An Empirical Evidence of Hedging Performance in Indian Commodity Derivatives Market

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Introduction:

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. 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.

Hedging using Futures Contracts involves identification and quantification of the hedge ratio (the ratio of the number of Futures contracts, each on one unit of the underlying asset to be hedged, as compared with one unit of the cash asset that needs to be hedged). The extent of volatility in Futures contract prices as compared with the volatility in cash market prices needs to be ascertained along with the correlation between the cash price and Futures price. The calculation of the hedge ratio is all the more important because of the threat of being under-hedged or over-hedged. A crucial input in the hedging of risk is the optimal hedge ratio. Numerous studies point out that the expected relationship between economic or financial variables may be better captured by a time varying parameter model rather than a fixed coefficient model. So the optimal hedge ratio can be a time varying rather than constant.

Thus, the role of hedging while using multiple risky assets, using Futures market for minimizing the risk of Spot market fluctuation has attracted considerable attention. The focus of current empirical financial research is on effective use of Futures contract in making hedging decisions and there is considerable amount of research being carried out to find optimal hedge ratio and improve the hedging effectiveness.

Literature Review:

The relationship between the Futures and Spot prices is of great significance to those who wish to hedge the price risk using Futures contracts. (M Ajoy Kumar & M R Shollapur, 2015) There is long-term equilibrium relationship between the Futures and Spot prices of all Commodities. The long-run causality flows from Futures market to the Spot market and not in the opposite direction in all Commodities. The Futures markets are able to meet their intended objectives of price discovery and hence aid in price risk hedging. As the price discovery process becomes more efficient, the hedgers in agricultural Commodities would start deriving greater benefits while managing the price risk.

The Optimal hedge ratio and hedging effectiveness provided by Futures contract has been researched extensively. Various estimation techniques have been developed for estimation of constant as well as dynamic hedge ratio, which is based on conditional distribution of covariance of Spot and Futures returns and conditional variances. 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. Hedging effectiveness of Futures markets is one of the important determinants of success of Futures contracts (Silber, 1985; Pennings&Meulenberg, 1997).

The Minimum-Variance Hedge Ratio (Benninga, et al., 1983) has been suggested as slope coefficient of the OLS regression, for changes in Spot prices on changes in Futures prices. Many authors defined

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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.

The use of regression for calculating the hedge ratio and hedging effectiveness has been criticized on mainly two grounds (Brajesh Kumar, Priyanka Singh, Ajay Pandey, 2008). 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 co-integrated 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 (VECM) Model, which considers the long run co-integration between Spot and Futures, is therefore widely used.

Objectives:

1) To identify long term and short term Co-integration in Spot and Future prices of selected Commodities.
2) To estimate the hedge ratio and hedging effectiveness for select actively traded Indian commodity Futures using selected models.

Research Methodology:

Scope of the study:

This paper investigates optimal hedge ratio and hedging effectiveness of 4 Non-agricultural (Crude Oil, Natural Gas, Gold, Nickel) Futures Contracts traded on Multi Commodity Exchange (MCX) in India using VECM Model. The data period considered in the analysis is from January 2010 to December 2014.

Data Sources:

The study is based on secondary data i.e. Spot and Future prices of Crude oil, Natural gas, Copper, Nickel, Gold and Silver and has been collected from **www.mcx.com** and using Bloomberg database and for a period of 5 years from January 2010 to December 2014. The Commodities are selected based on most actively traded Commodities in terms of Volume. One month, two month and three months contract where trading volume is high are analysed.

Tools for analysis:

Model for Estimating Hedging Effectiveness and Hedge Ratio

Several models are used to estimate constant hedge ratio. The OLS, VAR and VECM models estimate constant hedge ratio. In this study, only VECM is used to estimate hedge ratio as many critics contradict the efficiency of OLS and VAR.

Test of Unit Root and Co Integration

Augmented Dickey Fuller model is used to test the presence of unit root. A unit root test helps in determining whether a time series data variable is stationary. The Augmented Dickey Fuller test is a well – known test that is used to check if the data points are stationary and as such has been used on the Spot and Future prices of Commodities. The data points were found to be stationary at first difference. In order to test the co-integration between Spot and Future prices, we used the Johansen's co-integration test. Johansen Co–integration is a statistical tool used to analyse time – series variables. Co-integration signifies when time series data points exhibit a similar or common stochastic drift. The study has tried to analyse the long term co integration in movement of Spot prices and Future prices of selected Commodities.

Vector Error Correction Model (VECM)

When Futures and Spot prices are co-integrated, return dynamics of the both prices can be modelled through vector error correction model. Vector error correction 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 co-integrated variables (Harris et al. 1995; Cheung and Fung, 1997; Ghosh, Saidi and Johnson, 1999).

Results and Interpretation:

Descriptive Statistics

Table 1: Descriptive Statistics for Spot and one month Future Contracts

	Crude Oil		Natural Gas		Gold		Nickel	
	Spot	Future	Spot	Future	Spot	Future	Spot	Future
Mean	0.003452	0.00314	0.002195	0.00204	0.0005	0.0005	0.025395	0.024329
Median	0.000196	0.00027	0.000659	4.46E-05	0.0004	0.0005	0.011733	0.01348
Maximum	0.2687	0.2519	0.385242	0.394968	0.0324	0.0335	23.0173	22.16193
Minimum	-0.09259	-0.09403	-0.3397	-0.28618	-0.0355	-0.0454	-16.3689	-14.9753
Std. Dev.	0.03547	0.03344	0.058699	0.054876	0.0097	0.0100	3.255496	3.056098
Skewness	4.3011	4.321989	1.016078	2.341932	-0.1347	-0.8444	1.607557	2.102048
Kurtosis	35.37	37.1361	30.86103	34.82341	6.0635	11.0914	35.23704	36.6337
Jarque-Bera	6502.37	7164.483	5298.746	6405.708	85.8267	1000.67	6675.66	7129.461
Probability	0	0	0	0	0.0498	0.1610	0	0

Table 2: Descriptive Statistics for Spot and two month Future Contracts

	Crude Oil		Natural Gas		Gold		Nickel	
	Spot	Future	Spot	Future	Spot	Future	Spot	Future
Mean	0.17582	0.1566	0.000809	0.000669	0.000444	0.0004	0.044709	0.040793
Median	0.02561	0.021273	0.000152	-0.00015	0.000292	0.0005	0.025204	0.045305
Maximum	26.058	26.1383	0.331948	0.345217	0.040278	0.0358	12.17752	13.28402
Minimum	-7.582	-7.4778	-0.29251	-0.22558	-0.05571	-0.051	-8.37365	-6.38391
Std. Dev.	2.645	2.5798	0.042685	0.036663	0.010142	0.0098	2.335191	2.244512
Skewness	4.926	5.803	1.020373	2.964102	-0.74642	-0.673	0.866248	1.728623
Kurtosis	50.596	61.766	38.82247	48.74259	12.61827	9.612	15.34908	18.20246
Jarque-Bera	29628.07	41780	19053.09	29483.75	2393.326	935.88	1226.76	1769.578
Probability	0	0	0	0.000533	0.000119	0	0.007185	0.002425

Table 3: Descriptive Statistics for Spot and three month Future Contracts

	Crude Oil		Natural Gas		Gold		Nickel	
	Spot	Future	Spot	Future	Spot	Future	Spot	Future
Mean	0.1135	0.1037	0.055046	0.022714	0.122684	0.123335	0.019018	0.016766
Median	0.0217	0.0206	0.00165	-0.03691	0.088468	0.046548	0.03879	0.003805
Maximum	27.316	29.375	29.52681	34.14643	12.29389	12.36259	22.01703	22.56442
Minimum	-7.605	-6.347	-29.5122	-20.5879	-7.68823	-6.79429	-12.708	-10.0261
Std. Dev.	2.369	2.351	3.56333	3.131357	1.348193	1.321575	2.228827	2.095848
Skewness	5.151	7.278	0.176191	3.37096	2.32022	2.486481	2.450123	3.626574
Kurtosis	59.897	90.1799	49.99521	60.4322	41.97161	42.79101	44.77182	52.70145
Jarque-Bera	57552.8	13625.2	49088.18	63270.79	36809.23	41746.96	34159.47	45618.06
Probability	0	0	0	0	0.166184	0.073339	0	0

Summary statistics of contract wise Spot and Future prices of four Commodities are provided in table numbers' 1 to 3. The rate of return as given by the mean is greater for the Spot markets than compared with Futures market under each category of contract except in the case of gold for three month Future contract.

The volatility as given by the standard deviation is higher for far away contracts as compared to near month contracts. Natural gas and Crude oil have a highly volatile Future and Spot market as compared to

other commodity. The measure of Skewness indicates that none of the data points are symmetric with the exception of Natural Gas one month and two month Spot where in the data points lie within +/- 1 and are moderately skewed. The kurtosis data points for all data series lies above three which indicates leptokurtic behaviour of the data series featuring sharper peaks longer and fatter tails on both the ends.

The Jarque - Bera test is used to test the normality of the data series. The null hypothesis for the test is given as H_0 = all the data series are normally distributed. As it can be observed from the above tables and it reject the null hypothesis. Hence, indicating that the data series aren't normally distributed.

1. Unit root test

A unit root test helps in determining whether a time series data variable is stationary. The Augmented Dickey Fuller test is a well – known test that is used to check if the data points are stationary and as such has been used on the closing prices of all the indexes. It is found that for all the Commodities, Spot prices, one month Future prices, two month Future prices and three month Future price series have unit root and return series are stationary. That means the data points were found to be stationary at first difference.

2. Johansen test for co-integration

The Johansen test for co-integration tries to establish the presence of co integrating relationship between contract wise Spot and Future prices. The contract wise results of the test are summarized in table 3. This tries to find the number of co integrating equations. Here the test is try to determine the long term association and causal relationship between the Spot and Future markets.

Table 3: Johansen test for Co integration (Spot and Futures), One month contract

Commodity	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Probability**
Crude Oil	None *	0.330986	78.044	15.49471	0
	At most 1 *	0.1915	26.997	3.084	0
Natural Gas	None *	0.351427	76.487	15.49471	0
	At most 1 *	0.175135	23.462	3.841466	0
Nickel	None *	0.313668	67.767	15.49471	0
	At most 1 *	0.163369	21.771	3.841466	0
Gold	None *	0.310485	51.927	15.49471	0
	At most 1 *	0.138546	14.923	3.841466	0.0085

*Note: * denotes rejection of hypothesis at 5 percent significance*

Table 4: Johansen test for Co integration (Spot and Futures), Two month contract

Commodity	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.**
Crude Oil	None *	0.323669	141.3246	15.49471	0.0001
	At most 1 *	0.166754	44.8332	3.841466	0
Natural Gas	None *	0.279661	119.8107	15.49471	0.00009
	At most 1 *	0.148006	39.20443	3.841466	0
Nickel	None *	0.380126	64.71961	15.49471	0
	At most 1 *	0.175527	18.58603	3.841466	0.00012
Gold	None *	0.297444	107.4023	15.49471	0.00006

	At most 1 *	0.123537	29.29105	3.841466	0.0008
*Note: * denotes rejection of hypothesis at 5 percent significance*					

Table 5: Johansen test for co integration (Spot and Futures), Three month contract					
Commodity	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.**
Crude Oil	None *	0.326959	212.4607	15.49471	0.0001
	At most 1 *	0.166332	66.8438	3.841466	0
Natural Gas	None *	0.29546	183.164	15.49471	0.0001
	At most 1 *	0.166791	62.18652	3.841466	0
Nickel	None *	0.328546	210.4688	15.49471	0.0001
	At most 1 *	0.164384	65.41891	3.841466	0
Gold	None *	0.344774	148.0757	15.49471	6.25E-05
	At most 1 *	0.15269	44.32186	3.841466	0.00025
*Note: * denotes rejection of hypothesis at 5 percent significance*					

The above tables' highlight that the prices of Spot and Future for one month contract, two month contract and three month contract for all the four Commodities are co-integrated and hence exhibit a long term equilibrium and causal relationship. It is a very important characteristic that when prices are trending either upward or downward they exhibit a co related movement in their prices. It can also be noted that irrespective of the duration of the contract the prices move in a co integrated and manner. If such a relationship isn't observed among both the data series, the efficiency of Futures market in providing a hedging platform decreases.

The presence of co integrating equations also supports the fact that there exists a causal relationship between both the markets throughout different contract durations. A strong association and causal relationship between Spot and Future market also facilitates better and efficient hedging opportunities.

3. Vector error correction model

The Johansen test helps us in understanding the association and long term trends in movement among both the markets. The Vector error correction model helps in analysing the short run causality between both the markets. It explains the direction and significance of long run and short run causality that each market can have on one another. The error correction mechanism between both the markets helps in maintaining the prices of both the markets at equilibrium.

Table 6: Estimates of Vector Correction Model- One month contract				
Commodity	**Crude Oil**	**Natural Gas**	**Gold**	**Nickel**
Cs	-0.77072*	-1.49003*	-1.70665*	-1.10137*
$s_{,t-1}$	-0.04265	0.032577	0.228172	-0.2154
$S_{,t-2}$	-0.04796	-0.08225	-0.03294	-0.18839
$f_{,t-1}$	0.170745*	-0.76845*	-0.70411*	-0.47897*
$f_{,t-2}$	-0.00526*	-0.26785*	-0.22496*	-0.12961*
constant	-2.3218	-0.00046	-0.000005	0.008362

*Note: * indicates rejection of null hypothesis at 5 percent.*

Table 7: Estimates of Vector Correction Model - Two Month Contract

Commodity	Crude Oil	Natural Gas	Gold	Nickel
Cs	-0.98052*	-1.14382*	-1.73951*	-1.75144*
$S_{,t-1}$	-0.07245	-0.15046	0.221629	0.240022
$S_{,t-2}$	-0.04154	-0.16519	-0.03149	0.003672
$f_{,t-1}$	0.1778*	-0.50856*	-0.74357*	-0.81562*
$f_{,t-2}$	-0.0153*	-0.17103*	-0.23314*	-0.25992
constant	-2.711	0.0176	-0.00034	0.028782

*Note: * indicates rejection of null hypothesis at 5 percent.*

Table 8: Estimates of Vector Correction Model - Three Month Contract

Commodity	Crude Oil	Natural Gas	Gold	Nickel
Cs	-0.77072*	-0.164898*	-1.71334*	-1.51355*
$S_{,t-1}$	-0.04265	0.120651	0.222702	0.078529
$S_{,t-2}$	-0.04796	0.063554	-0.08265	-0.09386
$f_{,t-1}$	0.170745*	0.143312*	-0.78534*	-0.73547*
$f_{,t-2}$	-0.00526*	0.084349*	-0.23269*	-0.20762
constant	-2.3218	0.180127	0.003224	0.005095

*Note: * indicates rejection of null hypothesis at 5 percent.*

The above tables explain the co-efficient of VECM model with the Future market as dependant variable and the Spot market as explanatory variable. Hedging always takes place in the Futures market with perspective from the Spot market hence we are trying to understand the causality between both the markets.

It can be observed from the table that the error co-efficient is negatively significant for all the Commodities across all contracts. This shows that is long term error correction flowing from the Spot market to the Futures market. This finding further substantiates our findings from the co-integration test that there must be at least one long term causal relationship in one direction. Here the long term causal relationship is flowing from the Spot markets to the Futures market.

The following error correction variables are explained as:

$S_{,t-1}$	: Spot one day lag
$S_{,t-2}$	: Spot two day lag
$f_{,t-1}$	: Future one day lag
$f_{,t-2}$	: Future two day lag

Table 9: Hedge ratio and hedging effectiveness – Two month contract

	Covariance (Spot, Future)	Variance (Spot)	Variance (Future)	Hedge Ratio	Variance (Hedged)	Variance (Unhedged)	Hedging Effectiveness
Crude oil	0.336638	2.775959	1.763409	0.17995	2.658298	2.775959	0.03777
Natural Gas	0.300303	7.541847	4.129521	0.14384	7.783651	7.541847	-0.00554
Gold	0.371437	0.986537	1.055268	0.31678	0.8883	0.986923	0.099664
Nickel	1.200637	2.615323	2.122996	0.78445	2.467592	2.615323	0.154863

The table shows that S_{t-1} and S_{t-2} is not significant for any of the Commodities across all the contracts, which signifies that there exist no short run causal relationship between the Spot and Future prices. It implies that Future prices in the short run move independently of Spot prices. In such cases the hedging of risks and volatilities from Spot market to Future market is very difficult as it is not possible to establish any short run causal relationship between both the markets and hence the hedging won't be effective or provide for optimal risk coverage. It can be observed that F_{t-1} is significant across all the Commodities for all the contracts which explain that Future one lag returns influence the present day Future prices. Similarly it can also be observed that F_{t-2} is significant for all the Commodities except for nickel in two month and three month contract.

In can be summarized that exist a strong unidirectional causality flowing from the Spot markets to the Future markets in the long run. However there exists no causality between Spot and Futures in the short run. It can also be inferred that Spot markets factor in new information and pass on the same to the Futures market in the long, however Futures market in the short run are affected by its own previous movements. It can also be observed that the long run causality as captured by Crude oil contracts gets stronger in the near month and then weakens in the far away month.

The optimal hedge ratio and hedge effectiveness for all Commodities for next to near month contract are presented in table 10. Two month contracts have optimal hedge ratios in the range of 0.14 to 0.78, the lowest being of Natural gas and the highest being of Nickel. It can be observed that Natural Gas doesn't provide an optimal hedging opportunity in the short run given the volatility in global crude oil prices. Nickel however provides a hedging effectiveness of 15 percent followed by gold at 9 percent.

Table 10: Hedge ratio and hedging effectiveness – Three month contract

	Covariance (Spot, Future)	Variance (Spot)	Variance (Future)	Hedge Ratio	Variance (Hedged)	Variance (Unhedged)	Hedging Effectiveness
Crude oil	0.237432	2.722838	1.728795	0.170482	2.637196	2.722838	0.032569
Natural Gas	0.302222	6.755116	4.029318	0.147866	6.852202	6.755116	-0.00167
Gold	0.386854	1.048446	1.076329	0.33316	0.932025	1.048446	0.108233
Nickel	1.221142	2.696146	2.216407	0.784862	2.468582	2.696146	0.148708

The optimal hedge ratio and hedge effectiveness for all Commodities for far away contract are presented in table 4c. Three month contracts have an optimal hedge ratio in the range of 0.14 to 0.78, the lowest being of Natural gas and the highest being of Nickel. It can be observed that Natural Gas doesn't provide an optimal hedging opportunity in the short run given the volatility in global crude oil prices. Nickel however provides a hedging effectiveness of 14 percent followed by gold at 10 percent.

Conclusions:

The inherent purpose of structured products aims in mitigating risk, transferring risk, efficient price discovery among others. This paper has tried to study the linkages and co-integrated movement in commodity prices and its implications on the hedge ratio and hedging efficiency comprising of four Commodities. The findings indicate a strong co-integration in the movement of Spot and Future prices indicating a long run synchronized movement in prices. The paper also identifies a long term equilibrium relationship between Future and Spot prices. In the short run there exists uni-directional causality among different Commodities.

It is also found that Indian commodity derivatives market serves the purpose of risk transfer by aiding in efficient hedging opportunities. The efficient hedge ratio is found to be in the range of 0.14 to 0.78. It was also found that crude oil could provide an efficient hedging ratio which can be attributed to the volatility in global crude oil prices. Nickel provided a hedging efficiency of 14 percent across different contracts.

India has witnessed a tremendous growth path in organized Commodities market, however still a lot more needs to be done.

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