Efficiency of Commodity Futures in Price Discovery and Risk Management : An Empirical Study of Agricultural Commodities in India

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Abstract

The present study examined the efficiency of commodity futures in price discovery and risk management for agricultural commodities in India. The price discovery function was examined by using Johansen's test of cointegration (1991), vector error correction model (VECM), Wald chi-square test, and Granger causality test. The risk-management function was examined by using ordinary least squares (OLS) method and VECM to estimate optimal hedge ratio (OHR) and hedge effectiveness (HE). The study used secondary data consisting of daily closing prices of spot and futures markets for a period of 10 years (2004 – 2013) for three agricultural commodities, that is, Chana, Chilli, and Turmeric, which are traded in National Commodity & Derivatives Exchange Ltd. (NCDEX). It was found that there is a long-run association between commodity spot and futures prices of Chana, Chilli, and Turmeric. The VECM results revealed that there is a long-run causality running from futures prices to spot prices, which enable the spot market to adjust its short-run deviations from long-run equilibrium path with nearly 2.17%, 2.78%, and 4.41% speed of adjustments in Chana, Chilli, and Turmeric, respectively. The Granger causality test results revealed that there is only a unidirectional causality from futures returns to spot returns of commodities - Chilli and Turmeric. However, in the case of Chana, there is a bidirectional causality between futures and spot returns. According to hedge ratios of OLS and VECM results, it was found that the commodity futures provide 50%, 56%, and 55% variance reduction in their spot prices of Chana, Chilli, and Turmeric, respectively. It is observed that the commodity futures are more effective in hedging, and the near month futures contracts are suitable for hedging.

Keywords: **commodity futures, price volatility, price discovery, price risk management**

JEL Classification : C22, C32, G14, O13, Q13

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Commodities, like other asset classes whose prices are determined by all the various information that flow into the markets about their fundamentals, inherently carry price volatility. Commodity price volatility is the most critical issue faced by the producers of primary commodities. As for agricultural commodities in India, direct government intervention in the form of floor price, guaranteed price, minimum support price, etc aimed at protecting buyers was not so successful. Of late, gradual liberalization of domestic markets left this direct intervention limited and allowed market forces to decide the prices. This reform initiative resulted in market-based instruments for commodity risk management such as commodity futures. On the other hand, price volatility is making it difficult for the companies and traders to plan their production activities and allocate resources efficiently. Therefore, the price volatility drives the demand for hedging the price risk in the commodity market.

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Commodity derivatives market performs the most important economic functions of price discovery, price stabilization, and risk management. The transparency, which emerges from their trading mechanism, ensures the price discovery in the underlying market. Further, they serve as risk management tools by facilitating the trading of risks among the market participants.

Risk transfer and price discovery are the two major contributions of futures markets to the organization of economic activity (Evans, 1978 ; Silber, 1981 ; Working, 1962). Risk transfer refers to hedgers using futures contracts to shift price risk to others. Price discovery refers to the use of futures prices for pricing cash market transactions (Gardbade & Silber, 1983 ; Lake, 1978 ; Working, 1948 ; Wiese, 1978). Price discovery is the process through which markets attempt to reach equilibrium prices (Schreiber & Schwartz, 1986 ; Working, 1948). In a static sense, price discovery implies the existence of equilibrium price and in a dynamic sense, the price discovery process describes how information is produced and transmitted across the markets. In addition, it also impounds information to all the market participants. The significance of both these contributions depends upon a close relationship between the prices of futures contracts and cash (spot) commodities. Theoretically when two markets for the same asset are faced with the same information arriving simultaneously, the two markets should react at the same time in a similar fashion. If the two markets do not react at the same time, one market will then lead the other. When such a lead-lag relation appears in case of price adjustments, the leading market is viewed as contributing a price discovery function for that sector (Bose, 2008).

Under efficient markets, new information is impounded simultaneously into cash and futures markets (Zhong, Darrat, & Otero, 2004). In other words, financial market pricing theory states that market efficiency is a function of how fast and how much information is reflected in prices. The rate at which prices exhibit market information is the rate at which this information is disseminated to market participants (Zapata, Fortenbery, & Armstrong, 2005). In reality, institutional factors such as liquidity, transaction costs, and other market restrictions may produce an empirical lead-lag relationship between price changes in the two markets. The market that provides the greater liquidity and low trading cost as advocated by Fleming, Ostdiek, and Whaley (1996) is likely to play a more important role in price discovery. The price discovery between spot and futures prices series exist either in unidirectional way or in both directions, depending on the market under investigation.

Futures markets should be able to generate prices that express future expectations on cash prices, and should be able to transmit that information effectively across the market (Tomek, 1980 ; Working, 1948). The essence of the price discovery function of future markets hinges on whether new information is reflected first in changed futures prices or in changed cash price (Hoffman, 1931).

Effective price discovery requires the direct participation of several players in commodity markets : farmers/producers, intermediaries, wholesalers, consumers, investors, and other players. In India, the majority of farmers/producers traditionally produce mainly for consumption, and so do not generally participate in commodity markets. The fragmented rural market is a huge challenge in the marketing/trading of agricultural commodities. Thus, commodity markets in India are generally dominated by speculating traders and brokers. In fact, often trading in futures markets is banned because prices become too speculative (Nath & Lingareddy, 2008).

Price discovery also depends heavily on physical market infrastructure, as well as handling costs, storage costs, transportation costs, tax rates, and other factors. In India, there is a nationwide network of regulated markets for commodities, though the rural periodical markets are largely unregulated. Also, thin markets are expected to be inefficient and are characterized by price variability, that is, low trading volume implies a relatively small amount of information and perhaps information of low quality (Tomek, 1980). The poor flow of information would be expected to affect the price discovery function.

With a growing population of 1.21 billion (Census 2011), nature and growth potential of its economy, India would remain one of the largest markets for traders in global commodities. Since India is one of the largest producers of agricultural commodities, it is time for India to take a dominant role in price leadership at the national and international levels. In this backdrop, it is important to empirically examine the price discovery and risk management mechanism of select agricultural/primary commodities in India.

Review of Literature

In the empirical financial economics literature, the question of whether the spot or the futures markets play a dominant role in the price discovery process has often been raised and investigated. Quan (1992) found that price discovery takes place in spot market and gets transmitted to futures market. In contrast, Gardbade and Silber (1983) concluded that futures market plays a major role in the price discovery and spot market has a role in price discovery too. Although the spot and futures markets of an asset are subject to the same information, the lead-lag relationship between spot and futures markets indicates whether there is unidirectional flow of information from the futures (spot) market to the spot (futures) market or a bidirectional flow of information between these markets. The lead-lag relationship between spot and futures shows how fast one market reflects the new information vis-à-vis another and how well they are connected. If a departure from equilibrium occurs, prices in one or both markets should adjust to correct the disparity. In other words, it helps in understanding the strength of linkages between these markets and the speed of adjustments. The present section outlines empirical literature on price discovery and risk management in the spot-futures markets in the international and Indian context. The review of the earlier studies here is attempted chronologically in order to get a comprehensive picture.

Jian and Leatham (1999) examined the price discovery function for three U.S. wheat futures markets: the Chicago Board of Trade, Kansas City Board of Trade, and Minneapolis Grain Exchange. Their tests results revealed the existence of one equilibrium price across the three futures markets in the long run, but no cointegration among prices in the three representative cash markets.

Pindyck (2001) provided an explanation of short-run commodity price movements that is based on "fundamentals," that is, rational shifts in supply and demand in each of the two markets. The author also explained how prices, rates of production, and inventory levels are interrelated, and are determined via equilibrium in two interconnected markets. Thomas (2003) showed some evidence on the role played by the nascent futures markets in price discovery. They offered three policy proposals: using reference rates for strengthening transparency, exploring a greater role for cash settlement, and treating warehouse receipts as securities.

Yang, Brian, and Leatham (2005) examined the lead-lag relationship between futures trading activity (volume and open interest) and cash price volatility of major agricultural commodities through Granger causality tests and generalized forecast error variance decompositions methods. They found that an unexpected increase in futures trading volume unidirectionally causes an increase in cash price volatility for most commodities. Further, they found a weak causal feedback between open interest and cash price volatility.

Lokare (2007) examined the efficacy and performance of commodity derivatives in steering the price risk management. He found that almost all the commodities threw an evidence of co-integration in both spot and futures prices, presaging that these markets were marching in the right direction of achieving improved operational efficiency, *albeit*, at a slower pace. He also found that hedging proved to be an effective proposition in respect of some commodities, while the others entailed moderate or considerably higher risk.

Easwaran and Ramasundaram (2008) examined the integration between spot and futures markets in agricultural commodities in India by using Bartlett's homogeneity of variance test. The results indicated that price discovery did not occur in agricultural commodity futures market. The econometric analysis of the relationship between price return, volume, market depth, and volatility showed that the market volume and depth were not significantly influenced by the return and volatility of futures as well as spot markets.

Nath and Lingareddy (2008) tried to explore the effect of futures trading on spot prices of pulses by using correlations, regression analysis, and the Granger causality test. They found that volatility in urad as well as pulses prices was higher during the period of futures trading than in the period prior to its introduction as well as after the ban of futures contract.

Mahalik, Acharya, and Babu (2009) examined price discovery and volatility spillovers in Indian spot-futures commodity markets by using cointegration (Johansen, 1991), VECM, and the bivariate EGARCH

(Nelson, 1991) model. This study used data on futures and spot indices of Multi-Commodity Exchange (MCX). They found that commodity futures markets effectively served the price discovery function in the spot market, implying that there is a flow of information from futures to spot commodity markets. Besides, the bivariate GARCH model indicated that the volatility spillovers from futures to the spot market were dominant in the case of ENERGY and COMDEX index while the AGRI-Spot market acted as a source of volatility towards the agri-futures market.

Ghosh (2010) found that there is little evidence to suggest that futures prices serve as a reference price for transacting contracts in the physical market, and as a natural corollary, futures market volatility cannot lead to volatility in the physical market. The level of liquidity was low in the futures markets, as the markets were not only lacking of speculative volumes, it did not even seem to have served the purpose of hedgers.

Ali and Gupta (2011) studied the long-term relationship between futures and spot prices for the agricultural commodities like Maize, Chickpea, Black Lentil, Pepper, Castor Seed, Soyabean, and Sugar. They found cointegration in the futures and spot prices, a short-term relationship between spot and futures market, and the futures markets had ability to predict spot prices for Chickpea, Castor seed, Soyabean, and Sugar. There was a bi-directional relationship in the short-run among Maize, Black Lentil, and Pepper.

Mukherjee (2011) made an attempt to re-validate the impact of futures trading on agricultural commodity market in India by using multiple regression model, VAR model, and GARCH model. It was found that the price volatility for most of the selected agricultural commodities was higher in pre- futures period and got significantly reduced after getting listed in futures. It was also found that there was a comparative advantage of futures market in disseminating information, leading to a significant price discovery and risk management.

Kumar and Pandey (2011) investigated the effectiveness of the price discovery function of commodity futures markets in India. It was found that the Indian commodity futures markets did not dominate the price discovery process as they did in other developed markets. For the precious metals and energy commodities, the futures markets lead the price discovery role. In the case of agricultural commodities and industrial metals, the price discovery takes place in both spot and futures markets. For the precious metals and energy commodities, which are more tradable in nature, futures markets are not affected by spot markets.

Dey and Maitra (2012) examined the price discovery process on Pepper by applying Granger causality, co-integration, and error correction model. They found that there was a unidirectional causality from futures to spot prices in the pepper futures market.

Sehgal, Rajput, and Dua (2012) empirically examined the effect of futures trading activity (trading volume; proxy of futures liquidity) on spot price volatility for seven agricultural commodities (guar seeds, turmeric, soya bean, black pepper, barley, maize, and castor seed). They found that unexpected futures trading volume was Granger causing spot price volatility and was significant for five out of seven agricultural commodities (guar seed, turmeric, soybean, maize, and castor seed). Reversed effect was found for one commodity, that is, Pepper - the effect of spot volatility on futures trading and for barley, no causality was revealed either from futures to spot or vice-versa.

Chauhan, Singh, and Arora (2013) analyzed the market efficiency of the Indian commodity market and volatility spillover effects between the spot and futures market with reference to agri-commodities : guar seed and chana. They found that the commodity futures markets effectively served the price discovery function in the spot market, implying that there was a flow of information from futures to spot commodity markets. They also found that the volatility spillovers from futures to the spot market were dominant. However, it was found that in case of agri-commodities, the volatility in spot market may influence the volatility in the futures market.

Gupta and Varma (2015) investigated the impact of futures trading on spot markets of rubber in India. Their study focused on the price discovery role of futures, direction of volatility spillovers, and the relationship between the futures trading activity and the spot price volatility. The co-integration and error correction model results showed a stronger information flow from the futures to spot markets, indicating price discovery in futures. The results of Granger causality tests showed the existence of a bidirectional volatility spillover in the two markets and that futures trading activity is both a cause and consequence of spot volatility.

Most of the previous studies revealed the fact that spot and futures markets may not react at the same time after the flow of new information. Some lead-lag relationship is commonly observed in most of the cases. The dearth of conclusive statement on price discovery creates scope for the further examination of the issue in detail for the Indian commodity futures market. Though commodity markets in emerging economies like India have been growing, not much research has been done on testing the efficiency of commodity derivatives in price discovery and risk management of agricultural/primary commodities in India. Therefore, it has become necessary, from time to time, to conduct empirical studies to measure the efficiency of commodity futures in price discovery and risk management in agricultural commodities.

The study attempts to address the following question: *Whether the commodity futures prices are useful in price discovery and risk management functions of spot prices efficiently?*

Objective of the Study

The objective of the study is to find the efficiency of commodity futures market in price discovery and risk management through hedging for agricultural commodities in India.

Hypotheses

➭ **H01:** There is no significant long-run association between commodity futures and spot prices.

➭ **H02:** There is no significant Granger causality from commodity futures prices to spot prices.

➭ **H03:** There is no significant decrease in the variance of commodity spot returns (price risk) by hedging through commodity futures.

Data and Research Methodology

(1) Sources of Data : This study is based on secondary data and consists of the daily closing prices of spot and near-month futures contracts of Chana, Chilli, and Turmeric for a period of 10 years, that is, from 2004 - 2014. The prices were collected from the National Commodity & Derivatives Exchange Limited (NCDEX) website for the research period.

(2) Sample Selection : The study selected the NCDEX as it is the largest national commodity exchange for agricultural commodities' trading. The study selects three primary agricultural commodities, that is, Chana, Chilli, and Turmeric as sample commodities which have national importance and contribute to more export revenue.

(i) Chana : It is placed third in the importance list of the food legumes that are cultivated throughout the world. India is the largest producer of chickpea (chana) followed by Pakistan, Turkey, and Iran. India produces around 6 to 8 million tonnes and contributes to around 70% of the total world production. Chana is the most largely produced pulse crop in India, accounting to a share of 40% of the total pulse production.

(ii) Chilli : Global production of Chilli stands at about 20.00 lakh MT to 25.00 lakh MT per annum. India is the largest producer and contributes about 10.00 lakh MT to 12 lakh MT annually followed by China, Nigeria, Peru, Bangladesh, Hungary. Domestically, Andhra Pradesh contributes 49% of total production followed by Karnataka (14%), Orissa (7%), Maharashtra (5%), West Bengal (5%), Rajasthan (5%) , and Tamil Nadu (4%). Globally, Indian chillies are of superior quality which makes India the largest exporter of Chillies.

(iii) Turmeric : India is the world's largest producer of turmeric and produces nearly 80-85% of world's total production, which stands at around 6.0 lakh MT to 7.0 lakh MT per year. Major producers in India are Andhra Pradesh, Tamil Nadu, Orissa, West Bengal, Karnataka, and Maharashtra. India is the world's leading exporter, prime export destinations being UAE, USA, Sri Lanka, Japan, and UK. Indian turmeric is considered to be of best quality due to high curcumin content and is increasingly getting known for its medicinal and cosmetic applications.

(3) Processing of Data : The study analyses the near-month contracts because these are highly liquid and the most active contracts. The near-month futures time series is prepared based on a rolling basis. The study also removes the maturity week data from the near-month futures series to remove the maturity bias. The daily closing prices of spot and futures of sample commodities have been converted into 'Natural Logarithm, that is, *ln* of daily closing prices' to minimize the heteroscedasticity in data. Daily 'Returns' on all the sample commodities, both in spot and futures markets, are computed as continuously compounded return, that is, natural logarithmic differences of lagged price series as follows:

$$SR_t = ln\left(\frac{SP_t}{SP_{t-1}}\right) \text{ x } 100$$

$$FR_t = ln\left(\frac{FP_t}{FP_{t-1}}\right) \text{ x } 100$$

Where, SR_t and FR_t are natural logarithmic daily percentage returns at time t ; FP_{t-1} and FP_t and SP_{t-1} and SP_t are daily closing prices of commodity futures and their underlying commodities in spot market on two successive days $t-1$ and t, respectively.

(4) Research Methodology : The study examines the efficiency of commodity futures in price discovery through long-run equilibrium between spot and futures markets, long-run and short-run causality between the futures and spot markets by using Johansen test of cointegration (1991), vector error correction model (VECM), and Wald chi-square (χ^2) test. Granger causality test has been employed to know the direction of causality between the two markets and how it results into the process of price discovery. In order to test the efficiency of commodity futures in risk management, the study uses ordinary least squares (OLS) method and VECM to estimate optimal hedge ratio (OHR) and hedge effectiveness (HE) through construction of hedged portfolios and un-hedged portfolios. Finally, the analysis shows how it results into the process of risk management.

(i) Testing Stationarity of Commodity Futures and Spot Returns : Augmented Dickey Fuller (ADF) test has been employed to analyze the stationarity of price and returns series of spot and futures of sample commodities. The following equation describes the estimation of stationarity under the ADF test :

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta Y_{t-j} + \varepsilon_t$$

The unit root test is carried out under the null hypothesis $\gamma = 1$ against the alternative hypothesis of $\gamma < 1$. Once the value for the test statistic is computed, it can be compared to the relevant critical value for the ADF test. If the test statistic is less than the critical value, then the null hypothesis of $\gamma = 1$ is rejected and no unit root is present and the series become stationary.

(ii) Estimation of Long-run Association Between Commodity Futures and Spot Prices - Cointegration Analysis Using Johansen Test of Cointegration (1991) : The price linkage between futures market and spot market is examined using cointegration (Johansen, 1991) analysis that has several advantages. First, cointegration analysis reveals the extent to which two markets have moved together towards long run equilibrium. Secondly, it allows for adjustment in divergence of respective markets from long-run disequilibrium in the short run. The co-integrating vector identifies the existence of long run equilibrium, while error correction dynamics describes the price discovery process that helps the markets to achieve equilibrium (Schreiber & Schwartz, 1986).

There are two test statistics for cointegration under the Johansen approach, which are formulated as:

Trace Test :

$$\lambda trace\,(r) = -T\Sigma^{k}_{i=r+1} \ln(1-\hat{\lambda}\,i)$$

Maximum Eigen value test :

$$\lambda max\,(r, r+1) = -T\ \ln(1-\hat{\lambda}_{i+1})$$

where, r is the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}_i$ is the estimated value for the ith ordered Eigen value from the Π matrix. It is the ith largest Eigen value of matrix Π. T is the sample size or number of observations. $\hat{\lambda}_{i+1}$ is the $(1+r)^{th}$ largest squared Eigen value. Each Eigen value will have associated with it a different cointegrating vector, which will be eigen vectors. A significantly non-zero Eigen value indicates a significant cointegrating vector.

λ*trace* is a joint test where the null is that the number of cointegrating vectors is less than or equal to r against an unspecified or general alternative that there are more than r.

λ*max* conducts separate tests on each Eigen value, and has as its null hypothesis that the number of cointegrating vectors is r against an alternative of $r+1$.

If the test statistics is greater than the critical value from the Johansen's tables, reject the null hypothesis that there are r cointegrating vectors in favour of the alternative that there are r+1 (for λ*trace*) or more than r (for λ*max*).

(iii) Estimation of Long-run and Short-run Adjustment/Convergence Towards Equilibrium (Causality) Between Commodity Spot and Futures Prices : If spot and futures prices are cointegrated, then causality must exist at least in one direction (Granger, 1986). Besides, Ghosh (1993), Lien and Luo (1994), and Lien (1996) argued that if the two price series are found to be cointegrated, then there exists valid error correction representations of the price series that includes short-term dynamics and long-run information. For this purpose, to examine the lead-lag relationship or the long-run and short-run speed adjustment/convergence towards equilibrium or long-run steady state (causality) between spot and futures prices of sample commodities, the study uses the vector error correction model (VECM) as spot and futures prices are cointegrated.

➭ **Vector Error Correction Model (VECM) :** It is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with non-stationary series that are known to be cointegrated. The VEC specification restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The cointegration term is known as the error correction term (ECT) since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The error correction models are formed in both directions, one with the spot price as the dependent variable, and the other with the futures price as the dependent variable. Ferret and Page (1998, p. 76) had the following to say on the interpretation of these relationships: "If the change in X_t is dependent, not only on past changes of itself, but also the equilibrium error and past changes of Y_t, then it can be said that Y_t leads X_t" (p. 76).

The long-run and short-run causality between spot and futures prices is estimated by using the following VECM :

$$\Delta S_t = \alpha_s + \lambda_S Z_{t-1} + \Sigma^{k}_{i=2} \beta_{Si} \Delta S_{t-i} + \Sigma^{l}_{j=2} \gamma_{Fj} \Delta F_{t-j} + \varepsilon_{St} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\Delta F_t = \alpha_F + \lambda_F Z_{t-1} + \Sigma^{k}_{i=21} \beta_{Fi} \Delta F_{t-i} + \Sigma^{l}_{j=2} \gamma_{Sj} \Delta S_{t-j} + \varepsilon_{Ft} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where, S and F are the intercepts and ε_{St} and ε_{Ft} are the error terms. Z_{t-1} is the error correction term, which measures how the dependent variable adjusts to the previous period's deviation from the long-run equilibrium:

$$Z_{t-1} = S_{t-1} - \alpha - \delta F_{t-1}$$

where, δ is the cointegrating vector and α is the intercept. The two-variable error correction model expressed in equations (1) and (2) is a bivariate VAR*(n)* model in first difference augmented by the error-correction terms, $\lambda_S Z_{t-1}$ and $\lambda_F Z_{t-1}$.The coefficients λ_S and λ_F are interpreted as the speed of adjustment parameters. The larger the λ_S, the greater the response of S_t to the previous period's deviation from the long-run equilibrium. The error correction coefficients, λ_S and λ_F, serve two purposes. They are (a) to identify the direction of causality between spot and futures prices; and (b) to measure the speed with which deviations from the long-run relationship are corrected by changes in the spot and futures prices.

(iv) Estimation of Presence of Short-run Causality Between Commodity Futures and Spot Prices Using Wald Chi-square (χ^2) Test : The Wald Chi-square (χ^2) test gives an indication of the 'short-term' causal effects (or strict exogeneity of the variables). The null hypothesis for the equation (1), $H_0 : \Sigma^{l}_{j=2} \gamma_{Fj} = 0$, suggests that the lagged terms of ΔF do not belong to the regression, that is, ΔF does not cause ΔS. Conversely, the null hypothesis for the equation (2) is $H_0 : \Sigma^{l}_{j=2} \gamma_{Sj} = 0$, suggesting that the lagged terms of ΔS do not belong to the regression, that is, ΔS do not cause ΔF. The joint test of these null hypotheses can be tested by Wald chi-square (χ^2) test. If the coefficients of γ_{Sj} are statistically significant, but the coefficients of γ_{Fj} are not statistically significant, then S is said to cause F (unidirectional). The reverse causality holds if coefficients of γ_{Fj} are statistically significant while γ_{Sj} are not, that is, F causes S (unidirectional). Nevertheless, if both γ_{Sj} and γ_{Fj} are statistically significant, then causality runs both ways (bidirectional). Independence is identified when γ_{Sj} and γ_{Fj} coefficients are not statistically significant in both the regressions. In this present study, the Wald Chi-square (χ^2) test is performed to test the null hypothesis that the joint value of coefficients of future prices at different select lag lengths is zero.

(v) Estimation of Direction of Causality - Granger Causality : Engle and Granger (1987) and Johansen (1991) suggested that if cointegration exists between two variables in the long-run, then there must either be unidirectional or bi-directional causality between these variables. If spot and futures prices are cointegrated, then causality must exist at least in one direction (Granger, 1986). Co-integration indicates that causality exists between the two series, but it fails to show the direction of the causality relationship. Further, to find out the direction of the causality, the Granger causality test is conducted with the help of the following equations:

Causal Relationship from Futures to Spot market :

$$R_{St} = \alpha_0 + \Sigma^{p}_{k=1} \alpha_{1k} R_{S(t-k)} + \Sigma^{p}_{k=1} \beta_{1k} R_{F(t-k)} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Causal Relationship from Spot to Futures market :

$$R_{Ft} = \alpha_0 + \Sigma^{p}_{k=1} \alpha_{1k} R_{S(t-k)} + \Sigma^{p}_{k=1} \beta_{1k} R_{F(t-k)} + \mu_t \text{ .... (ii)}$$

In the above two equations, R_{St} and R_{Ft} are returns of spot and futures price in period t and $R_{S(t-k)}$ and $R_{F(t-k)}$ are the spot and futures price returns in k previous periods, that is, period *(t- k)*. α_k and β_k are the coefficients and μ_t are the error terms. For the first equation, the null hypothesis $\beta_k = 0$ implies that previous periods' futures returns do not Granger- cause present periods' spot price returns. However, if the null is rejected using a standard joint test like the F-test, then it would imply that the previous periods' futures price returns help in predicting today's spot price returns. Similarly, for the second equation rejection of the null $\beta_k = 0$ (which means previous periods' spot prices do not cause today's futures prices) would signify the power of the previous values of spot price returns in predicting today's futures price returns.

(vi) Effectiveness of Commodity Futures in Hedging : Hedging effectiveness measures how much reduction in variances of the commodity prices/returns takes place when it is held simultaneously with a futures contract. Johnson (1960) was the first to derive the number of futures contracts necessary to hedge a certain spot position based on minimizing the variance of the hedged portfolio. Johnson (1960) and Stein (1961) introduced the concept of portfolio theory through hedging cash positions with futures. 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.

Ederington (1979) applied this concept in determining a risk minimizing hedge ratio and derived a measure of hedging effectiveness. The hedge ratio that generates the minimum portfolio variance should be the optimal hedge ratio, which is also known as the minimum variance hedge ratio (MVHR). One of the important theoretical issues in hedging is the determination of the optimal hedge ratio and hedging effectiveness. The minimum-variance hedge ratio (Benninga, Eldor, & Zilcha, 1983, 1984) has been suggested as slope coefficient of the OLS regression in which changes in spot prices is regressed on changes in futures prices. The optimal hedge ratio for any unbiased futures market can be given by ratio of covariance of (cash prices, futures prices) and variance of (futures prices). The study uses OLS and VECM to estimate constant hedge ratios and hedge effectiveness of the sample commodity futures.

➯ **Hedge Ratio and Hedge 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:

$$R(u) = S_{t+1} - S_t$$
$$R(h) = (S_{t+1} - S_t) - h^*(F_{t+1} - F_t)$$

Variances of an unhedged and a hedged portfolio are:

$$Var(u) = \delta_s^2$$
$$Var(h) = \delta_s^2 + h^2 \delta_f^2 - 2h^* \delta_{sf}$$

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 portfolios ; σ_S and σ_F are standard deviation of the spot and futures returns ; $\sigma_{S,F}$ is the covariance; *Var(u)* and *Var(h)* are variances of unhedged and hedged positions. Hedging effectiveness is defined as the ratio of the variance of the unhedged position minus variance of hedge position over the variance of unhedged position.

The hedging effectiveness *(HE)* is calculated as:

$$HE = \frac{Var(u) - Var(h)}{Var(u)}$$

➯ **Hedge Ratio - Ordinary Least Square (OLS) Method :** In this method, changes in spot prices are regressed on the changes in futures prices. The minimum-variance hedge ratio has been suggested as slope coefficient of the OLS regression. The *R*-square of this model indicates the hedging effectiveness.

$$R_{st} = \alpha + \beta_{ft} + \varepsilon$$

where, R_{st} and R_{ft} are the spot and futures returns for period *t*. β provides an estimate of the optimal hedge ratio (the minimum hedge ratio h^*). The R^2 of this model indicates the hedging effectiveness.

➯ **Hedge Ratio - The Vector Error Correction Model (VECM) :** It is obvious that the OLS model ignored the effect that the two series are cointegrated, which was further addressed by Ghosh (1993), Lien and Luo (1994), Lien (1996), and Johnson (1999). When futures and spot prices are cointegrated, return dynamics of the both prices can be modelled through vector error correction model (VECM). VECM specifications allow a long-run equilibrium error correction in prices in the conditional mean equations (Engle & Granger, 1987). If the futures and spot series are co-integrated of the order one, then the Vector error correction model of the series is given as:

$$\Delta S_t = \alpha_S + \lambda_S Z_{t-1} + \Sigma^k_{i=2} \beta_{Si} \Delta S_{t-i} + \Sigma^l_{j=2} \gamma_{Fj} \Delta F_{t-j} + \varepsilon_{St} \text{ ....} (1)$$
$$\Delta F_t = \alpha_F + \lambda_F Z_{t-1} + \Sigma^k_{i=21} \beta_{Fi} \Delta F_{t-i} + \Sigma^l_{j=2} \gamma_{Sj} \Delta S_{t-j} + \varepsilon_{Ft} \text{ ....} (2)$$

where, α_S and α_F are the intercepts and ε_{St} and ε_{Ft} are the error terms. Z_{t-1} is the error correction term, which measures how the dependent variable adjusts to the previous period's deviation from the long-run equilibrium:

$$Z_{t-1} = S_{t-1} - \alpha - \delta F_{t-1}$$

where, δ is the cointegrating vector and α is the intercept. The two-variable error correction model expressed in equations (1) and (2) is a bivariate VAR*(n)* model in first difference augmented by the error-correction terms, $\lambda_S Z_{t-1}$ and $\lambda_F Z_{t-1}$. The coefficients λ_S and λ_F are interpreted as the speed of adjustment parameters.

After estimating the system of equation, the residual series are generated to calculate the variance, covariance of the series to estimate the minimum variance hedge ratio. The error terms in the equations, ε_{St} and ε_{Ft} are independently identically distributed (IID) random vector. The minimum variance hedge ratio is calculated as :

$$H = \frac{\sigma_{sf}}{\sigma_f}$$

where, H = hedge ratio, $Var(\varepsilon_{St}) = \sigma_s$, $Var(\varepsilon_{Ft}) = \sigma_f$, $Cov(\varepsilon_{St}, \varepsilon_{Ft}) = \sigma_{sf}$

Data Analysis and Results

The Table 1 shows the descriptive statistics of daily returns of spot and futures of sample commodities. It reveals that the returns on spot and futures of Chilli are much higher than the returns of Chana and Turmeric during the study period. The variability in returns, that is, volatility in spot and futures returns of Chilli and Turmeric is relatively greater than the volatility in spot and futures returns of Chana as revealed from standard deviation. Positive skewness is observed in the returns of spot and futures of Chilli and indicates a distribution with an asymmetric tail extending towards right side and hence a higher probability of earning positive returns. Negative skewness is observed in the returns of spot and futures of Chana and Turmeric and indicates a distribution with an asymmetric tail extending toward more negative values. A large kurtosis figure (> 3) is also observed in the returns of spot and futures of Chana, Chilli, and Turmeric, indicating a Leptokurtic distribution, which implies the distribution of returns have fat tails compared to the normal distribution. This means high probability for extreme values.

The Table 2 shows the results of stationarity test on the *ln* values of prices and returns series of spot and futures of Chana, Chilli, and Turmeric, respectively. The results of the ADF test confirm that the data series of spot and futures prices is non- stationary at level form ($p > 0.05$) and the data series of spot and futures returns is stationary ($p < 0.05$). Hence, Johansen test of cointegration is used to check long-run equilibrium relationship between spot and futures prices of sample commodities. As the results of cointegration are sensitive to lag length, AIC criteria has been applied and it is found that the optimal lag length is 4 days for Chana, 2 days for Chilli, and 3 days for Turmeric, respectively (see Annexure 1).

The Table 3 shows the results of Johansen test of cointegration. The results reveal that there is a presence of one cointegration equation between spot and future prices of Chana, Chilli, and Turmeric and this signifies the long-run association. The trace test results points out that the number of cointegration equations are less than or equal

Table 1.Descriptive Statistics of Daily Returns of Spot and Futures (2004 - 2014)

NCDEX - Agricultural Commodities - Near Month Contracts						
Descriptive Statistics	**Chana**		**Chilli**		**Turmeric**	
	SR	**FR**	**SR**	**FR**	**SR**	**FR**
Mean	0.03	0.02	0.13	0.12	0.05	0.06
Median	0	0	-0.07	-0.04	-0.02	-0.06
Maximum	10.39	10.63	47.3	42.95	23.31	31.9
Minimum	-12.17	-25.76	-49.78	-58.06	-44.65	-36.45
Std. Dev.	1.48	1.72	3.13	3.95	2.66	3.34
Skewness	-0.22	-1.61	2.38	0.58	-4.25	0.21
Kurtosis	9.82	31.24	124.04	68.1	96.48	32.48
No. of Observations	2675	2675	1186	1186	1385	1385

Table 2.Testing of Stationarity of Commodity Spot and Futures Prices & Returns

Augmented Dickey Fuller test - Log Prices						
Particulars	**Chana**		**Chilli**		**Turmeric**	
	***t*-Statistic**	**Prob.***	***t*-Statistic**	**Prob.***	***t*-Statistic**	**Prob.***
Log Spot Prices	-1.9832	0.2945	-1.9014	0.3319	-0.9676	0.7664
Log Futures Prices	-2.0081	0.2835	-2.0964	0.2463	-1.0835	0.7243
Augmented Dickey Fuller test - Ln futures and Spot Returns						
Particulars	**Chana**		**Chilli**		**Turmeric**	
	***t*-Statistic**	**Prob.***	***t*-Statistic**	**Prob.***	***t*-Statistic**	**Prob.***
Spot Returns	-47.1132	0.0001	-31.6243	0.0000	-32.8881	0.0000
Futures Returns	-50.8304	0.0001	-31.6399	0.0000	-36.5393	0.0000

Test critical values : 1% level -3.432948 ; 5% level -2.862574 ; 10% level 2.567366

*MacKinnon (1996) one-sided *p*-values.

Table 3. Estimation of Long-run Association Between Commodities Futures and Spot Prices

Johansen Co-integration Test							
LSP LFP - Chana - Near Month Contracts							
Hypothesized	**Eigenvalue**	**Trace Test**			**Max-Eigen Value Test**		
No. of CE(s)		**Statistic value**	**Critical Value**	**Prob.****	**Statistic value**	**Critical Value**	**Prob.****
None *	0.022399	64.30359	15.49471	0.0000	60.50876	14.2646	0.0000
At most 1	0.00142	3.794828	3.841466	0.0514	3.794828	3.841466	0.0514
LSP LFP - Chilli - Near Month Contracts							
Hypothesized	**Eigenvalue**	**Trace Test**			**Max-Eigen Value Test**		
No. of CE(s)		**Statistic value**	**Critical Value**	**Prob.****	**Statistic value**	**Critical Value**	**Prob.****
None *	0.036177	47.28236	15.49471	0.0000	43.62791	14.2646	0.0000
At most 1	0.003082	3.654446	3.841466	0.0559	3.654446	3.841466	0.0559
LSP LFP - Turmeric - Near Month Contract							
Hypothesized No.	**Eigenvalue**	**Trace Test**			**Max-Eigen Value Test**		
of CE(s)		**Statistic value**	**Critical Value**	**Prob.****	**Statistic value**	**Critical Value**	**Prob.****
None *	0.031188	44.94325	15.49471	0.0000	43.7877	14.2646	0.0000
At most 1	0.000836	1.155554	3.841466	0.2824	1.155554	3.841466	0.2824

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level; Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) *p*-values

to one ; whereas, maximum Eigen value test results confirm the presence of one cointegration equation. To examine the lead-lag relationship or the long-run and short-run speed adjustment /convergence towards equilibrium between spot and futures prices, the study uses the vector error correction model (VECM) as spot and futures prices are cointegrated.

The Table 4 shows the error correction terms (ECT) of spot and futures prices of Chana, Chilli, and Turmeric for different lags and indicates the long-run and short-run speed adjustment (convergence) towards equilibrium or long-run steady state. When the coefficient of error correction term (coefficient of CointEq1) is negative in sign and significant, then it can be said that there is a long-run causality running from futures prices to dependent spot prices. The ECTs of *ln* spot prices of commodities under study are negative in sign (Chana: -0.021754, Chilli: -0.02778, and Turmeric: -0.044087) and significant ($p < 0.05$). This implies that there is a long-run causality running from futures prices to spot prices which enable the spot market to adjust to the short-run deviation from long-run equilibrium path with nearly 2.17%, 2.78%, and 4.41% speed of adjustments in sample commodities, that is, Chana, Chilli, and Turmeric, respectively. The speed of correction in the futures market of Chana and Chilli is 4.47% and 3.92% against spot market, which indicates a highly informative futures market. At the same time, insignificant ECT of *ln* futures prices of Turmeric indicates futures market efficiency towards maintaining stable long-run equilibrium.

The Table 5 reveals the results of Wald Chi-square (χ^2) test that the joint value of all the coefficients of *ln* futures prices of Chana, Chilli, and Turmeric at select lag lengths are not equal to zero, which indicates the presence of the short-run causality between the spot and futures markets of commodities understudy ($p < 0.05$).

The Table 6 presents the results of Granger causality. The Granger causality test was conducted from lag one to lag five to assess the direction of causality on all the week days prices in futures and spot market. The results disclose that there is only a unidirectional causality from futures returns to spot returns of commodities Chilli and Turmeric ($p < 0.05$). However, in the case of Chana, there is a unidirectional causality from futures to spot returns for lag one ($p < 0.05$) and bidirectional causality between futures and spot returns for the remaining lags ($p < 0.05$).

Table 4. Estimation of Long-run and Short-run Adjustment (Causality) Between Spot and Futures Prices

VEC - Vector Error Correction Estimates of LSP LFP for Near Month Contracts

		Chana		Chilli		Turmeric	
Error Correction:		**D(LSP)**	**D(LFP)**	**D(LSP)**	**D(LFP)**	**D(LSP)**	**D(LFP)**
CointEq1	Coefficient	-0.021754	0.044737	-0.02778	0.039219	-0.044087	0.028871
	Standard Error	0.0086	0.01087	0.01179	0.01497	0.01317	0.01708
	t-statistics	[-2.52934]	[4.11402]	[-2.35688]	[2.61933]	[-3.34655]	[1.68986]
	Prob.	0.0115	0.0000	0.0186	0.0089	0.0008	0.0913
D(LSP(-1))	Coefficient	-0.140273	0.048932	0.01054	-0.093393	-0.052826	0.052339
	Standard Error	0.02521	0.03188	0.04125	0.05241	0.03802	0.04931
	t-statistics	[-5.56322]	[1.53491]	[0.25550]	[-1.78214]	[-1.38939]	[1.06145]
	Prob.	0.0000	0.1249	0.7984	0.0750	0.1649	0.2887
D(LSP(-2))	Coefficient	0.019354	0.068243	-0.053819	-0.064645	-0.087443	-0.02068
	Standard Error	0.02536	0.03206	0.04119	0.05233	0.03741	0.04852
	t-statistics	[0.76315]	[2.12833]	[-1.30652]	[-1.23540]	[-2.33715]	[-0.42623]
	Prob.	0.4454	0.0334	0.1916	0.2169	0.0196	0.6700
D(LSP(-3))	Coefficient	-0.087573	0.009288			0.034782	0.017152
	Standard Error	0.02527	0.03196			0.03606	0.04677
	t-statistics	[-3.46491]	[0.29065]			[0.96443]	[0.36672]
	Prob.	0.0005	0.7713			0.3350	0.7139
D(LSP(-4))	Coefficient	-0.064059	0.055019				
	Standard Error	0.02233	0.02823				
	t-statistics	[-2.86897]	[1.94893]				
	Prob.	0.0042	0.0514				
D(LFP(-1))	Coefficient	0.3772	0.007302	0.068277	0.147738	0.158608	0.000229
	Standard Error	0.02035	0.02573	0.03298	0.0419	0.03045	0.03949
	t-statistics	[18.5370]	[0.28384]	[2.07006]	[3.52609]	[5.20862]	[0.00579]
	Prob.	0.0000	0.7766	0.0387	0.0004	0.0000	0.9954
D(LFP(-2))	Coefficient	-0.057483	-0.037123	0.075657	0.046685	0.132713	0.042404
	Standard Error	0.02224	0.02812	0.03311	0.04206	0.03066	0.03976
	t-statistics	[-2.58449]	[-1.32010]	[2.28490]	[1.10991]	[4.32921]	[1.06660]
	Prob.	0.0098	0.1869	0.0225	0.2673	0.0000	0.2863
D(LFP(-3))	Coefficient	-0.004722	-0.01027			0.028648	0.021175
	Standard Error	0.02212	0.02796			0.03003	0.03894
	t-statistics	[-0.21348]	[-0.36727]			[0.95411]	[0.54380]
	Prob.	0.8310	0.7134			0.3402	0.5867
D(LFP(-4))	Coefficient	0.036744	-0.03691				
	Standard Error	0.02128	0.02691				
	t-statistics	[1.72643]	[-1.37164]				
	Prob.	0.0844	0.1703				
C	Coefficient	0.000256	0.000205	0.001179	0.001203	0.000432	0.000522
	Standard Error	0.00026	0.00033	0.0009	0.00114	0.00069	0.0009
	t-statistics	[0.97738]	[0.61949]	[1.30903]	[1.05089]	[0.62308]	[0.58069]
	Prob.	0.3285	0.5356	0.1908	0.2935	0.5333	0.5615
R-squared		0.166567	0.013296	0.024333	0.01566	0.066839	0.005486
Adj. *R*-squared		0.163748	0.009959	0.020192	0.011482	0.062084	0.00042
F-statistic		59.09103	3.984085	5.875785	3.748278	14.05914	1.082847
Prob(*F*-statistic)		0.0000	0.000045	0.0000	0.002264	0.0000	0.371762

Note: *p* - values denote significance at the 5% level of significance

Table 5. Estimation of Presence of Short-run Causality Between Futures and Spot Prices

Wald Test: - LSP LFP - Near Month Contracts									
Test Statistic	**Chana**			**Chilli**			**Turmeric**		
	Value	***df***	**Prob.**	**Value**	***df***	**Prob.**	**Value**	***df***	**Prob.**
F-statistic	107.539	(4, 2661)	0.0000	4.825	(2, 1178)	0.0082	12.497	(3, 1374)	0.0000
Chi-square	430.155	4	0.0000	9.650	2	0.0080	37.490	3	0.0000

Note: *p* values denote significance at 5% level of significance

Table 6. Estimation of Direction of Causality - Granger Causality

Pairwise Granger Causality Tests										
SR FR - Near Month Contracts		**Chana**			**Chilli**			**Turmeric**		
Null Hypothesis:	**Lag Length**	**Observns**	***F*-Statistic**	**Prob.**	**Observns**	***F*-Statistic**	**Prob.**	**Observns**	***F*-Statistic**	**Prob.**
FR does not Granger Cause SR	1	2674	451.89	0.0000	1185	7.09	0.0079	1384	29.49	0.0000
SR does not Granger Cause FR			3.328	0.0682		2.588	0.108		2.91	0.0883
FR does not Granger Cause SR	2	2673	228.94	0.0000	1184	7.524	0.0006	1383	27.26	0.0000
SR does not Granger Cause FR			5.505	0.0041		1.769	0.171		1.084	0.3385
FR does not Granger Cause SR	3	2672	157.65	0.0000	1183	6.51	0.0002	1382	19.62	0.0000
SR does not Granger Cause FR			3.844	0.0093		1.652	0.1758		0.706	0.5483
FR does not Granger Cause SR	4	2671	120.03	0.0000	1182	4.846	0.0007	1381	14.881	0.0000
SR does not Granger Cause FR			4.058	0.0028		1.038	0.3864		1.675	0.1533
FR does not Granger Cause SR	5	2670	95.67	0.0000	1181	3.938	0.0015	1380	12.02	0.0000
SR does not Granger Cause FR			3.936	0.0015		0.995	0.4173		1.218	0.2984

Note: *p* values denote significance at 5% level of significance

Table 7. Hedge Ratio and Hedge Effectiveness of Commodity Futures Using OLS method

Agri - Commodities - Near month Contracts	**Chana**		**Chilli**		**Turmeric**	
	Un-Hedged	**Hedged**	**Un-Hedged**	**Hedged**	**Un-Hedged**	**Hedged**
Return	0.026	0.015	0.126	0.060	0.055	0.023
Variance	2.183	1.473	9.767	4.841	7.064	3.752
Hedge Ratio *(h*)*		0.491*		0.562*		0.545*
Hedge Effectiveness *(HE)*		0.325		0.505		0.469

Note: * denotes significance at 5% level of significance

The Table 7 shows the results of the hedge ratio and hedge effectiveness of commodity futures returns of sample commodities on their spot returns using OLS model. The hedge ratios of Chana, Chilli, and Turmeric are 0.491, 0.562, and 0.545, respectively. It means the sample commodity futures provide 49.1%, 56.2%, and 54.5% variance reduction in their spot markets, respectively. The estimates of hedge effectiveness of Chana, Chilli, and Turmeric are 0.325, 0.505, and 0.469, respectively. It reveals that a farmer who is trying to minimize price risk by hedging in futures markets is able to reduce the risk by 32.5%, 50.5%, and 46.9% by selling 49.1%, 56.2%, and 54.5% of produce in near month contracts of Chana, Chilli, and Turmeric, respectively.

The Table 8 shows the results of the hedge ratio and hedge effectiveness of commodity futures returns of sample commodities on their spot returns using VECM. The hedge ratio of Chana, Chilli, and Turmeric are 0.501, 0.566, and 0.546, respectively. It means the sample commodity futures provide 50.1%, 56.6%, and 54.6% variance

Table 8. Hedge Ratio and Hedge Effectiveness of Commodity Futures using VECM

Agri - Commodities - Near month Contracts	Chana		Chilli		Turmeric	
	Un-Hedged	Hedged	Un-Hedged	Hedged	Un-Hedged	Hedged
Return	0.026	0.015	0.126	0.059	0.055	0.023
Variance	2.183	1.473	9.767	4.842	7.064	3.752
Hedge Ratio *(h*)*		0.501		0.566		0.545
Hedge Effectiveness *(HE)*		0.325		0.504		0.469

Note: * denotes significance at the 5% level of significance

reduction in their spot markets, respectively. The estimates of hedge effectiveness are 0.325, 0.504, and 0.469, respectively. It reveals that a farmer who is trying to minimize price risk by hedging in futures markets is able to reduce the risk by 32.5%, 50.4%, and 46.9% by selling 50.1%, 56.6%, and 54.6% of produce in near month contracts of Chana, Chilli, and Turmeric, respectively. Further, it also observed that the OLS model and VECM model gave the same results.

Findings

The Johansen test of cointegration results reveals that there is a long-run association, that is, equilibrium between spot and futures prices of Chana, Chilli, and Turmeric. The VECM results reveal that the coefficients of ECT of *ln* spot prices of commodities under study are negative in sign (Chana : -0.021754, Chilli : -0.02778, and Turmeric : -0.044087) and significant ($p < 0.05$). It implies that there is a long-run causality running from futures prices to spot prices which enable the spot market to adjust to the short-run deviation from long-run equilibrium path with nearly 2.17%, 2.78%, and 4.41% speed of adjustments in sample commodities, that is, Chana, Chilli, and Turmeric, respectively. The speed of correction in the futures market of Chana and Chilli is 4.47% and 3.92% against spot market which indicates a highly informative futures market. At the same time, insignificant ECT of *ln* futures prices of Turmeric indicates futures market efficiency towards maintaining stable long-run equilibrium. The Wald test results reveal the presence of the short-run causality between the spot and futures markets of commodities under study. The Granger causality test results reveal that there is only a unidirectional causality from futures returns to spot returns of commodities Chilli and Turmeric. However, in the case of Chana, there is a unidirectional causality from futures to spot returns for lag one and bidirectional causality between futures and spot returns for remaining lags. According to hedge ratios of OLS and VECM results, it is found that the commodity futures provide 50%, 56%, and 55% variance reduction in their spot prices of Chana, Chilli, and Turmeric, respectively. It further found that a farmer who is trying to minimize price risk by hedging in futures markets is able to reduce the risk by 32.5%, 50.5%, and 46.9% by selling 49.1%, 56.2%, and 54.5% of produce in near month contracts of Chana, Chilli, and Turmeric, respectively. It is observed that the commodity futures are more effective in hedging in the case of Chilli and Turmeric as compared to Chana. So, it is revealed that the near month futures contracts are suitable for hedging.

Conclusion

It is concluded that there is a long-run association, that is, equilibrium between commodity spot and future prices of sample commodities. This indicates there is no scope for long-run arbitrage opportunity. The results of cointegration and VECM highlight that futures market contributes largely to the price discovery, suggesting that news are first aggregated in the prices of the futures and then transferred to the spot market. The results of the Granger causality between futures and spot price returns suggest that the futures market dominates the spot market of Chana, Chilli, and Turmeric. In bidirectional causality, the spot and futures both are contributing to the price discovery. It is observed that the commodity futures are more effective in hedging in the case of Chilli and Turmeric as compared to Chana. So, it is revealed that the near month futures contracts are suitable for hedging. The results, therefore, highlight the comparative advantage of futures markets in disseminating information and thereby leading to a significant price discovery and risk management which would further help the underlying spot market to develop successfully. The causation from futures to spot markets showed a stronger flow of information from the futures to spot market and confirmed the efficiency of the futures market in discovering the prices for spot markets for the sample commodities.

Implications

As derivatives market resembles the price expectations of the farmers, the commodity futures will be helpful in efficient price discovery and risk management in the agricultural spot market in India. Despite gaps, the futures price and spot prices are related in the long-run. The farmer can use futures to hedge price risk. The fact that India's agricultural sector is dominated by small scale farmers, who neither have the financial capability nor the expertise in commodity trading, discourages them from participating in commodity derivatives markets. In this scenario, it would be beneficial to promote aggregators or market makers, who can trade on behalf of the farmers and improve the price discovery process and risk management decisions. Strengthening of market linkages and the infrastructure, that is, warehousing facilities, grading, and standardization can bring more market participants in the agricultural segment.

Limitations of the Study and Scope for Further Research

The study is based on a sample of select commodities. Since sampling itself suffers from certain inherent limitations, the findings are to be generalized subject to the limitations of sampling, that is, limitations of the sample may affect the quality of the findings. The findings on the price discovery and risk management in the spot - futures markets is limited to the study period, that is, 2004 - 2013 and is based on secondary data collected from the Exchanges' websites. The behaviour in the market movements may differ during different time periods. The results pertain to the study period, that is, 2004 – 2013 which may differ from other time periods. The study on the price discovery and risk management is confined to the sample commodities traded in NCDEX. The effectiveness of risk management in sample commodities by using commodities futures is studied through hedging technique only.

The following are some areas where the scope lies for further research related to studying the efficiency of commodity derivatives in price discovery and risk management :

(i) The hedge ratio and hedging effectiveness can be analyzed by using time varying hedge ratio techniques.

(ii) Portfolio diversification using commodity derivatives.

(iii) Efficiency of commodity derivatives in price discovery and risk management in non-agricultural commodities.

(iv) Estimation of volatility spillover in commodities markets in India.

(v) Commodity derivatives vs financial derivatives in price discovery and risk management in India.

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Annexure 1

(i) Optimal Lag Selection - Near Month Contracts

VAR Lag Order Selection Criteria -

Endogenous variables: LSP LFP - Chana

Lag	LogL	LR	FPE	AIC	SC	HQ
0	5000.367	NA	8.13E-05	-3.741293	-3.736884	-3.739697
1	15147.52	20271.52	4.10E-08	-11.33347	-11.32025	-11.32869
2	15442.96	589.7779	3.30E-08	-11.55162	-11.52957*	-11.54364
3	15456.55	27.10598	3.27E-08	-11.5588	-11.52793	-11.54763
4	15471.98	30.75584*	3.25e-08*	-11.56735*	-11.52767	-11.55299*

Endogenous variables: LSP LFP - Chilli

Lag	LogL	LR	FPE	AIC	SC	HQ
0	842.2153	NA	0.000828	-1.420482	-1.411901	-1.417248
1	5006.643	8307.735	7.30E-07	-8.454173	-8.428429*	-8.444469
2	5017.61	21.83968*	7.22e-07*	-8.465950*	-8.423044	-8.449776*
3	5021.583	7.899248	7.22E-07	-8.465905	-8.405836	-8.443262
4	5024.191	5.176524	7.23E-07	-8.463552	-8.38632	-8.434439

Endogenous variables: LSP LFP - Turmeric

Lag	LogL	LR	FPE	AIC	SC	HQ
0	750.5869	NA	0.00116	-1.083339	-1.075768	-1.080507
1	6276.749	11028.33	3.93E-07	-9.07489	-9.052178	-9.066394
2	6304.389	55.07988	3.79E-07	-9.109101	-9.071248*	-9.094941
3	6317.253	25.59748*	3.74e-07*	-9.121929*	-9.068934	-9.102105*
4	6320.497	6.445701	3.75E-07	-9.120834	-9.052699	-9.095347

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion