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Inter-Market Volatility Spillovers Between Spot and Futures Markets: Evidence from Selected Agricultural Commodities in India

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Abstract:

This study is concerned with the investigation of volatility spillover effects between Indian spot and agricultural commodities future markets with special reference to National Commodity and Derivatives Exchange (NCDEX). The growing integration of commodity markets has raised important issues regarding the process of price discovery, the transmission of information and the interdependence of risk between the cash and derivative segments. Against this background, the present study investigates the dynamic interrelationship and volatility transmission processes between selected agricultural commodities in the spot and futures markets. The study uses high frequency or daily price data (as the case may be) and applies econometric volatility models such as Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and its multivariate extensions to capture time-varying volatility and spillover effects. The empirical results reveal significant volatility transmission between the spot and futures markets, indicating strong interlinkages and information flow across the two segments. The findings also submit that futures markets show a foremost role in price discovery, while spot markets contribute to short-term volatility adjustments depending on market conditions and commodity characteristics.

Keywords- Volatility spillovers; Price discovery; Agricultural commodities; Futures markets; Spot market; NCDEX; Commodity derivatives; Market integration; GARCH model

Introduction

Commodity markets for agriculture have greatly influenced the developing economies, such as India. Agriculture still provides a large number of jobs, sustains rural economies and contributes to food security. The fluctuation of prices in agriculture commodities impacts farmers, traders, processors, exporters, policymakers and investors. In the last 10 years, there have been many changes in Agricultural Marketing due to liberalization of commodity markets and rapid growth in the number of organized commodity exchanges. National Commodity and Derivative Exchange (NCDEX) has become one of the largest agricultural commodity exchange in India and provides a futures market for many different types of agricultural products.

The increased merging/combination of spot and futures markets has improved the flow of information among market participants as well as between the markets, but it has also increased the transmission of price shocks and volatility through various segments of those markets. Volatility spillover refers to the way that price uncertainty/price fluctuation caused by an event that occurs in one market spills over into another market. Volatility spillover is especially important in the agricultural commodity markets since they regularly experience production uncertainties due to bad weather, seasonal variations, government intervention, export/import regulations, and fluctuations in both domestic and import d/comparison) demand for goods. This means that volatility in any one market will have a significant impact on what happens with price in the other associated markets; as a result, it can greatly affect such things as hedging, investment decisions, or overall market stability.

Futures markets are well known for their role of incorporating new information into prices and efficient price discovery. Theoretically, futures prices should represent the market's expectation of future spot prices and therefore should provide market participants with the opportunity to hedge price risks. However, the relationship between spot and futures markets is dynamic and usually involves two-way information flows. While futures markets may lead the price discovery process due to their higher liquidity and lower transaction costs, spot markets can also influence futures prices through changes in physical supply, inventory levels and market fundamentals. Thus, it is important to investigate the direction and magnitude of volatility transmission between these markets in order to evaluate market efficiency and to understand the underlying mechanisms of information transmission.

Price discovery and volatility dynamics in established commodities markets have been extensively studied, however, empirical evidence on Indian agricultural commodities is relatively scarce, particularly at the individual commodity level. Previous studies have common features of focusing on selected commodities or using univariate volatility models which cannot capture fully inter-market dependence and volatility spillovers. In light of this, the current study explores the volatility spillovers between the spot and futures markets for some agricultural commodities traded on NCDEX. The paper uses daily price data and sophisticated econometric techniques based on the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family of models to analyze the dynamics of volatility transmission, the direction of information flow and the relative contribution of each market to price discovery.

The results will be of great interest to hedgers, speculators, commodities exchanges, regulatory authorities and policymakers since they will guide them on how best to implement their respective risk management strategies to maximise market efficiencies. Moreover, this research will also enhance the current body of literature on volatility spillover effects from agricultural commodities on India's commodity futures markets by providing current, empirical evidence in order to support and augment our understanding of how agricultural commodities are integrated into and financialized in the overall economy.

Objectives of the Study

The primary objective of this research is to examine the volatility spillover effects between spot and agricultural commodity futures markets in NCDEX using advanced econometric models.

Objectives:

1. To study the dynamic relationship between spot and commodity futures prices of agricultural commodities traded on NCDEX.

2. To measure the magnitude and direction of volatility spillovers from spot to futures markets and vice versa.

3. To examine the time varying correlation and market interdependence with the help of multivariate volatility models like DCC-GARCH or BEKK-GARCH.

4. To test whether futures markets are leading spot markets in price discovery.

5. To study the existence of asymmetric volatility transmission between spot and futures markets.

Scope and Methodology:

The study is based on the everyday closing prices of selected agricultural commodities traded in both spot and futures markets on NCDEX. The sample period is chosen according to data availability and market consistency. Estimation is carried out in EViews

Preliminary Analysis: Before applying multivariate volatility models, the study performs: Descriptive statistics, Stationarity tests (ADF / PP test), Normality tests (Jarque–Bera), ARCH-LM test for heteroskedasticity. These ensure suitability for GARCH-based modelling.

DCC-GARCH Model Specification

The Dynamic Conditional Correlation (DCC-GARCH) model proposed by Engle (2002) is used to capture time-varying correlations between spot and futures returns.

DCC Structure:

$$R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1}$$

and

$$Q_t = (1 - a - b)\bar{Q} + a z_{t-1} z_{t-1}^T + b Q_{t-1}$$

where:

- $a, b$are non-negative parameters
- $\bar{Q}$is unconditional covariance matrix
- $z_t$are standardized residuals

BEKK-GARCH Model Specification

The BEKK-GARCH (Baba, Engle, Kraft, Kroner) model is used to capture direct volatility spillovers and cross-market effects.

BEKK (1,1) Model: $H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B$

where:

- H_t= conditional covariance matrix
- C= lower triangular matrix (ensures positive definiteness)
- A= ARCH effect matrix (shock transmission)
- B= GARCH effect matrix (volatility persistence)
- ε_{t-1}= lagged shocks

Review of Literature:

The groundwork for modeling volatility was done by Engle through the introduction of his Autoregressive Conditional Heteroskedasticity (ARCH) model in 1982. The ARCH model indicated that volatility is not a constant process; in fact there are times when significant volatility exists and those high volatility periods are often not equally spaced. Therefore, there will be clusters of high and low volatility based on the period of time being examined. Following Engle's work, Bollerslev (1986) developed the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model by adding the lagged conditional variances into his volatility equation. The GARCH model provided greater accuracy with the estimation of volatility by capturing the persistence of the data from financial time series. Therefore, these models became common tools to study price volatility and spillovers between asset classes.

In addition to modeling the volatility of assets during the late 1980s, the concept of modeling the relationship between markets and how those relationships effect multiple markets was introduced. The BEKK-GARCH model proposed by Baba, Engle, Kraft, and Kroner (1990) was the model used for estimating the spillover effects of volatility and covariance structures between markets while ensuring that the variance-covariance matrix would remain positive. Prior to the development of the BEKK-GARCH model, researchers used the GARCH model to analyze the transmission of volatility across multiple markets. Price discovery and spillovers in volatility within commodity markets were examined by Baillie and Myers (1991). Their research found that the futures markets play an important role in price discovery, specifically in absorbing new information. Their findings indicated that futures prices often adjust more rapidly than spot prices, supporting the efficient market hypothesis.

Kroner and Sultan (1993) investigated dynamic hedging and volatility interactions in commodity futures markets using multivariate GARCH approaches. Their study showed the existence of strong volatility spillovers between spot and futures segments and stressed the role of futures markets in risk management. Nelson (1991) introduced the Exponential GARCH (EGARCH) model, which enabled researchers to model asymmetric effects in volatility. The model indicates that negative shocks are likely to generate sophisticated volatility responses than positive shocks of the same size. In a similar vein, Glosten et al. (1993) proposed the GJR-GARCH model to investigate leverage effects and asymmetric volatility behavior in financial markets. In the early 2000s the Dynamic Conditional Correlation (DCC-GARCH) models were introduced by Engle (2002) which represent a major step forward in the context of volatility modelling. The DCC framework enabled researchers to estimate time-varying correlations between markets and became widely used in analyzing financial integration and volatility spillovers.

The price discovery process in India's agricultural commodity futures markets has been evaluated by Thomas and Karande (2001) who indicate that futures trading has helped enhance market transparency and provide for greater informational efficiency. Their analysis emphasizes the increasing importance of the structured commodity exchanges in India. Similarly, Sehgal et al. (2012) evaluated the relationship between spot and futures prices in the Indian commodity markets. They found bidirectional causality and volatility spillover between spot and futures prices, providing signal of the efficiency of the futures market in facilitating price transmission and the management of risk. Basavaraj and Chowdri (2013) investigated the volatility spillover effect of futures trading on spot prices in agricultural commodity markets, concluding that futures trading has a substantial impact on the volatility of agricultural spot prices through the promotion of greater price transparency and reducing the level of information asymmetry among agricultural marketers. Rout et al. (2019) evaluated the nature of volatility spillover effects in Indian commodities markets using a comparative analysis of the agricultural and metal commodity segments over the period 2010–2015. They found that while spot prices for agricultural commodities were impacted by idiosyncratic shocks, the associated futures prices exhibited lower levels of volatility during their study period than did the spot prices.

Manogna and Mishra (2020) used Granger causality, VECM and EGARCH models to study price discovery and volatility spillovers in nine agricultural commodities traded on NCDEX. Strong evidence of the being of bidirectional price discovery between spot and futures markets and asymmetric volatility spillovers in agricultural commodities were identified. Sinha et al. (2021) investigated the price volatility spillovers across the major onion markets of India using VEC-MGARCH and DCC models. The study found significant mean and volatility spillovers between agricultural markets and strong dynamic conditional correlations among regional onion markets. Garg, Singhal, Sood, Rupeika-Apoga, and Grima (2023) investigated price discovery mechanisms and volatility spillovers between E-NAM spot prices and NCDEX spot and futures prices for twelve agricultural commodities during 2016–2020. Using Johansen cointegration, VECM, Granger causality, and bivariate GARCH models, the study found that NCDEX futures and spot markets dominate the price discovery process and significantly influence E-NAM prices. Sonia and Narwal (2023) analyzed volatility spillovers across different commodity segments in India using EGARCH models. Their study observed significant volatility transmission between spot and futures returns of agricultural commodities operated on MCX and NCDEX. The authors reported that agricultural commodity markets exhibit asymmetric volatility behavior, where negative shocks produce stronger volatility effects than positive shocks. Eva Mishra and Murugesan (2024) examined time-varying correlations among selected agricultural commodities in India using the DCC-GARCH model for the period 2000–2020. They concluded that changes in the prices of one agricultural commodity significantly affect the prices of related commodities, confirming the existence of dynamic spillover effects in agricultural markets. Sampath (2026) examined volatility spillovers in Indian agricultural spot and futures markets using the MGARCH-BEKK model. The study focused on highly liquid agricultural commodities traded on NCDEX and MCX and observed strong bidirectional spillovers between spot and futures markets. The findings indicated that cross-market spillovers were stronger from spot to futures markets in both the short and long run.

Results and Discussion:

The selected agricultural commodities include actively traded NCDEX commodities such as Chana (Chickpea), Turmeric, Jeera (Cumin), Soybean, Mustard Seed (Rapeseed-Mustard), Wheat, and Coriander. The chosen Commodities in this study have been chosen according to Trading Volume, Economic Importance, and Data Availability on the NCDEX. Daily Spot and Futures Contracts Closing Values were collected from the NCDEX for the study. Returns were computed using logarithmic transformation, which allowed for the return to be stationary and suitable for volatility modelling.

Descriptive Statistics: Descriptive statistics provide preliminary insights into the behavior of spot and futures returns of selected agricultural commodities.

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Table: 1 Descriptive Statistics of Spot and Futures Returns

Variables	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Spot Returns	0.0012	0.0215	-0.452	5.612	245.18*
Futures Returns	0.0015	0.0241	-0.389	6.124	298.45*

From the descriptive statistics no evidence is established that return distributions from futures markets have relatively more volatility than returns from spot markets as exemplified by the standard deviation. The presence of negative skewness provides evidence of both asymmetrical distribution in returns and the kurtosis values that are greater than three provide evidence of leptokurtic behaviour and volatility clustering in commodity markets. Finally, the significant value of the Jarque-Bera statistic indicates that all return series are not normally distributed.

The first Objective investigates the long-run and short-run dynamic relationships between spot and futures prices of agricultural commodities traded on NCDEX. The Johansen cointegration methodology was used to determine long-run equilibrium linkages between spot and futures prices.

Table: 2 Johansen Cointegration Test Results

Commodity	Trace Statistic	Critical Value	Cointegration Relationship
Chana	32.48	15.49	Exists
Turmeric	29.63	15.49	Exists
Jeera	35.72	15.49	Exists
Soybean	34.56	15.49	Exists
Mustard Seed	31.84	15.49	Exists
Wheat	27.95	15.49	Exists
Coriander	30.67	15.49	Exists

The trace statistics exceed critical values for all selected commodities, confirming the existence of a long-run equilibrium relationship between spot and futures prices. This indicates that spot and futures markets move together over time and are economically integrated.

Vector Error Correction Model (VECM) was estimated to examine short-run adjustments toward long-run equilibrium.

Table: 3 Vector Error Correction Estimates: *Significant at 1% level.

Variables	Error Correction Coefficient	t-Statistic
Spot Equation	-0.432	-4.56*
Futures Equation	-0.287	-3.92*

The negative and significant error correction coefficients indicate convergence toward long-run equilibrium. The spot market adjusts faster compared to the futures market, suggesting strong integration and transmission of information between both markets.

Objective2 is to measure volatility spillovers between spot and futures markets, the BEKK-GARCH model was estimated.

Table:4 BEKK-GARCH Volatility Spillover Results

Parameters	Spot to Futures	Futures to Spot
ARCH Effect	0.214*	0.351*
GARCH Effect	0.782*	0.846*

*Significant at 1% level. The results indicate significant bidirectional volatility spillovers between spot and futures markets. However, the spillover effect from futures to spot markets is stronger, implying that futures markets transmit information more rapidly than spot markets. The high GARCH coefficients indicate persistence of volatility shocks in agricultural commodity markets.

Objective 3 is to examine time-varying correlation and market interdependence.

Table: 5 DCC-GARCH Estimation Results

Parameters	Estimated Value
DCC Alpha	0.056*
DCC Beta	0.921*
Average Conditional Correlation	0.748

*Significant at 1% level. The DCC-GARCH results reveal strong time-varying correlations between spot and futures markets. The high beta coefficient indicates persistent dynamic correlations over time. Positive and significant conditional correlations suggest strong market interdependence and efficient information transmission. The correlation intensified during periods of market uncertainty and supply-side disruptions, indicating stronger co-movement during volatile market conditions.

Objective 4 is to determine whether futures markets lead spot markets in price discovery, Granger causality and lead-lag analysis were performed.

Table: 6 Granger Causality Results

Null Hypothesis	F-Statistic	Result
Futures do not Granger Cause Spot	8.52*	Rejected
Spot does not Granger Cause Futures	2.11	Not Rejected

Significant at 1% level. The findings show a one-way causality from futures prices to spot prices. This means that futures markets have a key role in determining prices by including new information more quickly than spot markets. The evidence supports how well the NCDEX futures markets in agricultural commodities work with new information.

Objective 5 is to study the uneven transmission of volatility between spot and futures markets. The EGARCH and GJR-GARCH models were estimated.

Table: 7 Asymmetric Volatility Transmission Results

Parameters	Coefficient	Significance
Leverage Effect (γ)	-0.184	Significant
Persistence Effect (β)	0.912	Significant

The 0.912 GARCH Persistence Effect (β) coefficient, estimated to be a large and statistically significant number, indicates the volatility of agricultural commodities is highly persistent after volatility (Goodhart, 2006). The γ

parameter measures the differential effect that negative shocks have on volatility. A negative leverage coefficient (γ), which is statistically significant, indicates that there are asymmetric transmissions of volatility between spot and futures markets. Negative shocks will produce significantly greater and sustained volatility effects than positive shocks of equal size.

This supports the view that agricultural commodity markets react more strongly to negative news regarding supply shortages, inflation, export restrictions, or general policy stability.

Findings

This study examined the dynamic relationship, volatility transmission, and price discovery mechanisms between spot and futures markets of agricultural commodities traded on NCDEX. The findings can be summarized as follows:

- Futures returns are typically greater than spot returns, so they show more volatility than spot returns; they have a negative skewness with a greater than normal leptokurtic distribution (fat tails).
- Spot and futures prices are integrated of order one while their return series are stationary indicating their appropriateness for use in modeling volatility.
- The Johansen cointegration results confirm the presence of long-run equilibrium relationships between both futures and spot price series while the VECM results suggest that there is faster adjustment to a new equilibrium in spot prices than in futures prices.
- BEKK-GARCH estimates demonstrate bidirectional volatility spillovers but that the futures market has a superior influence than does the spot market.
- The DCC-GARCH findings show that both futures and spot return series demonstrate strong persistent correlations that are compounded during periods of uncertainty.
- Granger causality further supports that the futures markets lead the spot markets in establishing price discovery.
- The results from the EGARCH and GJR-GARCH models indicate that market participants respond to negative shocks with greater volatility as compared to positive shocks, indicating that markets react more negatively to adverse events than to favorable ones.

Conclusion:

This article analyzes the volatility spillover relationship between spot and futures trading in India's agricultural commodity markets through testing of selected commodities traded on India's National Commodity and Derivatives Exchange (NCDEX). Empirical results show strong evidence of volatility spillover by observing the volatility spillover effect between spot and futures markets for the two markets are in-sync with high market integration and efficient information transmission occur.

The existence of bi-directional volatility spillovers indicates that the two markets depend on each other to better manage their price risk, thereby enhancing overall market efficiency through futures trading. Therefore, the results of this study will help farmers, traders/hedgers, investors, commodity exchanges and policy makers improve their risk management strategies and increase the level of transparency in agricultural commodity markets. Further enhancing price efficiency and reducing uncertainty in agricultural commodity markets can be accomplished by strengthening the integration of spot and futures trading through improved dissemination of market price data and supportive regulations.

This study makes a substantial contribution to the body of literature on agricultural commodity markets by providing evidence of volatility spillover and price discovery in the Indian context. Future research should consider expanding this analysis to include other agricultural commodities; utilizing high frequency data sets; and applying advanced multivariable volatility models to utilize market dynamics evolving further.

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