Price Discovery Mechanism in the Indian Agricultural Commodity Futures Market – An Empirical Analysis

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Abstract

Purpose: In India, commodity futures markets are the best alternative to the securities markets because of their familiarity with risk hedging. It makes sense that information regarding futures contract pricing is provided by the way prices behave in the futures market analysis. The relationship between futures contract prices and commodities spot market prices is made clearer by the price discovery process. The current study provided an example of how 10 agricultural prices were determined.

Methodology : The present study adopted exploratory and causal research designs based on cash and near-month futures contract prices of the selected agricultural commodities chosen through the purposive sampling method. The study used the augmented Dickey–Fuller (ADF) test, co-integration analysis, Granger causality test, and vector error correction model (VECM) to comprehend the efficiency of the price discovery mechanism of agricultural commodity futures markets in India.

Findings : The study's statistical findings demonstrated that the cash and futures markets possessed comparable proficiency in terms of price discovery methods for chana, jeera, maize, moong, and soybean. However, the cash market drove the futures market for coriander and cotton cake, and the futures market directed the spot market for price discovery for barley, turmeric, and wheat.

Practical Implications : The study's findings will be beneficial to market participants in adopting a range of arbitrage and trading techniques as well as to policymakers in confirming the consistency of both spot and futures markets, given the growing state of the commodity futures market in India.

Originality : The novelty of the present study is the selection of sample agricultural commodities that were actively trading and highly liquid in the commodities market using the purposive sampling method. The statistical results have highlighted the effectiveness of price discovery in spot and futures markets for all the commodities covered in the study. Traders thus profited from the study's conclusions when they periodically framed their trading strategies.

Keywords : price discovery, agricultural commodities, spot prices, futures prices, equilibrium

JEL Classification Codes : C58, G13, Q02, Q13

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The commodity derivatives market has become a key segment in contemporary finance in India. The futures market offers a range of financial instruments for hedging the risk in commodity derivatives. It is now necessary to investigate the effectiveness of the futures market due to the rapid increase in transaction volume and the numerous regulatory framework modifications that have occurred since 2003. One of the

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important aspects that underscore the efficacy of the commodity futures market is the price discovery function (Garbade & Silber, 1983). In general, price discovery is the course of finding the basic value of an asset. Theoretically, the futures price imitates the basic information and would be identical to the basic value. The prices in the spot and futures markets conceptually converge as the contract's maturity date approaches. However, many empirical studies have revealed that the futures prices may differ heavily from the prices of the spot market during price discovery, showing the subsistence of mispricing (Jacobs, 2016).

It is difficult to comprehend the complexities of the futures market in typical economic theorems. Eventually, the prices of the commodities in the spot market are driven by the basic market-related factors, viz., demand and supply, the structure of the markets, and the regulatory framework of the government. In contrast, the price of futures is influenced by the actions of market participants, viz., hedgers, speculators, traders, etc. We can better understand futures pricing and how futures prices influence spot market prices over time by examining the behavior of commodities futures prices. Hence, the price discovery process is indispensable to ensure efficacy and transparency in the aggressive market environment.

Stabilizing price volatility and planning crop patterns at the farm level are made possible by the markets' sharing of pricing information (Elumalai et al., 2009; Tomek, 1980). The price discovery of futures contracts affects the spot market transactions and reveals an asset's complete information and value (Sehgal et al., 2012). Hence, an efficient course of price discovery, which assists sections of the economy, is essential. In order to reduce price risk and aid in planning from farming to marketing, farmers are provided with information about current prices on the futures market. Additionally, customers discover information on commodity prices at the same time, which aids in their decision to buy (Mangano & Mishra, 2020).

Several kinds of research were conducted on price discovery, mostly in advanced nations concentrating on securities, commodities, and currencies. The studies conducted on the price discovery function of agricultural commodities in developing nations are limited. However, some of them have focused on lead–lag association among spots along with futures market prices of agricultural commodities, and the results of those studies are found inconsistent. Therefore, research on the long- and short-term balance between the futures and spot markets is crucial. Consequently, the purpose of the study is to look into the relationship between spot and futures markets over the long and short terms.

Review of Literature

Huda et al. (2023) stated that making the markets operationally successful in developing nations is a challenging task due to undersized markets and the absence of liquidity, poor infrastructure, poor regulatory system, lack of understanding about commodity exchanges among market partakers, and the government intrusion that can alter the market prices. Addressing these concerns and promoting the growth of successful commodity derivatives markets in developing countries will inevitably involve intervening in the policy. This will involve providing financial support, building the necessary infrastructure, establishing robust legal protections, and enhancing market exchanges between market players.

Dhivya et al. (2023) stated that the government has almost withdrawn its interference to encourage the private sector, which is analogous to the demand and supply forces. Hence, the farmers suffer not only due to yield-related risk but also price-related risk. Therefore, the commodity futures markets must fix the commodity prices per the existing demand and supply. This can be done only by understanding the direction of causality among spot and futures markets in India. This will help farmers understand the differences in pricing that are present in different marketplaces and how the prices in one market affect the prices in other markets.

Garg et al. (2023) compiled time series secondary data for 12 agricultural commodities traded on the e-NAM and NCDEX, ranging from April 2016 to December 2020, and evaluated using Granger causality, vector error correction model (VECM), and Johansen co-integration models in order to study the price discovery system, lead–lag association, and volatility spillover among spot and futures prices. The study observed the long-term association with the Johansen co-integration test and stated that the spot and futures markets in India are leading in the price discovery process, and the spot and futures segments of NCDEX are leading to the e-NAM spot prices having one or two-dimensional association.

In Indian e-auction, spot and futures markets, Vijayakumar (2022) investigated price discovery and the market performance of cardamom using information gathered from the Spices Board of India and MCX of India Ltd. To explain the presence of price discovery and market efficacy, the author employed regression analysis, the Granger causality test, the Johansen co-integration test, and VECM. According to the statistical results, price discovery occurs in the electronic auction market and affects both spot and futures pricing. Prices from electronic auctions of cardamom have a negative correlation with futures prices and a positive correlation with cash market prices. The study also revealed that the cardamom electronic auction was more vigorous in price discovery than cardamom futures prices.

Pani et al. (2022) used econometric models, including Johansen co-integration analysis, Granger causality test, and VECM, to investigate the price discovery function of the metal, energy, and bullion. Johansen's co-integration test's empirical output confirmed the long-run symmetrical association among the spot and futures prices of aluminum, crude oil, lead, natural gas, nickel, silver, and zinc. Granger's causality test results showed that there was a two-way relationship between the spot and futures prices of silver, zinc, lead, nickel, aluminum, and gold. According to VECM's findings, nickel spot and futures prices are equally competent in the price discovery role. The study also highlighted that the price discovery function for copper and zinc tends to go from the cash market to the futures market and that the price discovery function for lead, silver, and aluminum tends to go from the futures market to the cash market.

Li and Deng (2021) used data gathered from China's commodity futures exchanges from 2016 to 2020 to study investor attention and price discovery efficiency in the futures market. The empirical findings of the study indicated that the price discovery efficiency of the futures market was significantly and favorably impacted by investor attentiveness. The study had two major findings: first, in the Chinese commodity futures market, there is greater attention of investors, which has significantly improved the price discovery efficiency; second, the larger proportion of hedging by the traders has underpinned the relationship between investor attention and price discovery efficiency. Venkatesh et al. (2021) tried to highlight the impediments associated with price signals, volatility spillovers, and the association among the spot as well as futures prices in India's commodity market. The study examined how well commodity futures performed in the NCDEX's price discovery function for chana and castor seeds between 2016 and 2018.

Rout et al. (2021) assessed the competency and worth of the futures market in terms of volatility, price discovery, and hedging efficiency. The empirical results of the study revealed that (a) commodities like soybean, chana, jeera, etc. had bidirectional causality; whereas, commodities like turmeric, chilli, etc. had unidirectional causality; (b) the lead–lag association differed across the commodities ; (c) there was an existence of downside risk in spot and futures markets ; (d) the volatility transmitted from spot to futures markets; and (e) there was an absence of hedging efficiency in the commodity futures market.

Gong et al. (2021) studied how interactions among different categories of traders impacted price discovery by designing a pricing method for the futures market. The study results showed that behavioral aspects such as the investors' risk appetite, the rate of logicality, and market liquidity collectively affected market stability conditions. After the market's stability conditions are established, the information is combined by the market to provide a more advanced understanding of price. The study also indicated that the price discovery function is difficult for the markets to understand if investors have a high rate of rationality or a high appetite for risk.

The price discovery volatility spillover attribute of agricultural commodities in spot and futures contracts was examined by Manogna and Mishra (2020). The results of the study showed the price discovery in all commodities. However, the price discovery function occurred in the futures market for six commodities: turmeric, guar, castor, coriander, soybean, and chana. In contrast, the price discovery function occurred in the spot market for three commodities: cottonseed, jeera, and rape mustard seed. Shalini et al. (2020) studied the price discovery process in commodities concerning the turmeric market in India. For the analysis, daily closing prices of spot and futures contracts from 2016 to 2018 were used. The same was analyzed using the econometric tools, viz., ADF test, Granger's causality test, and co-integration technique. The study's empirical findings verified that the turmeric market had a price discovery function and that the cash markets were particularly adept at figuring out turmeric prices.

Bohl et al. (2019) studied the importance of speculators in price discovery in the commodity derivatives market by compiling the spot and future prices of corn, soybean, live, and feed cattle. The empirical results of different metrics used in the study revealed that speculative movement minimized the degree of noise in the futures market, whereas it increased their comparative role in the price discovery process. Irfan and Hooda (2017) used daily price data collected from the official NCDEX website spanning from 2005 to 2015 to examine the competitiveness of agricultural commodities derivatives with reference to price discovery. The findings of the study validated the lead–lag relationship and unidirectional causality between the cash and futures markets for all agricultural commodities.

Research Gap

Few studies have been conducted on the price discovery procedure of agricultural commodities in India compared to the studies conducted worldwide. The results of all those studies are almost inconsistent. While one set of studies states that the futures market tends to the cash market, the other states that the cash market tends to the futures market. This may be because of considering different commodities, contracts, and periods for different studies. If the markets are efficient and information is symmetrical, there is no lead–lag association between spot and futures prices. However, the price of futures frequently displays the price discovery function on spot prices, which is regarded as one of the primary purposes of the commodity futures market because of the influence of trading costs, leverage, short selling, etc. Information asymmetry leads to the lead–lag relationship among cash and futures markets. A lead–lag relationship between futures and spot prices is also caused by investors' prompt reaction to the futures market's reduced cost as opposed to the spot market. Therefore, in order to comprehend the causal relationship between the two markets, the investigation must go beyond the body of current academic knowledge.

Objectives of the Study

The primary objective of the current study is to examine whether the spot market influences the futures market or vice-versa. Secondary goals include determining the long-term equilibrium relationship between the spot and futures pricing of specific agricultural commodities and determining if short-term changes in the spot market affect the futures market and vice-versa.

Hypotheses

- **H01 :** The time series (spot and futures prices) are stationary, and there is a unit root.

↳ **H02** : No co-integration association exists among the spot and futures prices of the chosen agricultural commodities.

↳ **H03** : Futures prices do not Granger cause spot prices for the chosen agricultural commodities.

↳ **H04** : Spot prices do not Granger cause futures prices for the chosen agricultural commodities.

Research Methodology

Exploratory and causal research methodologies are used depending on the goals and hypotheses. The study's foundation is secondary data, specifically the spot prices and near-month futures contract prices of a few chosen agricultural commodities that are highly liquid and regularly traded in the commodities market throughout the study period. The daily time series data (spot and futures contract prices) were compiled from the official website of NCDEX, covering the period from January 1, 2020 to March 31, 2022. Using the purposive sampling method, 10 commodities, that is, Barley, Chana, Coriander, Cotton Cake, Jeera, Maize, Moong, Soybean, Turmeric, and Wheat, were selected for the study. The statistical analysis of the data was carried out with EViews software. First, the variables were converted into log returns.

$$\text{The daily returns of spot price} = \ln \frac{S_t}{S_{t-1}} \quad \text{-------- (1); and}$$

$$\text{The daily returns of futures price} = \ln \frac{F_t}{F_{t-1}} \quad \text{-------- (2)}$$

Second, the stationarity in the respective time series was tested using the ADF test. The long-term relation between cash prices and futures prices was found using co-integration analysis. The nature of causality between the variables was disclosed through the Granger causality test. The speed of adjustment and the lead–lag association were verified through error correction models.

Econometric Tools

Stationary Test

The majority of financial time series data are commonly found to be non-stationary and have the unit root. However, the stationarity in the time series is highly essential, and such series can be used for financial modeling. In the present study, stationarity in the time series (spot and futures prices) data has been tested using the augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1981), which is based on time series regression equation based on random walk with an intercept. This test uses the null hypothesis that the time series under the study has a unit root, i.e., the data series is non-stationary. The general pattern of any non-stationary series is the random walk. We may write the random walk model (RWM) with the stochastic process as (Gerakos & Gramacy, 2013; Rao & Mukherjee, 1971; Viswanatha Reddy, 2020) :

$$\Delta Y_t = \beta_1 + \beta_2 + \delta Y_{t-1} + \sum_{i=1}^{k} \alpha_i \, \Delta Y_{t-i} + \varepsilon_t \quad \text{———— (3)}$$

where Δ = the first disparity operator; ΔY_{t-i} = lagged values of the response variable, for example, ΔY_{t-1} =

$(Y_{t-1} - Y_{t-2}), \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, and so forth; ε_t is a white noise error term; β_1 is a constant; β_2 is the coefficient of slope on time trend t; δ is a coefficient of lagged Y_{t-1}; and Y_t is the logarithm of the market price index.

To check for stationarity in the data, the ADF test with intercept was run on the spot and futures contract prices. The null hypothesis (H_{01}) is tested through "t-statistics," which is given by the following formula:

$$t = \frac{\hat{\delta} - \delta_{H_0}}{\text{SE of } \hat{\delta}} \qquad \text{--------} \quad (4)$$

If the calculated value of *"t"* is more significant than the critical value, we do not reject the null hypothesis. The respective time series has the unit root, and it is non-stationary. Instead, the null hypothesis is rejected if the calculated value of *"t"* is smaller than the critical "*t*" value. There would be no unit root, and the time series under study would be stationary. If the time series is non-stationary, we should initially analyze its level and then progressively study it at the first and second differences. The null hypothesis can also be accepted or rejected using probability and value. Reject the null hypothesis if the probability value ($p<0.05$) is less than 0.05, and vice- versa (Viswanatha Reddy, 2019).

Co-Integration Analysis Among Spot and Futures Prices

Determining the long- or short-term relationship between spot and futures markets is crucial for determining if persistent information in a given market is symmetrical or asymmetrical after assessing the stationarity of the data. The Johansen co-integration test is the most commonly adopted method to examine the long-run association (Johansen & Juselius, 1990). Once the long-run equilibrium is established, it is necessary to find the short-term equilibrium using VECM (Engle & Granger, 1987). The co-integration equation yields the long-term relationship between the commodity prices in cash and futures markets, which are integrated in the same order. A first-degree stationary state for the time series variables must be confirmed before executing Johansen's co-integration test. It can handle $I(0)$ and $I(1)$ variables without much of a pre-testing problem.

There are two types of likelihood-ratio tests in Johansen's methodology to identify the co-integration among the two-time series: Trace and maximum eigenvalue. The trace test (λ_{trace}) tests if the number of co-integrating vectors is zero or one. The maximum eigenvalue test (λ_{max}) tests whether a single co-integrating equation is sufficient or if two are required. The trace statistic examines the null hypothesis (H_{02}) that there are "r" numbers of co-integrating equations, while the alternative hypothesis (H_{a2}) is that there are "n" numbers of co-integrating equations.

$$J_{trace} = -T \sum_{i=r+1}^{n} \log(1-\lambda_i),\ r = 0,1,2 \ldots\ldots\ldots. n-1 \qquad \text{--------} \quad (5)$$

On the other hand, the maximum eigenvalue statistic examines the null hypothesis (H_{02}) that there are "r" numbers of co-integrating equations, while the alternative hypothesis (H_{a2}) is that there are "$r+1$" numbers of co-integrating equations.

$$J_{max} = -T \log(1-\lambda_{r+1}),\ r = 1,2,3 \ldots\ldots\ldots. n-1 \qquad \text{--------} \quad (6)$$

where, T = Sample size,

n = Number of endogenous variables,

λ_i = The largest eigenvalue.

Granger's Causality Test

The price discovery function depends heavily on information flowing across markets or assets in a completely competitive environment. Next, it is critical to look into whether the futures market is influenced by the spot market or the other way around. Therefore, to measure the direction of influence between spot and futures market prices, Granger's causality test is used in the present study.

Let x_t and y_t be two distinct time series and are stationary; to conclude whether x_t Granger causes y_t, first, y_t is auto-regressed on itself, and the appropriate lag length is decided. In the subsequent step, the augmented auto-regression is estimated. The null hypothesis, *y(t)* does not Granger-cause *x(t),* is tested using the *F* - test, which verifies whether all coefficients of x_{t-j}, namely β_{t-j}, are equal to 0. If all β_{t-j} are found to be equal to 0, then x_{t-j} does not precede y_{t-j}. The restricted models of the test are:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, y_{t-i} + \sum_{j=1}^{q} \beta_{1j}\, x_{t-j} + \varepsilon_t \quad \text{———————} \quad (7)$$

$$x_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{2i}\, x_{t-i} + \sum_{j=1}^{q} \beta_{2j}\, y_{t-j} + \varepsilon_t \quad \text{———————} \quad (8)$$

The unrestricted models of the test are:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i\, \Delta y_{t-i} + \varepsilon_t \quad \text{———————} \quad (9)$$

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i\, \Delta x_{t-i} + \varepsilon_t \quad \text{———————} \quad (10)$$

where, Δx_t and Δy_t = First-order forward differences of the variable.

β_j = Parameters to be estimated.

$\varepsilon_{1,2}$ = Standard random errors.

The lag order "*p*," which is optimal, is the lag order chosen by the information criterion. The equations shown above are appropriate tools for examining the linear causal link between the variables. In the above model, if β_1 is statistically significant and β_2 is not, then the changes in variable "*y*" Granger causes in variable "*x*" or vice-versa. If both, i.e., β_1 and β_2, are statistically significant, then the variables have a bivariate causal relationship. If both, i.e., β_1 and β_2 are statistically insignificant, then neither "*x*" Granger causes "*y,*" nor "*y*" Granger causes "*x*."

Error Correction Model (ECM)

After the long-run equilibrium is established, it is also customary to discover the short-term equilibrium. The model that is typically estimated to ascertain the short-term association is the limited VAR family or ECM (Wooldridge, 2012). To address the disparity between the spot and futures markets, Sargan (1964) first proposed this kind of model, which Engle and Granger (1987) later popularized. First, if two-time series are co-integrated in first-order difference, the model contains at least one co-integrating equation. Therefore, the ECM is used to know the speed of adjustment and the lead–lag association among spot and futures markets. The lag terms in ECM metrics reveal the short-run adjustments. The price discovery process is validated by an error correction procedure within the system. It offers data that the market adjusts in order to reach the long-term equilibrium. This model explains the scale of inequality from one period to another period and the associated speed of modification that happens in cash and futures markets in attaining equality (Kumar Mahalik et al., 2014). The ECM equation is represented as follows:

$$\Delta S_t = \beta_0 + \beta_1 \Delta S_{t-1} + \beta_2 \Delta S_{t-2} + \delta_1 \Delta F_{t-1} + \delta_2 \Delta F_{t-2} + \Phi z_{t-1} + \mu_t \quad \text{----- (11)}$$

$$\Delta F_t = \beta_0 + \beta_1 \Delta S_{t-1} + \beta_2 \Delta S_{t-2} + \delta_1 \Delta F_{t-1} + \delta_2 \Delta F_{t-2} + \Phi z_{t-1} + \mu_t \quad \text{----- (12)}$$

z_{t-1} = The term error-correction highlights that past deviations from long-run equilibrium influence the short-run dynamics of the spot price.

Φ = As the futures price changes (increases or decreases), the equilibrium error shows how quickly the spot price returns respond.

The lag length for short-term equilibrium analysis is determined using the lag length criterion test. The values in parenthesis are *t*-statistics, which will state the significance of the estimates, and ** indicates the significance of the estimates.

Analysis and Results

Unit Root Test Results

Table 1 depicts the stationarity statistics of spot and futures prices of the selected agricultural commodities. The results of the ADF test performed for measuring the stationarity of the time series indicate that all the time series under study are non-stationary when the log values are considered (as shown by the probability values, which are more significant than 0.05). However, when the log returns are considered, all the time series are stationary (as shown by the probability values, which are lesser than 0.05). Therefore, log-returns of the spot and futures prices are considered for further analysis of long-run and short-run equilibrium, i.e., Granger causality and price discovery.

Table 1. ***ADF Unit Root Test***

Agricultural Commodities	Spot Price				Futures Price			
	Log Values		Log Returns		Log Values		Log Returns	
	t-statistics	Prob.	*t*-statistics	Prob.	*t*-statistics	Prob.	*t*-statistics	Prob.
Barley	0.580	0.989	–14.346	0.000**	1.878	0.999	–8.837	0.000**
Chana	–1.364	0.600	–18.702	0.000**	–1.289	0.635	–19.161	0.000**
Coriander	1.136	0.997	–19.544	0.000**	0.068	0.963	–20.891	0.000**
Cotton cake	–1.524	0.520	–19.917	0.000**	–1.635	0.463	–21.605	0.000**
Jeera	2.237	1.000	–18.672	0.000**	0.787	0.993	–20.630	0.000**
Maize	0.189	0.971	–14.660	0.000**	0.189	0.971	–11.398	0.000**
Moong	–1.548	0.503	–7.563	0.000**	–1.719	0.417	–8.728	0.000**
Soybean	–0.527	0.882	–20.210	0.000**	–0.758	0.829	–21.280	0.000**
Turmeric	–0.074	0.949	–14.613	0.000**	–0.804	0.816	–18.577	0.000**
Wheat	–1.172	0.683	–8.002	0.000**	–1.333	0.611	–9.386	0.000**

Note. **Significant at the 5% level of significance.

Table 2. *Co-Integration Analysis*

Agricultural Commodities	No. of Co- Integrating Equations	Lag Length	Max-Eigen Statistic	Trace Statistic	0.05 Critical Value	Prob.**
Barley	None (*r* = 0)	1–2	86.673	125.169	15.494	0.000*
	At most 1 (*r* ≤ 0)		38.495	38.495	3.841	0.000*
Chana	None (*r* = 0)	1–2	189.994	287.951	15.494	0.000*
	At most 1 (*r* ≤ 0)		97.957	97.957	3.841	0.000*
Coriander	None (*r* = 0)	1–2	166.469	271.891	15.494	0.000*
	At most 1 (*r* ≤ 0)		105.421	105.421	3.841	0.000*
Cotton Cake	None (*r* = 0)	1–2	244.681	370.287	15.494	0.000*
	At most 1 (*r* ≤ 0)		125.605	125.605	3.841	0.000*
Jeera	None (*r* = 0)	1–2	224.631	324.252	15.494	0.000*
	At most 1 (*r* ≤ 0)		99.621	99.621	3.841	0.000*
Maize	None (*r* = 0)	1–2	130.064	182.202	15.494	0.000*
	At most 1 (*r* ≤ 0)		52.138	52.138	3.841	0.000*
Moong	None (*r* = 0)	1–2	43.713	66.458	15.494	0.000*
	At most 1 (*r* ≤ 0)		22.745	22.745	3.841	0.000*
Soybean	None (*r* = 0)	1–2	235.492	366.492	15.494	0.000*
	At most 1 (*r* ≤ 0)		130.999	130.999	3.841	0.000*
Turmeric	None (*r* = 0)	1–2	166.818	245.270	15.494	0.000*
	At most 1 (*r* ≤ 0)		78.451	78.451	3.841	0.000*
Wheat	None (*r* = 0)	1–2	36.856	65.543	15.494	0.000*
	At most 1 (*r* ≤ 0)		28.687	28.687	3.841	0.000*

Note. Max-Eigen and Trace tests specify two co-integrating equations at the 5% level of significance.

Note. *indicates the rejection of the hypotheses at the 5% significance level.

Co-Integration Analysis Results

Determining the long-term relationship between the cash and futures markets is essential to understanding the persistence of information asymmetry in a given market. The results of Johansen's co-integration test are displayed in Table 2. Max-eigen statistic and trace statistic values are analyzed simultaneously. The co-integration test uses the log returns data of spot and futures market prices of all select 10 commodities. For all commodities, the existence of at least one co-integration equation is accepted, and the null hypothesis that there is no co-integration between the cash and futures markets is rejected at a 5% significance level. Hence, it is inferred that there is a long-run equilibrium between the log returns of the spot and futures market prices of the selected commodities. It implies that any series, i.e., the log returns of either spot or futures market prices, can be used to indicate future movements of the other series.

Granger Causality Test Results

Understanding the direction of causality among spot and futures markets is a critical dimension in the price discovery mechanism. The causal relationship between the spot and futures markets can be computed using the

Table 3. *Granger Causality Test Results*

Agricultural Commodities	Null Hypotheses	*F*-Statistic	Prob.	Conclusion	Decision
Barley	$F_t \to S_t$	1.0676	0.3450	Accept H_{03}	Unidirectional Causality
	$S_t \to F_t$	8.7850	0.0002**	Reject H_{04}	
Chana	$F_t \to S_t$	18.5537	0.0000**	Reject H_{03}	Unidirectional Causality
	$S_t \to F_t$	2.4362	0.0889	Accept H_{04}	
Coriander	$F_t \to S_t$	23.6194	0.0000**	Reject H_{03}	Unidirectional Causality
	$S_t \to F_t$	0.9954	0.3704	Accept H_{04}	
Cotton Cake	$F_t \to S_t$	0.4048	0.6679	Accept H_{03}	Unidirectional Causality
	$S_t \to F_t$	51.4811	0.0000**	Reject H_{04}	
Jeera	$F_t \to S_t$	51.4080	0.0000**	Reject H_{03}	Unidirectional Causality
	$S_t \to F_t$	2.8320	0.0599	Accept H_{04}	
Maize	$F_t \to S_t$	1.3256	0.2671	Accept H_{03}	Unidirectional Causality
	$S_t \to F_t$	10.9522	0.0000**	Reject H_{04}	
Moong	$F_t \to S_t$	2.2224	0.1163	Accept H_{03}	Unidirectional Causality
	$S_t \to F_t$	7.7247	0.0010**	Reject H_{04}	
Soybean	$F_t \to S_t$	15.7770	0.0000**	Reject H_{03}	Bidirectional Causality
	$S_t \to F_t$	16.5622	0.0000**	Reject H_{04}	
Turmeric	$F_t \to S_t$	6.0105	0.0027**	Reject H_{03}	Bidirectional Causality
	$S_t \to F_t$	6.7218	0.0013**	Reject H_{04}	
Wheat	$F_t \to S_t$	3.3235	0.0408**	Reject H_{03}	Bidirectional Causality
	$S_t \to F_t$	6.2763	0.0029**	Reject H_{04}	

Note. $F_t \to S_t$ means futures price does not Granger-cause spot price, and $S_t \to F_t$ means spot price does not Granger-cause futures price.

Note. **Significant at the 5% significance level.

Granger causality test. The test results in Table 3 show the unidirectional causal relationship between the spot and future prices of barley, chana, coriander, cotton cake, jeera, maize, and moong. The spot market affects the futures market in the case of barley, cotton cake, maize, and moong. In the case of chana, coriander, and jeera, the futures market is leading the spot market. The test results shown in the table also depict the bidirectional causality in the case of soybean, turmeric, and wheat. This reveals that the spot, as well as futures markets, influence each other.

Results of the Vector Error Correction Model

An error correction model (ECM) helps us to understand the changes in short-term relations between spot and

Table 4. *Error Correction Model (ECM)-Price Discovery*

Agricultural Commodities		Φ	ΔS_{t-1}	ΔS_{t-2}	ΔF_{t-1}	ΔF_{t-2}	Constant
Barley	ΔS_t	0.4941**	–0.1564	–0.0089	–0.4531**	–0.2164**	0.0001
		[6.7300]	[–1.9685]	[–0.1468]	[–5.3121]	[–2.8844]	0.1597

	ΔF_t	–0.2873**	–0.1676	–0.0518	–0.4725**	–0.2583**	0.0001
		[–5.2477]	[–2.8291]	[–1.1343]	[–7.4290]	[–4.6165]	0.2369
Chana	ΔS_t	1.0419**	–0.0380	–0.0750	–0.4877**	–0.2484**	0.0000
		[5.8317]	[–0.2624]	[–0.9206]	[–3.4904]	[–3.0844]	0.0775
	ΔF_t	–0.8124**	–0.5260**	–0.2256**	–0.1364**	–0.0956**	0.0001
		[–3.9971]	[–3.1924]	[–2.4348]	[–0.8580]	[–1.0438]	0.1210
Coriander	ΔS_t	0.0428	–0.8045**	–0.3716**	0.1664**	0.0790	0.0000
		[0.5770]	[–11.893]	[–7.1965]	[2.8940]	[2.1587]	0.1058
	ΔF_t	–1.2771**	–0.7522**	–0.2980**	0.2359**	0.0639	0.0000
		[–10.367]	[–6.7072]	[–3.4815]	[2.4734]	[1.0531]	0.0491
Cotton Cake	ΔS_t	0.1149**	–0.4562**	–0.1799**	–0.1211**	–0.0590	0.0000
		[1.1818]	[–4.1717]	[–2.5599]	[–1.6568]	[–1.3632]	0.0283
	ΔF_t	–1.4668**	–0.9489**	–0.3649**	0.1149**	0.0069	0.0000
		[–11.786]	[–6.7803]	[–4.0557]	[1.2280]	[0.1259]	–0.0063
Jeera	ΔS_t	0.5781**	–0.3064**	–0.1079**	–0.1934**	–0.0919**	0.0000
		[8.0616]	[–4.0656]	[–2.2033]	[–3.3633]	[–2.5625]	0.0150
	ΔF_t	–0.8833**	–0.9510**	–0.4052**	0.0486	0.0020	0.0000
		[–6.5031]	[–6.6616]	[–4.3672]	[0.4463]	[0.0298]	0.0428
Maize	ΔS_t	0.2213**	–0.5475**	–0.2438**	–0.1414**	–0.1086**	0.0002
		[3.1081]	[–8.5936]	[–4.2598]	[–2.4397]	[–2.6158]	0.2753
	ΔF_t	–1.1164**	–0.2415**	–0.0433	0.1648**	0.1658**	0.0003
		[–11.805]	[–2.8547]	[–0.5704]	[2.1417]	[3.0063]	0.2643
Moong	ΔS_t	–0.4348**	–0.5618**	–0.4678**	–0.0018	0.1270**	0.0001
		[–0.9668]	[–1.6116]	[–1.9355]	[–0.0057]	[0.6265]	0.0412
	ΔF_t	–2.2995**	–1.1004**	0.2812**	0.5399**	0.2812**	–0.0001
		[–5.2497]	[–3.2408]	[1.4241]	[1.7029]	[1.4241]	–0.0481
Soybean	ΔS_t	0.4960**	–0.2516**	–0.2010**	–0.1872**	–0.1698**	0.0001
		[5.1434]	[–2.9183]	[–3.6254]	[–2.5082]	[–3.6489]	0.0958
	ΔF_t	–1.1243**	–0.6086**	–0.3033**	0.0926	–0.0495	0.0000
		[–9.5263]	[–5.7674]	[–4.4705]	[1.0140]	[–0.8680]	0.0641
Turmeric	ΔS_t	0.0114	–0.5657**	–0.2266**	0.5965**	0.0135	0.0000
		[0.2448]	[–9.0482]	[–4.2285]	[1.6482]	[0.5443]	0.0131
	ΔF_t	–1.2859**	–0.6964**	–0.1863**	0.2781**	0.0754	0.0000
		[–11.697]	[–4.7449]	[–1.4818]	[3.2741]	[1.2896]	–0.0701
Wheat	ΔS_t	0.2662**	–0.2435**	–0.1904**	–0.0742	0.1109**	0.0000
		[2.1239]	[–1.6716]	[–1.6285]	[–0.7492]	[1.6130]	–0.0808
	ΔF_t	–1.0572**	–0.8876**	–0.2705**	0.0223	0.0406	0.0000
		[–5.5820]	[–4.0336]	[–1.5334]	[0.1495]	[0.3909]	0.0058

Note. The values in brackets refer to respective *t*-statistics for the coefficients.

Note. **Significant at the 5% level of significance.

futures markets. As the co-integration relation among spot and futures prices of select commodities is established in Table 2, the short-term equilibrium is predicted using the vector error correction models. The results of the co-integrating coefficient and the coefficients of both the lagged values of the spot and futures prices are given in Table 4. The lag length is 2 using the lag length criterion test. The vector error correction model equation coefficients for each agricultural commodity are also shown in Table 4.

Barley

The coefficient of ECM of the spot market returns is positive (0.4941) and significant. The influence of the spot's first lag (–0.1564) and the second lag (–0.0089) is negative and insignificant. The influence of the futures' first lag (–0.4531) and the second (–0.2164) is also negative but significant. Thus, the spot and futures market prices up to lag two significantly affect the spot prices negatively. The coefficient of ECM of futures market returns is negative (–0.2873) and significant. The weight of the spot's first lag (–0.1676) and the second lag (–0.0518) is negative and insignificant. The weight of the first lag (–0.4725) and second lag (–0.2523) of the futures is also negative but significant. Thus, the futures price up to lag 2 significantly affects the current futures prices negatively. Hence, the result completely disagrees with the Granger causality test, which indicates the unidirectional causality that the spot prices influence the variations in the futures market.

Chana

The coefficient of ECM of the spot market is positive (1.0419) and significant. The weight of the spot's first lag (–0.0380) and second lag (–0.0750) is negative and insignificant. The weight of the first lag (–0.4877) and second lag (–0.2484) of futures is also negative but significant. Thus, until lag 2, the futures prices significantly affect the current spot prices negatively. The coefficient of ECM of the futures market is negative (–0.8124) and significant. The influence of the first lag (–0.5260) and the second lag (–0.2256) of the spot is negative and significant. The influence of the futures' first lag (–0.1364) and the second lag (–0.0956) is also harmful and significant. Thus, the spot and futures prices, until lag 2, significantly affect the futures prices negatively. Hence, the result completely does not agree with the Granger causality test, which indicates the unidirectional causality that the futures market prices affect the prices of the spot market.

Coriander

The coefficient of ECM of the spot market is positive (0.0428) and insignificant. The weight of the first lag (–0.8045) and second lag (–0.3716) is negative and significant. The weight of the first lag (0.1664) is positive and significant, but the weight of the second lag (0.0790) is positive and insignificant. Thus, the spot prices until lag 2 and futures prices up to lag 1 significantly negatively impact current spot prices. The coefficient of ECM of futures market returns is negative (–0.2771) and significant. The influence of the first lag (–0.7522) and the second lag (–0.2980) of the spot is negative and significant. The influence of the futures' first lag (0.2359) is positive and significant, and the influence of the second lag (0.0639) is positive and insignificant. Thus, the spot prices until lag 2 and futures prices until lag 1 significantly negatively impact futures prices. Therefore, the result completely disagrees with the Granger causality test, which indicates the unidirectional causality that the futures market prices influence the variations in the spot market.

Cotton Cake

The coefficient of ECM of the spot market is positive (0.1149) and significant. The weight of the first lag (–0.4562) and the second lag (–0.1799) of the spot is negative and significant. The weight of the first lag (–0.1211) of the futures is negative and significant, and the weight of the second lag (–0.0590) is negative but insignificant. Thus, the spot prices up to lag 2 and futures prices up to lag 1 significantly negatively impact current spot prices. The coefficient of ECM of futures market returns is negative (–1.4668) and significant. The weight of the first lag (–0.9489) and the second lag (–0.3649) of the spot is negative and significant. The weight of the futures' first lag (0.1149) is positive and significant, and the second lag (0.0069) is positive but insignificant. Thus, the spot prices up to lag 2 show a significant negative impact and futures prices up to lag 1 show a significant positive impact on current futures prices. Therefore, the result completely disagrees with the Granger causality test, which indicates the unidirectional causality that the prices in the futures market cause for the deviations in the prices of the spot market.

Jeera

The ECM coefficient of the spot market is positive (0.5781) and significant. The weight of the first lag (–0.3064) and second lag (–0.1079) of the spot prices is negative and significant. The weight of the first lag (–0.1934) and second lag (–0.0919) of the futures is also negative and significant. Thus, the spot and futures price up to lag 2 significantly negatively impacts current spot prices. The coefficient of ECM of futures market returns is negative (–0.8833) and significant. The influence of the first lag (–0.9510) and second (–0.4052) lag of spot returns is negative and significant. At the same time, the first influence of the first lag (0.0.0486) and second lag (0.0020) of futures returns is insignificant. It shows the spot prices until lag 2, which significantly negatively impacts futures prices. Therefore, the result completely disagrees with the Granger causality test, indicating the unidirectional causality that the futures market prices cause variations in the cash market prices.

Maize

The ECM coefficient of the spot prices is positive (0.2213) and noteworthy. The weight of the first lag (–0.5475) and second lag (–0.2438) of the spot is negative and significant. The weight of the first lag (–0.1414) and second lag (–0.1086) of the futures is also negative and significant. Thus, the spot and futures price up to lag 2 significantly negatively impacts current spot prices. The ECM coefficient of futures market returns is negative (–1.1164) and significant. The influence of the first lag (–0.2415) is negative and significant, and the influence of the second lag (-0.0433) is negative but insignificant. The influence of the first lag (0.1618) and second lag (0.1658) of futures returns is positive and significant. Hence, the spot prices up to lag 1 show a significant negative impact and futures prices up to lag 2 significantly impact the current futures prices. Therefore, the result disagrees with the Granger causality test, which indicates the unidirectional causality that the prices in the spot market are causing the variations in futures market prices.

Moong

The ECM coefficient in the spot market is negative (–0.4348) and significant. The weight of the first lag (–0.5618) and the second lag (–0.4678) of the spot is negative and significant. The weight of the first lag (–0.0018) of the futures is negative and insignificant, and the weight of the second lag (0.1270) is positive but significant. Hence, the spot prices until lag 2 show a significant negative impact and futures prices until lag 2 show a significant positive impact on the current spot prices. The ECM coefficient of futures market returns is negative (–2.2497) and significant. The influence of the first lag (–1.1004) is negative, and the second lag (0.2812) of the spot is positive and significant. The influence of the first lag (0.5399) and second lag (0.2812) of futures returns is positive and significant. Hence, the spot prices up to lag 1 show a significant negative impact; lag 2 shows a significant positive impact, and the futures prices up to lag 2 show a significant positive impact on the current futures prices. Therefore, the result disagrees with the Granger causality test, indicating the unidirectional causality that the spot prices are causing the variations in futures prices.

Soybean

The ECM coefficient of the spot market is positive (–0.4960) and significant. The equilibrium of spot returns is significantly influenced by the first (–0.2516) and second (–0.2010) lags of spot returns. The first (–0.1872) and second (–0.1698) lags of futures returns are negative. Thus, the spot and futures price up to lag 2 significantly negatively impacts current spot prices. The ECM coefficient of futures market returns is negative (–1.1243) and significant. The equilibrium of futures returns is significantly influenced by the first (–0.6086) and second (–0.3033) lags of spot returns. However, the influence of futures returns' first and second lag is insignificant. Thus, the spot prices until lag 2 significantly negatively affect futures prices. Hence, the result disagrees with the Granger causality test, which indicates the bidirectional causality among spot and futures market prices.

Turmeric

The ECM coefficient of the spot market is positive (0.0114) and insignificant. The equilibrium of spot returns is significantly influenced by the first (–0.5657) and second (–0.2266) lag of spot returns and the first (0.5965) lag of futures returns. Thus, the spot prices up to lag 2 show a significant negative impact and futures prices up to lag 1 show a significant positive impact on current spot prices. The ECM coefficient of the futures market returns is negative (–1.2859) and significant. The equilibrium of futures returns is significantly influenced by the first (–0.6964) and second (–0.1863) lag of spot returns and the first (0.2781) lag of futures returns. Thus, the spot prices up to lag 2 show a significant negative impact and futures prices up to lag 1 show a significant positive effect on current futures prices. Hence, the result disagrees with the Granger causality test, indicating the bidirectional causality among spot and futures market prices.

Wheat

The ECM coefficient of the cash market is positive (0.2662) and noteworthy. The equilibrium of spot returns is significantly influenced by the first (–0.2435) and second (–0.1904) lag of spot returns and the second lag (0.1109) of futures returns positively. Thus, the spot prices up to lag 2 show a significant negative impact and futures prices up to lag 2 significantly impact current spot prices. The ECM coefficient of futures market returns is negative (–1.0572) and significant. The equilibrium of futures returns is significantly influenced by the first (–0.8876) and second (–0.2705) lag of spot returns. Thus, the spot prices until lag 2 significantly negatively affect futures prices. Hence, the result disagrees with the Granger causality test, indicating the bidirectional causality among the spot and futures market prices.

Conclusion

In the present paper, the empirical analysis uses the daily time series data from January 1, 2020 to March 31, 2022.

Using purposive sampling, 10 actively trading and highly liquid agricultural commodities are chosen for the study. The spot and near-month futures prices data are initially converted into log returns. The ADF test results say that the log values of the time series are non-stationary ; whereas, the log returns of the time series are stationary, and the same is considered for further analysis. Johansen's co-integration test discloses the long-run symmetrical relationship among the log returns of the spot and futures prices of the select commodities. The Granger's causality test exhibits the unidirectional causality that in the case of barley, cotton cake, maize, and moong, the spot market is guiding the futures market, and in the case of chana, coriander, and jeera, the commodity futures market is guiding the cash market. The test also exhibits the two-directional causality among the prices of spot and futures markets relating to soybean, turmeric, and wheat.

The results of ECM highlight the lead–lag association among cash market and futures market prices of the selected commodities. The subsistence of co-integration says that the spot market and futures market prices may have a short-run imbalance, which can be rectified through the arbitrage process. In the case of barley, jeera, maize, and soybean, the spot and futures prices till lag 2 show a significant negative impact on current spot prices. In the case of coriander and cotton cake, the spot prices up to lag 2 and futures prices up to lag 1 significantly negatively impact current spot prices. In the case of moong and wheat, the spot prices until lag 2 show a significant negative impact and the futures prices until lag 2 significantly impact the current spot prices. In the case of China, the futures prices until lag 2 affect substantially the current spot prices negatively. In the case of turmeric, the spot prices until lag 2 show a significant negative impact and futures prices up to lag 1 show a significant positive effect on the current spot prices.

In the case of jeera, soybean, and wheat, the spot market prices up to lag 2 show a significant negative impact on current futures prices. In the case of cotton cake and turmeric, the spot prices up to lag 2 show a significant adverse effect and futures prices up to lag 1 show a significant positive impact on current futures prices. In the case of barley, the futures price until lag 2 significantly affects the current futures prices negatively. In the case of chana, the spot and futures prices until lag 2 significantly affect the futures prices negatively. In the case of coriander, the spot prices until lag 2 and futures prices until lag 1 significantly negatively impact current futures prices. In the case of maize, the spot prices up to lag 1 show a significant negative impact and futures prices up to lag 2 significantly impact futures prices. In the case of moong, the spot prices until lag 1 show substantial adverse effects, lag 2 shows a significant positive impact, and the futures prices up to lag 2 show a significant positive effect on futures prices.

Since India's agricultural commodity futures market is booming, the study results are helpful to the market participants in adopting a range of trading and arbitrage strategies. The study is also beneficial to the policymakers to verify the consistency of the spot and futures markets.

Implications

The study has focused on a crucial aspect of commodity futures trading, viz., price discovery, and its findings will be very useful to several stakeholders: farmers, traders, processors, academicians, researchers, regulatory bodies, commodity derivative exchanges, and the government. Regulatory bodies may find its results helpful in addressing the issues and difficulties reported by the traders. The SEBI and commodity derivatives exchanges may also find this study more beneficial as it highlights the price discovery process.

Limitations of the Study and Scope for Further Research

The study period chosen for empirical analysis is from January 1, 2020 to March 31, 2022, which includes the most turbulent COVID-19 pandemic period. During the pandemic, the markets experienced some abnormal volatility, which may have affected the study results. Furthermore, only 10 items were selected for the study. Hence, there is enormous scope to extend the study by including more agricultural commodities. The analysis may also be developed to measure the volatility spillover, hedging efficiency, and the impact of macroeconomic factors on commodity futures price volatility.

Authors' Contribution

M. Lethesh created the problem statement, wrote the literature review, and assembled reputable research papers. He performed the numerical calculations with EViews 12.0. The concept was created by Dr. C. Viswanatha Reddy, who also created quantitative frameworks for data analysis. He collaborated with M. Lethesh in composing the manuscript.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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