.02	0.21	0.82^{*}	0.71^{*}	0.84^{*}	0.05	0.69^{*}	0.42^{*}	0.02	0.55^{*}
ω_F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α_F	$0.81^{\#}$	$0.02^{\#}$	0.05	0.05^{*}	0.05^{*}	$0.14^{\#}$	0.09^{*}	0.07^{*}	0.04	0.05	$0.09^{\#}$
β_F	0.19	0.97^{*}	0.23	0.90^{*}	0.94^{*}	0.85^{*}	0.84^{*}	0.91^{*}	0.60^{*}	0.00	0.89^{*}
ρ	0.80^{*}	0.49^{*}	0.70^{*}	0.66^{*}	0.49^{*}	0.37^{*}	0.38^{*}	0.20^{*}	0.44^{*}	0.44^{*}	0.50^{*}

*(#) denotes significance of estimates at 1% (5%) level

ii. Next to near month futures for the entire period (2004-2008)

Parameters	Soybean	Corn	Castor seed	Guar seed	Gold	Silver	Aluminium	Copper	Zinc	Crude	Natural gas
ω_S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α_S	0.43	0.60	0.14	0.10	0.18	0.15^{*}	0.38	$0.26^{\#}$	0.13	$0.26^{\#}$	0.45
β_S	$0.57^{\#}$	0.02	0.21	0.82^{*}	0.71^{*}	0.84^{*}	0.05	0.69^{*}	0.42^{*}	0.02	0.55^{*}
ω_F	0.00	0.00	0.00^{*}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α_F	$0.81^{\#}$	$0.02^{\#}$	0.05	0.05^{*}	0.05^{*}	$0.14^{\#}$	0.09^{*}	0.07^{*}	0.04	0.05	$0.09^{\#}$
β_F	0.19	0.97^{*}	0.23	0.90^{*}	0.94^{*}	0.85^{*}	0.84^{*}	0.91^{*}	0.60^{*}	0.00	0.89^{*}
ρ	0.80^{*}	0.49^{*}	0.70^{*}	0.66^{*}	0.49^{*}	0.37^{*}	0.38^{*}	0.20^{*}	0.44^{*}	0.44^{*}	0.50^{*}

*(#) denotes significance of estimates at 1% (5%) level

Appendix 5. Speculation ratio in near month futures contracts