Inspira- Journal of Modern Management & Entrepreneurship
ISSN : 2231–167 X, Volume 04 No. 02, April, 2014 pp. 279- 294

COMMODITY RISK MANAGEMENT – HEDGING AS A TOOL: EMPIRICAL EVIDENCE OF INDIAN COMMODITY MARKET

Dr. P.Sri Ram*

Risk management and price discovery are the two main functions of futures market. Futures markets were established with the prime objective of enabling companies and individuals to insure against the possible adverse effects of changes in interest and exchange rates. Similarly, futures were established to enable portfolio managers and other investors to insure against the possible adverse effects of changes in stock prices. Thus the main role of financial futures markets is the reduction of risk or 'hedging'. 'Hedging' has the significant role in stabilizing the market, realizing market efficiency and enabling minimization of risk and thus maximizing utility. The volatile financial market today has taken financial risk as centre point in every sphere of economic activity. Therefore, hedging of risk has become a very important concern worldwide.

However, ***hedging is still an underutilized tool*** that many choose not to use. International practices for hedging against commodity price risk involve both static and dynamic hedging techniques. In a static hedge, the physical commodity price is locked in by hedging in futures market. This is irrespective of whether the commodity price increases or decreases, the underlying objective being protection against market risk. In a dynamic hedge, judgmental positions are taken in futures markets, based on specific presumptions on possible price movements in the physical market. This may depend on fundamental factors of demand and supply that impact commodity prices. Dynamic hedge involves greater risk as compared with a static hedge.

Scope of the Study

This paper investigates optimal hedge ratio (constant and dynamic) and hedging effectiveness of three Agricultural (Potato, Mentha Oil & Wheat) and six Non-agricultural (Gold, Silver, Aluminium, Copper, Crude oil and Natural gas) futures contracts traded on national commodity exchanges (National Commodity and Derivatives Exchange (NCDEX), and Multi Commodity Exchange (MCX)) in India, using OLS, VAR, VECM & VECM-MGARCH models.

Objectives of the Study

- To estimate the hedge ratio and hedging effectiveness for select actively traded Indian commodity futures using selected models
- To determine the impact of hedging on the select actively traded Indian commodity futures using selected models and highlight the reasons for high/ low hedging effectiveness in Indian commodity futures market

* Assistant Professor, Department of Commerce, Goa University, Goa – 403 206, India,

Data Collected for the Study

- The study is based on secondary data i.e. spot and futures prices of Gold, Silver, Aluminium, Copper, Crude Oil, Natural Gas, Mentha Oil, Potato and Wheat, and has been collected from www.mcx.com & www.ncdex.com for a period of 4 years from March 2008 to March 2012. This study analysis the near month contracts and next to near month contracts, where trading volume is high.
- The commodities selected in this study are the ones that are most actively traded in the MCX and NCDEX market in terms of trading volume of the commodity futures contracts. (See Annexure 1 to 3)

Methodology for the Study

Daily returns for all the commodities (spot and futures) are calculated by the following equations:

$$R_{s,t} = ln\left[\frac{S_t}{S_{t-1}}\right] \qquad R_{f,t} = ln\left[\frac{F_t}{F_{t-1}}\right]$$

Where R_s and R_f represent daily spot and futures returns respectively. Closing prices of all the commodities are shown by S_t for Spot and F_t for Future, on the corresponding day *t*.

To Investigate the Hedge Ratios and 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 un-hedged and a hedged portfolio can be written as:

$R_U = S_{t+1} - S_t$

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

Variances of an un-hedged and a hedged portfolio are:

Var (U) = σ_s^2

Var (H) = $\sigma_s^2 + H^2\sigma_f^2 - 2H\ \sigma_{s,f}$

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 hedged and un-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 un-hedged position minus variance of hedged position over the variance of un-hedged position.

$$Effectiveness\ (E) = \frac{(var\ (U) - var(H)}{var\ (U)}$$

Models for Estimating Hedging Effectiveness and Hedge Ratio

Several models are generally used to estimate constant and dynamic hedge ratio and hedging effectiveness. The OLS, VAR and VECM models estimate constant hedge ratio whereas the dynamic hedge ratio is estimated through VECM-Multivariate GARCH model

Diagnostic Tests

The returns are calculated as the first difference of the log of the daily closing price for both spot and futures data. The results show that daily spot and future return for all the commodities have positive kurtosis and high Jarque-Bera statistics, which implies that the distribution is skewed to the right and they are leptokurtic (heavily tailed and sharp peaked), i.e., the frequency distribution assigns a higher probability to returns around zero as well as very high positive and negative returns.

The Jarque–Bera statistic test indicates that the null hypothesis of normality is rejected and shows that all the series exhibit non-normality and presence of

heteroscedasticity. Thus, VECM-MGARCH model is more suitable for testing of hypothesis. The time-series of spot and futures price for all the commodities covered in this study are highlighted in Figure 1.

Tests of Unit Root and Co Integration

This study uses Augmented Dickey Fuller model to test for the presence of unit root in the spot and futures price (log) series and return series. The results of ADF test presented in Table 12 – Table 14 indicate that the t-statistics for all the return series is less than the critical values at 1%, 5% and 10% confidence level. On the other hand, the t-statistics for all the price (log) series is higher than the critical values at 1%, 5% and 10% confidence level. Thus, the ADF test statistics confirm that the return series are stationary and the price series (log) have a unit root (non-stationary). In order to test the co-integration between spot and future prices we used the Johnson's maximum likelihood test (1991). The results of Johnson's co-integration test suggest that all the spot and futures price (log) series have at-least one co-integrating vector and they are co integrated in the long run. The results of co-integration test are presented in Annexure.

Table 1 Johnson's Test of Co-integration (log series for spot and near month contract)

	Hypothesized Number of CE	Eigen Values	Trace Statistics	Critical Value	Prob.
GOLD	None*	0.10752	121.42100	15.49471	0.00010
	At most 1	0.00005	0.04864	3.84147	0.82540
SILVER	None*	0.10635	122.17370	15.49471	0.00010
	At most 1	0.00005	0.05859	3.84147	0.80870
ALUMINIUM	None*	0.12520	143.64410	15.49471	0.00010
	At most 1	0.00278	2.92426	3.84147	0.08730
COPPER	None*	0.09308	102.83280	15.49471	0.00010
	At most 1	0.00099	1.02968	3.84147	0.31020
CRUDE OIL	None*	0.16148	173.62800	15.49471	0.00010
	At most 1	0.00160	1.56159	3.84147	0.21140
NATURAL GAS	None*	0.16105	166.77450	15.49471	0.00010
	At most 1	0.00238	2.23621	3.84147	0.13480
MENTHA OIL	None*	0.03066	30.31649	15.49471	0.00020
	At most 1	0.00068	0.64494	3.84147	0.42190
WHEAT	None*	0.04445	28.22868	15.49471	0.00040
	At most 1*	0.00777	4.13277	3.84147	0.04210
POTATO	None*	0.03819	37.54479	15.49471	0.00000
	At most 1*	0.00666	5.49713	3.84147	0.01900

Table 2 Johnson's Test of Co-integration (log series for spot and next to near month Contract)

	Hypothesized Number of CE	Eigen Values	Trace Statistics	Critical Value	Prob.
GOLD	None *	0.1075	121.4210	15.4947	0.0001
	At most 1	0.0000	0.0486	3.8415	0.8254
SILVER	None *	0.1064	122.1737	15.4947	0.0001
	At most 1	0.0001	0.0586	3.8415	0.8087
ALUMINIUM	None *	0.1252	143.6441	15.4947	0.0001
	At most 1	0.0028	2.9243	3.8415	0.0873
COPPER	None *	0.0931	102.8328	15.4947	0.0001
	At most 1	0.0010	1.0297	3.8415	0.3102
CRUDE OIL	None *	0.1615	173.6280	15.4947	0.0001
	At most 1	0.0016	1.5616	3.8415	0.2114
NATURAL GAS	None *	0.1610	166.7745	15.4947	0.0001

	At most 1	0.0024	2.2362	3.8415	0.1348
MENTHA OIL	None *	0.0307	30.3165	15.4947	0.0002
	At most 1	0.0007	0.6449	3.8415	0.4219
WHEAT	None *	0.0444	28.2287	15.4947	0.0004
	At most 1 *	0.0078	4.1328	3.8415	0.0421
POTATO	None *	0.0382	37.5448	15.4947	0.0000
	At most 1 *	0.0067	5.4971	3.8415	0.0190

Hedging between Spot Price and Near Month Futures Contract:

OLS Regression Model Estimates

The results in Table 3 show the parameters of the model estimated using the ordinary least squares method. In case of the OLS method, the slope of the regression model is an estimate of the hedge ratio while R-square value gives the hedge effectiveness. The results in Table 3 show that the hedge ratio is maximum in case of Mentha Oil futures and minimum in case of Wheat futures. It is also observed that the hedge ratio for Gold, Silver, Aluminum and Crude Oil is around 0.5. The hedge effectiveness is quite high for Mentha Oil and Potato and low in case of Natural Gas, Copper, and Wheat.

Table 3 OLS Regression Model Estimates (spot and near month contract)

Category	**Commodity**	□	□□**(Hedge-Ratio)**	**R-Square**
PRECIOUS METALS	GOLD	0.00035	0.50212	0.25315
	SILVER	0.00037	0.55102	0.28395
NON-FERROUS METALS	ALUMINIUM	-0.00008	0.59646	0.26770
	COPPER	0.00020	0.22189	0.03534
ENERGY PRODUCTS	CRUDEOIL	0.00012	0.48126	0.17153
	NATURALGAS	-0.00078	0.35689	0.10495
AGRICULTURAL PRODUCTS	MENTHAOIL	0.00052	0.68537	0.57858
	POTATO	-0.00003	0.60953	0.56719
	WHEAT	0.00016	0.18994	0.08841

VAR Estimates

The estimates of the parameters of the spot and future equations as obtained using the VAR model is exhibited in Table 4. Table 5, illustrates the estimates of hedge ratio & the hedging effectiveness of the various future contracts using VAR Model.

Table 4 - ***Estimates of VAR model (spot and near month contract)***

		CONSTANT	**SPOT**		**FUTURES**	
			□□	□□	□□	□□
GOLD	Spot	0.00044	-0.61913	-0.21962	0.82799	0.36493
	Futures	0.00076	-0.06920	-0.05408	0.04229	0.02183
SILVER	Spot	0.00068	-0.64461	-0.30561	0.78075	0.36000
	Futures	0.00083	-0.10097	-0.12886	0.05110	0.06932
ALUMINIUM	Spot	-0.00014	-0.52143	-0.19622	0.69701	0.37559
	Futures	-0.00016	0.03126	0.04356	-0.00454	0.01717
COPPER	Spot	0.00003	-0.55785	-0.13980	0.98628	0.48036
	Futures	0.00020	0.00086	0.05389	0.04514	-0.01964
CRUDE OIL	Spot	0.00011	-0.53638	-0.17810	0.86326	0.37704
	Futures	0.00027	-0.00678	-0.02099	0.04854	0.01839
NATURAL GAS	Spot	-0.00053	-0.60790	-0.14688	0.88210	0.44236
	Futures	-0.00125	0.06549	0.02356	0.00541	-0.07210
MENTHA OIL	Spot	0.00151	-0.08235	-0.07693	0.28563	-0.01677
	Futures	0.00148	0.03330	0.04483	0.10840	-0.05136
POTATO	Spot	0.00050	0.03224	0.00471	0.03487	0.01436
	Futures	0.00089	0.03534	0.01919	0.01909	-0.02845

WHEAT	Spot	0.00016	0.16544	-0.02412	0.10090	0.02061
	Futures	0.00015	0.11612	-0.07715	-0.01842	-0.01202

Table 5 - ***Estimation of Hedge Ratio and Hedging Effectiveness***

	Covariance (Spot, Fut)	Variance (Spot)	Variance (Futures)	Hedge Ratio	Variance (Hedged)	Variance (Un-hedged)	Hedging Effectiveness
GOLD	0.00007	0.00008	0.00015	0.48579	0.00011	0.00015	0.25242
SILVER	0.00023	0.00030	0.00043	0.51945	0.00034	0.00047	0.28253
ALUMINIUM	0.00013	0.00022	0.00022	0.60067	0.00021	0.00029	0.26718
COPPER	0.00007	0.00016	0.00035	0.19104	0.00047	0.00049	0.03459
CRUDE OIL	0.00023	0.00041	0.00051	0.45483	0.00058	0.00070	0.17068
NATURAL GAS	0.00036	0.00056	0.00099	0.36035	0.00108	0.00121	0.10472
MENTHA OIL	0.00031	0.00036	0.00047	0.66890	0.00016	0.00038	0.57706
POTATO	0.00188	0.00202	0.00309	0.60755	0.00088	0.00202	0.56507
WHEAT	0.00002	0.00004	0.00011	0.18349	0.00004	0.00005	0.08810

VECM Estimates

Using the same approach as in case of VAR model, errors are estimated and hedging effectiveness and hedge ratio are calculated for VECM model and presented in Table 6 – Table 8. Table 8 illustrates the estimates of hedge ratio and the hedging effectiveness of the various future contracts. Although VECM model does not consider the conditional covariance structure of spot and futures price, but it is treated as best specified model for the estimations of constant hedge ratio and hedging effectiveness. VECM is used when the series are co-integrated.

Table 6- ***Estimates of VEC*** **Model** ***(Spot)***

	C_s	$\square_s$	$\square_f$	$\square_{s,t-1}$	$\square_{s,t-2}$	$\square_{f,t-1}$	$\square_{f,t-2}$
GOLD	0.03224	-0.56459	0.56124	-0.27822	-0.10866	0.37999	0.14350
SILVER	0.01851	-0.37319	0.37126	-0.41762	-0.22312	0.49663	0.21596
ALUMINIUM	-0.00876	-0.63948	0.64032	-0.12147	-0.01154	0.21536	0.11458
COPPER	-0.02337	-0.46516	0.46880	-0.28049	-0.04861	0.58273	0.27167
CRUDE OIL	-0.04115	-0.70739	0.71209	-0.09731	0.00762	0.30217	0.08864
NATURAL GAS	-0.00620	-0.97848	0.97876	-0.02665	0.02042	0.04340	0.00835
MENTHA OIL	-0.01008	-0.01556	0.01751	-0.07514	-0.07271	0.27607	-0.02420
POTATO	0.05661	-0.07702	0.06803	0.05512	0.02566	-0.00808	-0.02626
WHEAT	0.01501	-0.04620	0.04414	0.17032	-0.02191	0.06902	-0.00510

Table 7 - ***Estimates of VEC*** **Model** ***(Futures)***

	C_s	$\square_s$	$\square_f$	$\square_{s,t-1}$	$\square_{s,t-2}$	$\square_{f,t-1}$	$\square_{f,t-2}$
GOLD	0.00046	0.05817	-0.05813	-0.10421	-0.06530	0.08864	0.04473
SILVER	-0.00202	0.11878	-0.11844	-0.17316	-0.15498	0.14174	0.11529
ALUMINIUM	0.02548	0.09273	-0.09814	-0.02658	0.01762	0.06712	0.05657
COPPER	0.02546	0.23386	-0.23803	-0.13867	0.00878	0.24946	0.08668
CRUDE OIL	0.04509	0.21505	-0.22039	-0.14014	-0.07639	0.22137	0.10797
NATURAL GAS	0.02077	-0.07907	0.07492	0.11347	0.03889	-0.06056	-0.10620
MENTHA OIL	0.00200	0.05960	-0.06042	-0.00056	0.02049	0.14211	-0.02536
POTATO	0.09978	-0.03046	0.01498	0.05396	0.03812	0.00263	-0.04442
WHEAT	0.08088	0.01342	-0.02479	0.11931	-0.07009	-0.00493	-0.00110

Table 8 - ***Estimation of Hedge Ratio and Hedging Effectiveness (VEC Model)***

	Covariance (Spot, Fut)	Variance (Spot)	Variance (Futures)	Hedge Ratio	Variance (Hedged)	Variance (Un-hedged)	Hedging Effectiveness
GOLD	0.00007	0.00008	0.00015	0.49146	0.00011	0.00015	0.25257
SILVER	0.00023	0.00028	0.00043	0.53454	0.00034	0.00047	0.28319
ALUMINIUM	0.00013	0.00019	0.00022	0.61721	0.00021	0.00029	0.26686
COPPER	0.00008	0.00014	0.00034	0.21962	0.00047	0.00049	0.03526
CRUDE OIL	0.00025	0.00035	0.00051	0.49147	0.00058	0.00070	0.17110
NATURAL GAS	0.00035	0.00044	0.00099	0.35086	0.00108	0.00121	0.10471
MENTHA OIL	0.00031	0.00036	0.00046	0.67694	0.00016	0.00038	0.57729
POTATO	0.00185	0.00196	0.00306	0.60432	0.00088	0.00202	0.56505
WHEAT	0.00002	0.00004	0.00011	0.18908	0.00004	0.00005	0.08819

VECM-MGARCH (CCC) Estimates

In order to modify the estimation of hedge ratio for time varying volatility and to incorporate non-linearity in the mean equation VECM-MGARCH model is used. Errors of the VECM model are analyzed for presence of 'ARCH effect' and it is found that the errors have time varying volatility.

Hedge ratio and hedging effectiveness

Table 9 - ***Comparison of hedge ratio estimates for different models (spot and near month contract)***

	OLS	VAR	VECM	VECM-MGARCH
GOLD	0.50212	0.48579	0.49146	0.49726
SILVER	0.55102	0.51945	0.53454	0.49052
ALUMINIUM	0.59646	0.60067	0.61721	0.61762
COPPER	0.22189	0.19104	0.21962	0.22900
CRUDE OIL	0.48126	0.45483	0.49147	0.46335
NATURAL GAS	0.35689	0.36035	0.35086	0.36155
MENTHA OIL	0.68537	0.66890	0.67694	0.60832
POTATO	0.60953	0.60755	0.60432	0.77726
WHEAT	0.18994	0.18349	0.18908	0.16134

Table 10 - ***Hedging Effectiveness Results of Different Models (spot and near month contract)***

	OLS	VAR	VECM	VECM-MGARCH
GOLD	0.25315	0.25242	0.25257	0.25266
SILVER	0.28395	0.28253	0.28319	0.28006
ALUMINIUM	0.26770	0.26718	0.26686	0.26684
COPPER	0.03534	0.03459	0.03526	0.03523
CRUDE OIL	0.17153	0.17068	0.17110	0.17096
NATURAL GAS	0.10495	0.10472	0.10471	0.10471
MENTHA OIL	0.57858	0.57706	0.57729	0.57019
POTATO	0.56719	0.56507	0.56505	0.52154
WHEAT	0.08841	0.08810	0.08819	0.08622

Constant hedge ratio obtained from OLS, VAR, VECM and average of time varying hedge ratio obtained from VECM-MGARCH model is compared. It is observed that hedge ratio of VECM-MGARCH model for Potato, Natural gas, Copper, and Aluminium is high and hedging effectiveness provide greater variance reduction than other models.

Hedging between Spot Price and Next to Near Month Futures Contract *OLS Regression Model Estimates*

The results in Table 11 show that the hedge ratio is maximum in case of Potato futures and minimum in case of Wheat futures. It is also observed that the hedge ratio for Gold, Silver, Aluminum, Mentha Oil, and Crude Oil is above 0.5. The hedge effectiveness is quite high for Mentha Oil and Potato and low in case of Natural Gas, Copper, and Wheat.

Table 11 - ***OLS Regression Model Estimates (spot and next to near month contract)***

Category	Commodity	□	□ (Hedge-ratio)	R-Square
PRECIOUS METALS	GOLD	0.00034	0.50482	0.24813
	SILVER	0.00033	0.56024	0.29129
NON=FERROUS METALS	ALUMINIUM	-0.00008	0.65522	0.30158
	COPPER	0.00020	0.23868	0.03764
ENERGY PRODUCTS	CRUDE OIL	0.00010	0.52283	0.17719
	NATURAL GAS	-0.00081	0.36215	0.08667
AGRICULTURAL PRODUCTS	MENTHAOIL	0.00047	0.71282	0.57742
	POTATO	-0.00072	0.74512	0.78374
	WHEAT	0.00016	0.18506	0.06833

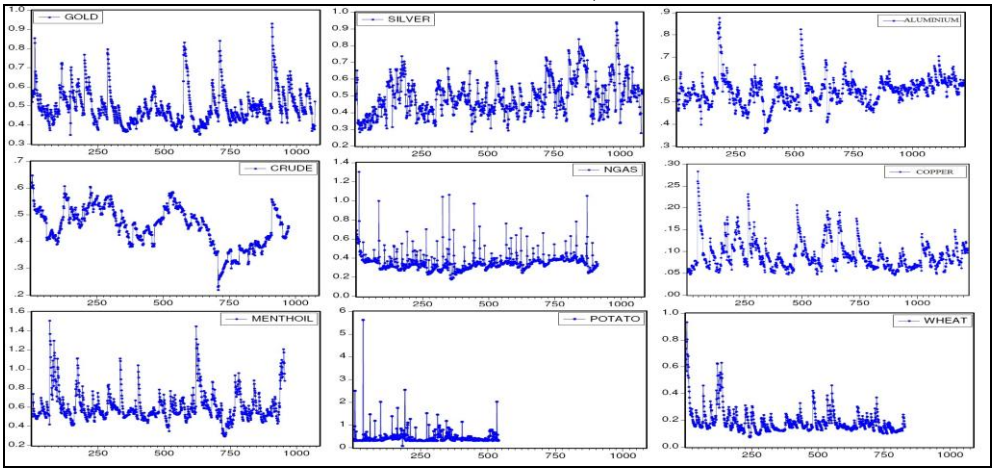
VAR Estimates

The parameter estimates for the spot and futures return series equation using VAR model are presented. In addition, the estimates of hedge ratio and the hedging effectiveness of different commodities using VAR model are summarized in Table 14. It can be observed that Mentha oil, Potato and Aluminium show high hedge ratios, while Copper and Wheat show low hedge ratios. Moreover, it can be seen that the next to near month futures contract for Copper, Natural gas, and Wheat provide low hedging.

Table 12 - ***Estimates of VAR Model (spot and next to near month contract)***

		CONSTANT	SPOT		FUTURES	
			□□	□□	□□	□□
GOLD	Spot	0.00042	-0.61575	-0.21321	0.83052	0.36215
	Futures	0.00076	-0.02072	-0.04509	0.03985	-0.03023
SILVER	Spot	0.00065	-0.63204	-0.30595	0.76259	0.35917

Figure 1
Variation of dynamic hedge ratio (VECM-MGARCH model for spot and near month futures contract)



	Futures	0.00083	-0.08237	-0.11576	0.02171	0.05218
ALUMINIUM	Spot	-0.00014	-0.53170	-0.20755	0.71634	0.38744
	Futures	-0.00013	0.02347	0.03949	0.01527	0.01598
COPPER	Spot	0.00001	-0.55897	-0.14680	1.02833	0.49333
	Futures	0.00021	0.00712	0.04943	0.05349	-0.02395
CRUDE OIL	Spot	0.00007	-0.50481	-0.16858	0.90487	0.35467
	Futures	0.00029	0.00197	-0.02048	0.05296	0.01787
NATURAL GAS	Spot	-0.00047	-0.50444	-0.09392	0.89727	0.38752
	Futures	-0.00120	0.05318	0.00963	0.00555	-0.05213
MENTHA OIL	Spot	0.00148	-0.09147	-0.07334	0.30896	-0.01880
	Futures	0.00153	0.06786	0.08259	0.06473	-0.10387
POTATO	Spot	0.00125	0.00917	-0.01017	0.01384	0.01447
	Futures	0.00281	0.02468	0.02939	-0.00239	-0.03376
WHEAT	Spot	0.00016	0.17985	-0.01810	0.09244	0.01401
	Futures	0.00016	0.06082	-0.05456	-0.03933	0.04244

Table 13 - ***Estimation of Hedge Ratio and Hedging Effectiveness (spot and next to near month contract)***

	Covariance (Spot, Fut)	Variance (Spot)	Variance (Futures)	Hedge Ratio	Variance (Hedged)	Variance (Un-hedged)	Hedging Effectiveness
GOLD	0.00008	0.00014	0.00007	0.48895	0.00011	0.00015	0.24744
SILVER	0.00031	0.00043	0.00023	0.54211	0.00033	0.00047	0.29047
ALUMINIUM	0.00022	0.00020	0.00013	0.65315	0.00020	0.00029	0.30101
COPPER	0.00016	0.00032	0.00006	0.19980	0.00047	0.00049	0.03658
CRUDE OIL	0.00042	0.00045	0.00022	0.49383	0.00057	0.00069	0.17630
NATURAL GAS	0.00063	0.00079	0.00029	0.36675	0.00109	0.00119	0.08647
MENTHA OIL	0.00036	0.00043	0.00030	0.69919	0.00016	0.00038	0.57603
POTATO	0.00583	0.00824	0.00611	0.74211	0.00129	0.00579	0.77694
WHEAT	0.00004	0.00009	0.00002	0.18286	0.00004	0.00005	0.06816

VECM Estimates

The estimates of VECM model for spot and futures return series are summarized in Table 14 – Table 16. The results in Table 16 illustrate the estimates of hedge ratio and the hedging effectiveness of the various futures contracts. VECM is treated as best specified model for the estimations of constant hedge ratio and hedging effectiveness.

Table 14 - ***Estimates of VEC Model (spot)***

	C_s	$\square_s$	$\square_f$	$\square_{s,t-1}$	$\square_{s,t-2}$	$\square_{f,t-1}$	$\square_{f,t-2}$
GOLD	0.05401	-0.32269	0.31696	-0.41845	-0.14553	0.57840	0.23575
SILVER	0.02293	-0.20563	0.20313	-0.50444	-0.25505	0.60863	0.28071

ALUMINIUM	-0.03239	-0.51746	0.52256	-0.20337	-0.04824	0.33343	0.18078
COPPER	-0.02522	-0.24742	0.25117	-0.41085	-0.09495	0.81153	0.38312
CRUDE OIL	-0.12616	-0.23538	0.25010	-0.35789	-0.10194	0.71509	0.25862
NATURAL GAS	-0.02215	-0.07681	0.08020	-0.46059	-0.08273	0.82034	0.34556
MENTHA	-0.01694	-0.03939	0.04265	-0.07274	-0.06312	0.28286	-0.03723
POTATO	0.28387	-0.10490	0.06067	0.08564	0.06492	-0.05455	-0.05195
WHEAT	-0.05645	-0.03924	0.04720	0.16256	-0.03898	0.05209	-0.01789

Table 15 - ***Estimates of VEC Model (futures)***

	C_s	$\square_s$	$\square_f$	$\square_{s,t-1}$	$\square_{s,t-2}$	$\square_{f,t-1}$	$\square_{f,t-2}$
GOLD	-0.00190	0.03044	-0.03015	-0.03925	-0.05131	0.06379	-0.01822
SILVER	-0.00640	0.08571	-0.08487	-0.13554	-0.13689	0.08605	0.08500
ALUMINIUM	0.03021	0.10484	-0.11103	-0.04311	0.00777	0.09470	0.05960
COPPER	0.02278	0.09979	-0.10344	-0.05277	0.02914	0.14226	0.02189
CRUDE OIL	0.09504	0.10875	-0.11995	-0.06615	-0.05040	0.14339	0.06483
NATURAL GAS	0.00854	-0.03805	0.03596	0.07617	0.01699	-0.03101	-0.07235
MENTHA	-0.00301	0.01210	-0.01157	0.06077	0.07757	0.07183	-0.09891
POTATO	0.39725	-0.11156	0.04986	0.11923	0.12415	-0.07587	-0.10643
WHEAT	0.09643	-0.01169	-0.00185	0.06971	-0.04396	-0.04696	0.03515

Table 16- ***Estimation of Hedge Ratio and Hedging Effectiveness (VEC Model)***

	Covariance (Spot, Fut)	Variance (Spot)	Variance (Futures)	Hedge Ratio	Variance (Hedged)	Variance (Un-hedged)	Hedging Effectiveness
GOLD	0.00008	0.00014	0.00007	0.49196	0.00011	0.00015	0.24752
SILVER	0.00030	0.00043	0.00024	0.55262	0.00033	0.00047	0.29071
ALUMINIUM	0.00020	0.00020	0.00014	0.67207	0.00020	0.00029	0.30080
COPPER	0.00015	0.00032	0.00007	0.21297	0.00047	0.00049	0.03714
CRUDE OIL	0.00040	0.00044	0.00023	0.51581	0.00057	0.00069	0.17680
NATURAL GAS	0.00062	0.00078	0.00028	0.35951	0.00109	0.00119	0.08648
MENTHA	0.00035	0.00043	0.00030	0.70073	0.00016	0.00038	0.57607
POTATO	0.00562	0.00793	0.00587	0.73987	0.00129	0.00579	0.77694
WHEAT	0.00004	0.00009	0.00002	0.18164	0.00004	0.00005	0.06814

VECM-MGARCH (CCC) Estimates

In order to modify the estimation of hedge ratio for time varying volatility and to incorporate non-linearity in the mean equation, VECM-MGARCH model is used. Errors of the VECM model are analyzed for presence of 'ARCH effect' and it is found that the errors have time varying volatility. The time varying hedge ratios for all the commodities analyzed in this study are presented in Figure 2.

Hedge ratio and hedging effectiveness:

Table 17 - ***Comparison of Hedge Ratio estimates by different models (spot and next to near month)***

	OLS	VAR	VECM	VECM-MGARCH
GOLD	0.50482	0.48895	0.49196	0.49630
SILVER	0.56024	0.54211	0.55262	0.51510
ALUMINIUM	0.65522	0.65315	0.67207	0.70423

COPPER	0.23868	0.19980	0.21297	0.21977
CRUDE OIL	0.52283	0.49383	0.51581	0.48077
NATURAL GAS	0.36215	0.36675	0.35951	0.34647
MENTHA OIL	0.71282	0.69919	0.70073	0.63875
POTATO	0.74512	0.74211	0.73987	0.53453
WHEAT	0.18506	0.18286	0.18164	0.18151

Table 18 - ***Hedging Effectiveness Results of Different Models (spot and next to near month)***

	OLS	VAR	VECM	VECM-MGARCH
GOLD	0.24813	0.24744	0.24752	0.24760
SILVER	0.29129	0.29047	0.29071	0.28890
ALUMINIUM	0.30158	0.30101	0.30080	0.29928
COPPER	0.03764	0.03658	0.03714	0.03734
CRUDE OIL	0.17719	0.17630	0.17680	0.17571
NATURAL GAS	0.08667	0.08647	0.08648	0.08633
MENTHA OIL	0.57742	0.57603	0.57607	0.57011
POTATO	0.78374	0.77694	0.77694	0.71625
WHEAT	0.06833	0.06816	0.06814	0.06814

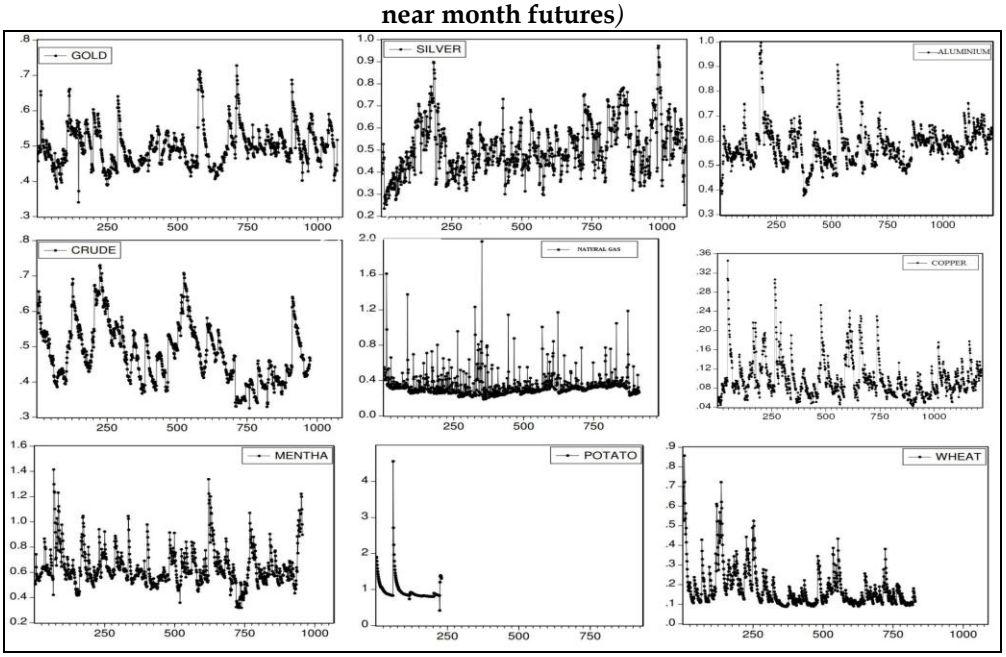
Constant hedge ratio obtained from OLS, VAR, VECM and average of time varying hedge ratio obtained from VECM-MGARCH model is compared in Table 32. It is observed that hedge ratio of VECM-MGARCH model for Aluminium is higher and provide greater variance reduction than other models (Table 33). The hedge effectiveness improves from OLS to VECM-MGARCH.

Findings

In case of near month futures, The results show that the hedge ratio is maximum in case of Mentha Oil futures and minimum in case of Wheat futures.The contracts for agricultural commodities provide 5%-50% of hedging effectiveness [Mentha Oil(57%), Potato (55%) and Wheat (8%)]. The hedge ratio for Gold, Silver, Aluminum and Crude Oil is around 0.5 and low hedging effectiveness (less than 25%). In precious metals, Gold contract provides hedging effectiveness of around 25% and Silver around 28%. Crude oil and Natural gas futures also have low hedging effectiveness (10%-17%). In case of industrial metals futures, hedging effectiveness is low for Aluminum and Copper futures having only 26% and 3% hedging effectiveness respectively. It 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 Potato where hedging effectiveness increases to 70%. For Silver, industrial metals and Natural gas, the hedging effectiveness of next to near month futures is same as near month futures. There are major differences in hedging effectiveness of next to near month futures for only potato.

To sum up, the study find that the Agricultural Commodities provide higher hedge ratio and hedging effectiveness as compared to non-agricultural commodities in Indian futures market. Hedging effectiveness provided by the near month futures is similar to that provided by the next to near month futures for most of the commodities. The results are similar for whether hedging is done using constant hedge ratio or dynamic hedge ratios. 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 /OLS model. However, we find some improvement in hedge ratio and hedging effectiveness for non-agricultural commodities.

Figure 2
Variation of dynamic hedge ratio (VECM-MGARCH model for spot and next to near month futures)



Annexure

- The details of the commodities, data period and source are summarized in Table I- Table III.
- I- *Details of commodity, data period and source (spot and near month)*

Category	Commodity	Data-periods	Futures Market	Spot Market
Precious Metals	Gold	3 March 2008 – 14 March 2012	MCX	Ahmedabad
	Silver	7 March 2008 – 14 March 2012	MCX	Ahmedabad
Non-Ferrous Metal	Aluminium	6-March 2008 – 03 April 2012	MCX	Mumbai
	Copper	3-March 2008 – 03 April 2012	MCX	Mumbai

Energy products	Crude Oil	3 March 2008 – 23 March 2012	MCX	Mumbai
	Natural Gas	3 March 2008 – 21 March 2012	MCX	Hazira
Agricultural products	Mentha Oil	3 March 2008 – 23 March 2012	MCX	Chandausi
	Potato	4 March 2008 – 23 March 2012	MCX	Agra
	Wheat	23 May 2009 – 23 March 2012	NCDEX	Delhi

- Table II - *Details of commodity, data period and source (spot and next to near month)*

Category	**Commodity**	**Data-periods**	**Futures Market**	**Spot Market**
Precious Metals	Gold	3 March 2008 – 14 March 2012	MCX	Ahmedabad
	Silver	6 March 2008 – 14 March 2012	MCX	Ahmedabad
Non-Ferrous Metal	Aluminium	6-March 2008 – 03 April 2012	MCX	Mumbai
	Copper	3-March 2008 – 03 April 2012	MCX	Mumbai
Energy products	Crude Oil	3 March 2008 – 23 March 2012	MCX	Mumbai
	Natural Gas	3 March 2008 – 21 March 2012	MCX	Hazira
Agricultural products	Mentha Oil	3 March 2008 – 23 March 2012	MCX	Chandausi
	Potato	16 March 2009 – 23 March 2012	MCX	Agra
	Wheat	23 May 2009 – 23 March 2012	NCDEX	Delhi

- Table III - *Details of commodity, data period and source (world spot and next to near month)*

Category	**Commodity**	**Data-periods**	**Futures Market**	**Spot Market**
Precious Metals	Gold	5 March 2008 – 14 March 2012	MCX	NYMEX
	Silver	6 March 2008 – 14 March 2012	MCX	NYMEX
Non-Ferrous Metal	Aluminium	6-March 2008 – 02 April 2012	MCX	LME
	Copper	5-March 2008 – 02 April 2012	MCX	LME
Energy products	Crude Oil	5 March 2008 – 23 March 2012	MCX	NYMEX
	Natural Gas	5 March 2008 – 21 March 2012	MCX	NYMEX

Descriptive Statistics of Spot and Future Daily Return Series

Table IV- Descriptive Statistics for Precious and Non-Ferrous Metals (spot and near month contract)

	GOLD		SILVER		ALUMINIUM		COPPER	
	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00071	0.00072	0.00077	0.00072	-0.00018	-0.00017	0.00025	0.00023
Median	0.00077	0.00093	0.00093	0.00140	0.00000	0.00052	0.00000	0.00039
Maximum	0.10450	0.08582	0.11246	0.10014	0.07570	0.07557	0.09028	0.08637
Minimum	-0.07224	-0.07172	-0.30340	-0.27600	-0.07659	-0.05977	-0.11549	-0.09942
Std. Dev.	0.01212	0.01215	0.02167	0.02096	0.01707	0.01481	0.02210	0.01872
Skewness	0.00653	-0.08111	-2.91529	-2.67743	-0.08202	0.28488	-0.20312	-0.20492
Kurtosis	13.52892	11.55264	43.93069	35.66310	6.20904	6.16090	6.02076	6.72758
Jarque-Bera	4947.04900	3265.38500	77631.49000	49756.34000	454.29230	453.89930	404.89040	612.90370
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table V - Descriptive Statistics for Energy Products (spot and near month contract)

	CRUDE OIL		NATURAL GAS	
	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00026	0.00028	-0.00123	-0.00125
Median	0.00000	0.00094	0.00000	-0.00118
Maximum	0.17484	0.10269	0.33406	0.27972
Minimum	-0.17823	-0.18631	-0.15952	-0.16483
Std. Dev.	0.02640	0.02272	0.03479	0.03158
Skewness	-0.02867	-0.51516	0.85561	0.75763
Kurtosis	11.28549	9.55690	13.66637	12.09736
Jarque-Bera	2806.17500	1800.72500	4575.60200	3334.98200
Probability	0.00000	0.00000	0.00000	0.00000

Table VI - Descriptive Statistics for Agricultural Products (spot and near month contract)

	MENTHA OIL		POTATO		WHEAT	
	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00170	0.00172	0.00053	0.00092	0.00019	0.00014
Median	0.00054	0.00036	-0.00021	0.00074	0.00021	0.00000
Maximum	0.16161	0.19254	0.53529	0.53499	0.03962	0.05646
Minimum	-0.11823	-0.16900	-0.77480	-0.86685	-0.04068	-0.11712
Std. Dev.	0.01961	0.02176	0.04496	0.05555	0.00673	0.01053
Skewness	1.30707	0.54120	-6.24449	-5.36545	-0.21068	-2.18637
Kurtosis	17.29435	14.79685	205.60860	131.29010	10.72825	29.02520
Jarque-Bera	8420.09500	5595.94600	916838.10000	368760.30000	2064.17000	23997.89000
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table VII - Descriptive statistics for precious and non-ferrous metals (spot and next to near month contract)

	GOLD		SILVER		ALUMINIUM		COPPER	
	SPOT	Futures	SPOT	Futures	SPOT	Futures	SPOT	Futures
Mean	0.00071	0.00073	0.00075	0.00074	-0.00018	-0.00016	0.00025	0.00024
Median	0.00076	0.00078	0.00091	0.00152	0.00000	0.00041	0.00000	0.00042
Maximum	0.10450	0.08112	0.11246	0.09194	0.07570	0.07184	0.09028	0.08452
Minimum	-0.07803	-0.08417	-0.30340	-0.27492	-0.07659	-0.06008	-0.11549	-0.09586

Std. Dev.	0.01211	0.01195	0.02167	0.02088	0.01707	0.01431	0.02210	0.01796
Skewness	-0.22549	-0.44496	-2.90402	-2.69566	-0.08202	0.18658	-0.20312	-0.23972
Kurtosis	13.75104	11.42551	43.72640	35.92679	6.20904	6.18396	6.02076	6.97999
Jarque-Bera	5191.17500	3218.19200	77214.52000	50791.58000	454.29230	452.18010	404.89040	700.39200
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table VIII - *Descriptive statistics for energy products (spot and next to near month contract)*

	CRUDE OIL		NATURAL GAS	
	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00026	0.00030	-0.00124	-0.00120
Median	0.00000	0.00119	0.00000	-0.00159
Maximum	0.17484	0.08427	0.33406	0.21572
Minimum	-0.17823	-0.18199	-0.15952	-0.15278
Std. Dev.	0.02636	0.02123	0.03457	0.02810
Skewness	-0.03137	-0.69408	0.95478	0.62052
Kurtosis	11.39786	10.01018	13.91859	10.00054
Jarque-Bera	2868.14000	2076.82900	4781.38100	1967.14700
Probability	0.00000	0.00000	0.00000	0.00000

Table IX - Descriptive statistics for agricultural products (spot and next to near month contract)

	MENTHA OIL		POTATO		WHEAT	
	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00170	0.00173	0.00137	0.00281	0.00019	0.00015
Median	0.00054	0.00077	-0.00040	0.00000	0.00021	0.00000
Maximum	0.16161	0.17963	0.77209	0.77120	0.03962	0.03729
Minimum	-0.11823	-0.13344	-0.55090	-0.84334	-0.04068	-0.12651
Std. Dev.	0.01961	0.02090	0.07608	0.09039	0.00672	0.00950
Skewness	1.30707	0.55833	4.36504	0.08111	-0.21068	-3.54763
Kurtosis	17.29435	13.04442	69.14895	61.53390	10.73777	47.66516
Jarque-Bera	8420.09500	4072.72900	42664.02000	32834.84000	2071.74500	70563.50000
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table X - Descriptive Statistics for Precious and Non-ferrous Metals (world spot and next to near month contract)

	GOLD		SILVER		ALUMINIUM		COPPER	
	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES	SPOT	FUTURES
Mean	0.00081	0.00087	0.00075	0.00089	-0.00020	-0.00019	0.00027	0.00028
Median	0.00126	0.00095	0.00290	0.00228	0.00053	0.00000	-0.00003	0.00025
Maximum	0.09619	0.08294	0.12539	0.09194	0.08986	0.07320	0.12795	0.10973
Minimum	-0.07398	-0.06871	-0.28703	-0.27492	-0.07104	-0.06008	-0.09825	-0.09586
Std. Dev.	0.01555	0.01297	0.02796	0.02266	0.01908	0.01570	0.02409	0.01997
Skewness	-0.02899	-0.03648	-1.65039	-2.43887	0.02510	0.18268	-0.03255	-0.17478
Kurtosis	7.14328	9.97119	17.34124	30.99340	4.52252	5.46142	5.27537	6.67558
Jarque-Bera	638.87140	1808.42700	8247.56600	30749.35000	84.21748	224.72130	184.16060	484.50800
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table XI- Descriptive Statistics for Energy Products (world spot and next to near month contract)

	CRUDE OIL		NATURAL GAS	
	SPOT	**FUTURES**	**SPOT**	**FUTURES**
Mean	0.00032	0.00037	-0.00163	-0.00151
Median	0.00081	0.00105	-0.00047	-0.00324
Maximum	0.20806	0.09631	0.28020	0.21572
Minimum	-0.21238	-0.18199	-0.28048	-0.15278
Std. Dev.	0.03186	0.02347	0.04331	0.03110
Skewness	-0.20562	-0.50059	0.51959	0.56285
Kurtosis	9.76544	8.61807	11.64691	8.46724
Jarque-Bera	1527.51500	1082.78900	2386.07900	980.17420
Probability	0.00000	0.00000	0.00000	0.00000

Table XII - Test of Unit Root (spot and near month contract)

	Return Series	**ADF(t stat)**	**Log of price Series**	**ADF(t stat)**
GOLD	Spot	-32.891*	Ln (Spot price)	-0.322
	Futures	-32.469*	Ln (Futures price)	-0.322
SILVER	Spot	-26.881*	Ln (Spot price)	-0.160
	Futures	-28.673*	Ln (Futures price)	-0.302
ALUMINIUM	Spot	-35.289*	Ln (Spot price)	-1.809
	Futures	-31.931*	Ln (Futures price)	-1.720
COPPER	Spot	-35.118*	Ln (Spot price)	-1.041
	Futures	-31.027*	Ln (Futures price)	-0.836
CRUDE OIL	Spot	-32.808*	Ln (Spot price)	-1.373
	Futures	-29.976*	Ln (Futures price)	-1.070
NATURAL GAS	Spot	-33.521*	Ln (Spot price)	-1.417
	Futures	-29.808*	Ln (Futures price)	-1.316
MENTHA OIL	Spot	-22.136*	Ln (Spot price)	0.916
	Futures	-27.101*	Ln (Futures price)	0.281
POTATO	Spot	-21.565*	Ln (Spot price)	-1.454
	Futures	-22.128*	Ln (Futures price)	-1.622
WHEAT	Spot	-23.110*	Ln (Spot price)	-1.978
	Futures	-28.673*	Ln (Futures price)	-2.286

Table XIII - Test of Unit Root (spot and next to near month contract)

	Return Series	**ADF(t stat)**	**Log of price Series**	**ADF(t stat)**
GOLD	Spot	-33.276*	Ln (Spot price)	-0.325
	Futures	-31.904*	Ln (Futures price)	-0.277
SILVER	Spot	-27.050*	Ln (Spot price)	-0.148
	Futures	-33.710*	Ln (Futures price)	-0.268
ALUMINIUM	Spot	-35.289*	Ln (Spot price)	-1.809
	Futures	-31.433*	Ln (Futures price)	-1.687
COPPER	Spot	-35.118*	Ln (Spot price)	-1.041
	Futures	-30.726*	Ln (Futures price)	-0.782
CRUDE OIL	Spot	-32.509*	Ln (Spot price)	-1.363
	Futures	-29.665*	Ln (Futures price)	-1.013
NATURAL GAS	Spot	-33.610*	Ln (Spot price)	-1.283
	Futures	-29.808*	Ln (Futures price)	-1.186
MENTHA OIL	Spot	-22.136*	Ln (Spot price)	0.916
	Futures	-27.641*	Ln (Futures price)	0.532
POTATO	Spot	-14.710*	Ln (Spot price)	-1.912
	Futures	-14.824*	Ln (Futures price)	-1.364
WHEAT	Spot	-23.129*	Ln (Spot price)	-1.979
	Futures	-29.609*	Ln (Futures price)	-2.394

* $p<0.05$

Table XIV - Test of Unit Root (world spot and next to near month contract)

	Return series	ADF(t stat)	Log of price series	ADF(t stat)
GOLD	Spot	-31.998*	Ln (Spot price)	-0.485
	Futures	-28.428*	Ln (Futures price)	-0.237
SILVER	Spot	-32.094*	Ln (Spot price)	-0.661
	Futures	-30.922*	Ln (Futures price)	-0.261
ALUMINIUM	Spot	-32.652*	Ln (Spot price)	-1.821
	Futures	-28.691*	Ln (Futures price)	-1.688
COPPER	Spot	-32.108*	Ln (Spot price)	-0.879
	Futures	-28.170*	Ln (Futures price)	-0.795
CRUDE OIL	Spot	-29.089*	Ln (Spot price)	-1.512
	Futures	-26.833*	Ln (Futures price)	-1.029
NATURAL GAS	Spot	-20.533*	Ln (Spot price)	-1.624
	Futures	-26.733*	Ln (Futures price)	-1.227

References

- Ahuja, Narender L. (2006), "Commodity Derivatives mark et in India: Development, Regulation and Future Prospective", International Research Journal of Finance and Economics, 1, 153 - 162.
- Ali, Jabir and Gupta, Kriti Bardhan (2007), "Agricultural Price Volatility and Effectiveness of Commodity Futures Markets in India", Indian Journal of Agricultural Economics. Vol. 62, No.3, pp. 537.
- Bhattacharya , Himdari (2007), "Commodity Derivatives Market in India", Economic and Political weekly, Money Banking and Finance Vol. 42 No. 13, pp. 1151 1162
- Chakrabarty, Ranajit and Sarkar Asima (2010), "Efficiency of the Indian Stock Market with Focus on Some Agricultural Product", Paradigm Vol.14 No. 1, pp. 85-96
- Desgupta, Basab (2004), "Role of Commodity Futures Market in Spot Price Stabilization, Production and Inventory Decisions with Reference to India", Indian Economic Review, Vol. XXXIX No.2, pp. 315-325
- Dummu, Tata Rao (2009), "Commodity Futures Market in India: Its Impact on Production and Prices", Indian Journal of Agricultural Economics, Vol. 64 No. 3, pp. 333-356.
- Iyer, Vishwanathan and Pillai Archana (2010), "Price Discovery and Convergence in the Indian Commodities Market." Indian Growth and Development Review, Vol. 3 No.1, pp. 53-61
- Ramaswami , Bharat and Singh , Jatinder Bir (2007), "Underdeveloped Spot Markets and Futures Trading: The Soya Oil Exchange in India:, electronic copy available on http://ssrn.com/abstract=962835 (accessed 30 September 2012).
- Roy, Ashutosh (2006), "Indian Agri Commodity Market, Risk Management and its Sustainable Growth: An Integrated Framework", electronic copy available on http://ssrn.com/abstract=1178702 (accessed 30 September 2012).
- Sehdevan, K.G. (2002), "Derivative and Price Risk Management: A Study of Agricultural Commodity Futures in India", A Seed Money Project Report of Indian Institute of Management, Lucknow.

□□□