An Empirical Study of Price Discovery in Commodities Futures Market

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Abstract

Price discovery is one of the major economic functions of the futures market. It provides a competitive response of futures prices which are derived from spot prices. Basically, a commodity derivative is multifarious in a growing country like India. India is one of the leading producers of agriculture commodities. The main aim of this study was to find out the effectiveness of commodity derivatives in price discovery in agriculture commodities in India. The price discovery relationship of 10 agricultural commodities was investigated. The daily price information of 10 agriculture commodities namely wheat, sugar, chili, mustard-seed, chana (Bengal gram whole), pepper, turmeric, soybean, barley, and maize were taken from NCDEX for the period from 2005 to 2015. The study used simple descriptive statistics, ADF test, PP-test, Johansen co-integration, and Granger causality test to find the answers. We found that there is long-run equilibrium relationship established in 10 commodities. The outcome of the Granger causality test showed unidirectional Granger lead-lag relationships between spot and futures markets in all agricultural commodities in which there were two co-integrations and causality. The findings of the study have important policy and regulatory implications for the Indian commodity futures market. The study will also be helpful to the investors and other market participants to understand the mechanism of the Indian commodity futures market.

Key words : **price discovery, Granger causality, market efficiency, futures market**

JEL Classification : C32, G13, G14, G15, G18

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Commodity trading started before separation of many countries in the world. After that, foreign rules and government policies came into consideration. Commodities are a separate class of assets. Commodities prices are very useful for the investors ; when investors are going to invest in commodities, then they require the derivative contracts. Commodity derivatives are a useful tool for investment. There are many commodity derivative instruments that are traded in the market. All such instruments have some features according to which they are classified as futures, forward, options, and swaps. Futures prices and spot prices have an important role in the commodity derivative market. Futures contracts provide a significant information about cash and storage markets. There are number of functions of futures markets as recommended by Fleming, Ostdiek, and Whaley (1996). These functions include price discovery, hedging, financing, liquidity, price stabilization, encouraging competition, increasing efficiency, inherent leverage, low transaction costs as well as accomplishing the desires of speculators. Price discovery is one of the major economic functions of the futures market. It provides a competitive response of futures price, which is derived from the spot price. As the outcome, initially, prices are

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updated in the futures market, which serves as the price discovery vehicle for the investors. There are other reflections, one market leading to other trading market (Tan & Lim, 2001) in which finance and liquidity factors are identified.

The Linkage between Futures and Spot Prices

The main aim of this study is to find out the effectiveness of commodity derivatives in price discovery in agriculture commodities in India. The price discovery relationship of 10 agricultural commodities has been investigated. The lead-lag relationship between futures and spot prices in returns and volatility has been a matter of concern throughout the world, that is, in both developed and developing countries in equity, currency, and commodity markets. There are numerous studies that have been conducted for returns and volatility spillovers relationship of spot and futures prices of commodities. These studies used high frequency data (Intra-day) trading. Studies conducted by Schroeder and Goodwin (1991) ; Antoniou and Garrett (1993) ; Chang, Jain, and Locke (1995) ; Hodgson, Masih, and Masih (2006), Floros and Vougas (2007) ; and Kavussanos, Visvikis, and Alexakis (2008) found that the futures prices played a dominant role over the spot prices. There are two major advantages of futures markets towards the economic activities that are price discovery and risk transfers (Garbade & Silber, 1983). Price discovery considers the use of futures prices for the pricing of cash market transactions.

Literature Review

A number of studies have been explored for the purpose of determining whether the price information is reflected first in the spot market or in its underlying futures market and to check the efficiency of the market. After exploring the studies, it is found that there is a controversy on the subject of lead lag relationship and the efficiency of the market. Various studies showed that spot market follows the futures market and at the same time, some other studies showed that futures market follow the spot market. The same issue is with market efficiency, that is, in case of market efficiency also, there is mixed result.

Samal and Swain (2015) empirically analyzed the Indian commodity futures market to examine whether it satisfied the market efficiency condition or not. The authors tried to analyze this with the help of theoretical and empirical literature and the efficient market hypothesis in the context of an emerging commodity market namely NCDEX. The study was conducted on three agricultural commodity futures traded on NCDEX using daily data of closing prices for the period of 12 months. The results of the study showed a significant linear relationship between the spot and futures prices of the selected agricultutal commodities. The VAR model clearly indicated that the lag value of futures had a significant influence on spot. The authors concluded that the spot prices and futures prices of the selected commodities were integrated as well as co- integrated. The results showed that the Indian commodity market for the selected agricultural commodities was efficient.

Kaur and Anjum (2014) conducted a study to analyze the relationship of spot and futures prices of wheat in India. The period of the study was from January 2006 to December 2011. The study found that there was a significant correlation between both the prices of wheat, that is, spot and futures prices had a significant correlation. This showed that there was a linear relationship between spot and futures prices of wheat in India. An increase in the spot prices of wheat resulted into a corresponding increase in the futures price of wheat. The authors concluded that futures market depended on the spot market, and the spot prices affected the commodity futures markets.

Shalini and Duraipandian (2014) found that the price discovery mechanism is more effective in case of most of the commodities but may not be very effective for some commodities. This study used a sample of nine

agricultural commodities, which were actively traded on the NCDEX in the study period from April 1, 2012 to March 31, 2013.

In India, a study was conducted by Sehgal, Rajput, and Dua (2012) and others on 10 agricultural commodities. In this study, data for a period from June 2003 - March 2011 was used to analyze the market and it was found that spot and futures prices of all sample commodities except turmeric were non stationary, and it was also found that they were integrated to order one. The authors also found that there was no co-integration in case of turmeric in this market. Long run equilibrium relationship was confirmed for nine out of 10 commodities. The study showed that there was a bi-directional lead relationship between spot and futures market in all the selected agricultural commodities with the only one exception of turmeric in which there was no causality and co-integration and was not informationally efficient. It was concluded that the Indian commodities market is still not perfectly competitive for some commodities (Sehgal et al., 2012).

As far as the long-term relationship between spot prices and futures for the agricultural commodities is concerned, a study on agricultural commodities like chickpea, maize, black pepper, lentil, castor seed, sugar, and soybean was conducted, and it was found that there was a co-integration in their futures and spot prices. It was also found that there was a short-term relationship between spot and futures prices of the selected commodities, and it was further found that the futures markets had the ability to predict spot prices for castor seed, chickpea, sugar, and soybean. The same study also confirmed that there was a bi-directional short run relationship among black lentil, maize, and pepper (Jabir & Gupta, 2011).

In 2010, a study was conducted in Italy in which the main focus was on the two main or most significantly traded commodities across the globe, that is, corn and soybean. The weekly data of spot and future prices from January 2004 to September 2010 was used. It was found that futures markets reacted more quickly to new or unexpected information than the underlying spot market. However, in times of crisis, and in particular, in phases of high price increase, the cash market also became an important factor in the price discovery process. The authors found that price discovery was more dependent on fundamental patterns rather than financial trading on futures markets (Baldi, Peri, & Vandone, 2010).

Fu and Qing (2006) conducted a study on the price discovery process and volatility of spot and futures markets in China. It was found that there was a long-term equilibrium. It was also found that there was a significant bidirectional flow of information between the Chinese spot and futures markets. Fu and Qing also found that the dominant role was played by the futures market. It was also found that the volatility spillovers from futures to spot were more significant than the other way around.

Vimal (2015) found a long run relationship between futures and spot prices of the commodities - wheat, castor seed, chilly, pepper, mustard, and soybean. The test of causality further distinguished uni-directional causality, where futures prices explained the spot prices of the commodities - wheat, castor seed, and jeera. Chilly, pepper, mustard, and soyabean showed bi-directional relationship between futures price and spot prices. Narsimhulu and Satyanarayana (2016) indicated uni-directional causality from the returns of futures prices to returns of spot prices of the commodities - chilli and turmeric. The study period were taken from 2004 to 2013. In the case of channa, bi-directional causality was found between the returns of futures prices and returns of spot prices. Soni and Singla (2013) found that guar gum was inefficient in the short and long run maturities period of contract.

Objectives of the Study

(i) To find out the effectiveness of commodity derivatives in price discovery in case of 10 selected agricultural commodities in India.

(ii) To investigate the price discovery relationship of 10 selected agricultural commodities.

Hypotheses

- **H01:** There is no stationarity in the returns of futures prices of commodities.
- **Ha1:** There is stationarity in the returns of futures prices of commodities.
- **H02:** There is no stationarity in the returns of spot prices of commodities.
- **Ha2:** There is stationarity in the returns of spot prices of commodities.
- **H03:** There is no co-integration between the returns of futures and spot prices of commodities.
- **Ha3:** There is co-integration between the returns of futures and spot prices of commodities.

Methodology

(1) Data Sources : This study is restricted to the Indian commodity market and 10 selected agriculture commodities only. The data for the succeeding research is spread over 10 years - from April 2005 to March 2015. The daily price information of 10 agriculture commodities namely wheat, barley, sugar, chili, maize, pepper, mustard-seed, soybean, turmeric, and chana (Bengal gram whole) were taken from NCDEX .

(2) Tools and Techniques : As per the objectives, the study is based on time series data. Eviews was employed for data analysis. First, we use the unit root test to check the stationarity of the data with the help of PP test (Phillips - Perron test statistic) and the ADF test (Augmented Dickey - Fuller Test Statistic). Johansen co-integration test is used to investigate the long term relationship between the spot and futures prices of the 10 selected agricultural commodities. The Engle Granger test identifies whether the causal relationships between the selected agriculture commodities are bi-directional causality or uni-directional causality.

Empirical Analysis and Results

This section carries out the time series data analysis and explains the empirical findings following which we will propose implications and amendments by which new opportunities of agricultural commodities segment can be unlocked in India. All empirical analysis data were taken from the period of April 2005 to March 2015 with 2130 points of observation.

In this study, daily returns are used without any adjustment for dividends and have been computed by using the following formula (Hussein & Omran , 2005). First, we converted all variables' time series data into log returns.

$$Rt = \ln(Pt / Pt - 1) * 100$$

The Table 1 shows the summarized data in meaningful ways such that all variables are rejigging statistics of futures price data. Skewness of the distribution of all futures prices of selected commodities data are positively or right skewed that means no. of high values are more in comparison to low values in the time series data. The finding of kurtosis shows all variables' values are greater than 3, which means that leptokurtic distribution is sharper than the normal distribution. The volatility of variables is in terms of standard deviation *(SD)* as percentage (%) of means are highest in case of barley (9.9%) and lowest in case of sugar (0.93%), which means that in case of barley, prices are highly volatile in comparison to the remaining nine agricultural commodities. As per the Jarque-Bera statistics (JB-test), all selected agricultural commodities are non-normal at the confidence interval of 95% since probabilities are less than 0.05. So, it is necessary to convert the commodities futures prices series into the return series.

Table 1. Descriptive Statistics of Futures Prices Data

Properties	Wheat	Sugar	Barley	Chili	Turmeric	Pepper	Maize	Soybean	Mustard-seed	Chana
Mean	0.0300	-0.0124	0.0294	0.0396	-0.0382	0.0733	0.0298	0.0614	0.0264	0.0102
Maximum	11.0069	12.3238	225.0067	32.8504	19.8851	9.5336	19.3458	12.6195	6.5694	16.8341
Minimum	-13.1519	-4.0770	-225.0067	-21.9795	-31.2375	-4.5031	-9.8494	-21.4312	-13.8642	-23.5698
Std. Dev.	1.0884	0.9366	9.9280	2.3966	2.7420	1.6166	1.6562	1.8098	1.2588	1.9110
Skewness	0.5469	3.7557	0.0314	2.4829	2.9689	0.4152	3.5901	3.0328	1.4472	0.3934
Kurtosis	43.8627	49.9597	496.0674	50.9048	41.7806	5.7331	40.2544	43.6331	24.4948	42.2732
Jarque-Bera	74218	100454	10798379	103026	68366	362	63935	74968	20894	68535
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	32.0128	-13.1898	31.2884	42.1818	-40.7421	78.1528	31.7254	65.5015	28.1047	10.9117
Sum Sq. Dev.	1262	934	104972	6117	8007	2783	2921	3488	1687	3889
Observations	2130	2130	2130	2130	2130	2130	2130	2130	2130	2130

Table 2. Descriptive Statistics of Spot Prices Data

Properties	Wheat	Sugar	Barley	Chili	Turmeric	Pepper	Maize	Soybean	Mustard-seed	Chana
Mean	0.0408	0.0385	-0.0054	0.0439	0.0399	0.1156	0.1901	0.0632	-0.0414	0.0244
Maximum	232.2130	12.7101	46.6267	20.2516	9.9724	5.1397	157.7819	4.0450	11.3659	5.4542
Minimum	-233.8130	-15.6559	-46.8345	-7.2880	-6.0297	-3.8917	-8.8011	-16.9742	-8.7768	-5.1388
Std. Dev.	10.1572	1.2023	2.1426	1.4267	0.9680	0.9451	4.9720	1.1827	1.5979	1.3144
Skewness	0.2442	0.7888	0.0888	4.9727	0.8115	0.4244	29.7955	3.4528	0.3291	0.2629
Kurtosis	518.7059	52.9026	423.9571	61.1103	15.1444	6.6139	945.0511	45.8420	10.5498	4.4569
Jarque-Bera	11857063	111135	7900386	154959	6693	614	39724257	83956	2561	107
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	43.61	41.18	-5.83	46.99	42.68	123.71	203.39	67.66	-44.34	26.08
Sum Sq. Dev.	110287	1545	4907	2176	1002	955	26426	1495	2729	1847
Observations	2130	2130	2130	2130	2130	2130	2130	2130	2130	2130

The Table 2 summarizes the data in significant ways such that all selected commodities are rejigging statistics of spot price data. Skewness of the distribution of spot prices of all selected agricultural commodities data is positively skewed, which means that number of high values are more in comparison to low values in the time series data. The volatility of commodities are in terms of standard deviation *(SD)* as percentage (%) of means are highest in wheat (10.15 %) and lowest in pepper (0.94%), which means in that in the spot market, wheat prices are highly volatile in comparison to the rest of the nine agricultural commodities. As per the Jarque-Bera statistics (JB-test), all selected agricultural commodities are non-normal at the confidence interval of 95% since the probabilities are less than 0.05. So, it is essential to convert the commodities' spot prices series into the return series.

The Tables 3 reports the correlation matrix between futures prices of all agricultural commodities over April 2005 to March 2015. Most of the commodities are moderate downhill (negative), weak downhill (negative), and moderate uphill (positive) related to each other. Wheat has the most efficient relationship among rest of the commodities, in which most of the commodities have a positive correlation expect maize and chana to which

Table 3. Correlation Matrix of Futures Prices Data

Properties	Wheat	Sugar	Barley	Chili	Turmeric	Pepper	Maize	Soybean	Mustard-seed	Chana
Wheat	1	0.0341	0.0197	0.1004	0.0285	0.0300	-0.0507	0.0663	0.0329	-0.0913
Sugar	0.0341	1	-0.0321	-0.0029	-0.0362	-0.0180	0.0094	0.0029	0.0528	-0.0472
Barley	0.0197	-0.0321	1	0.0245	0.0275	0.0260	0.0066	-0.0199	-0.0049	0.0267
Chili	0.1004	-0.0029	0.0245	1	0.3632	-0.0519	-0.0493	0.0470	-0.0076	0.0431
Turmeric	0.0285	-0.0362	0.0275	0.3632	1	0.0060	-0.0992	0.0606	-0.0597	0.0872
Pepper	0.0300	-0.0180	0.0260	-0.0519	0.0060	1	0.0051	0.0122	-0.0256	0.0005
Maize	-0.0507	0.0094	0.0066	-0.0493	-0.0992	0.0051	1	-0.0021	-0.1167	-0.0042
Soybean	0.0663	0.0029	-0.0199	0.0470	0.0606	0.0122	-0.0021	1	-0.0447	-0.0502
Mustard-seed	0.0329	0.0528	-0.0049	-0.0076	-0.0597	-0.0256	-0.1167	-0.0447	1	0.1479
Chana	-0.0913	-0.0472	0.0267	0.0431	0.0872	0.0005	-0.0042	-0.0502	0.1479	1

Table 4. Correlation Matrix of Spot Prices Data

Properties	Wheat	Sugar	Barley	Chili	Turmeric	Pepper	Maize	Soybean	Mustard-seed	Chana
Wheat	1	0.0226	0.0075	-0.0112	-0.0011	0.0408	-0.0162	-0.0135	-0.0407	-0.0235
Sugar	0.0226	1	0.0126	0.0762	-0.0167	-0.0001	0.0072	0.0011	0.0280	0.0337
Barley	0.0075	0.0126	1	0.0330	0.0018	-0.0053	-0.0008	-0.0302	0.0225	0.0042
Chili	-0.0112	0.0762	0.0330	1	0.0457	-0.0371	-0.0020	-0.0182	0.0592	-0.0799
Turmeric	-0.0011	-0.0167	0.0018	0.0457	1	0.0220	-0.0525	0.0368	-0.0250	-0.0426
Pepper	0.0408	-0.0001	-0.0053	-0.0371	0.0220	1	0.0133	-0.0329	-0.0165	0.0263
Maize	-0.0162	0.0072	-0.0008	-0.0020	-0.0525	0.0133	1	0.0456	-0.0457	0.0150
Soybean	-0.0135	0.0011	-0.0302	-0.0182	0.0368	-0.0329	0.0456	1	-0.0333	0.0411
Mustard-seed	-0.0407	0.0280	0.0225	0.0592	-0.0250	-0.0165	-0.0457	-0.0333	1	-0.0164
Chana	-0.0235	0.0337	0.0042	-0.0799	-0.0426	0.0263	0.0150	0.0411	-0.0164	1

wheat is negatively related, meaning futures prices of wheat moves in the opposite direction of the futures prices of maize and chana. Barley is the second best correlated commodity after wheat. Sugar, chili, turmeric, pepper, maize, soybean, and chana are partially correlated to all agriculture commodities. Mustard-seed has the least correlation with all the other selected agricultural commodities.

The correlation matrix (Table 4) shows the relationship between spot prices of all commodities over the period from April 2005 to March 2015. It can be seen from the Table 5 that the spot prices of most of the commodities have moderate downhill (negative), weak downhill (negative), and moderate uphill (positive) relation with each other. Sugar has the most efficient relationship out of all spot prices of commodities. Barley is the second best correlated commodity to all commodities after sugar in terms of spot prices of the commodities. Chili, turmeric, pepper, maize, soybean, musturd-seed, and chana - all are partially correlated to all agriculture spot prices of commodities. Wheat has the least correlation among the spot prices of all agricultural commodities. As per the Table 3, futures prices of wheat are highly correlated to other commodities, but as per the Table 4, wheat has a very low correlation with other selected commodities in the spot market. This shows that the being the major commodity in the selected commodities of the Indian market, wheat has a greater impact in the futures market as compared to the spot market.

The Table 5 shows the values of the ADF and PP test statistic. If the *t* - test statistic is more than the critical values

Table 5. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Wheat

Commodity	Test	Contracts	Model	Variables	*t*-test	*P*-value	Coefficient	1% level	5% level	10% level
	ADF- Test	Futures Price	Level	Intercept	-33.1903	0.0000	-1.0182	-3.4363	-2.8640	-2.5681
				Trend & intercept	-33.1827	0.0000	-1.0184	-3.9667	-3.4140	-3.1291
				None	-33.1828	0.0000	-1.0174	-2.5671	-1.9411	-1.6165
Wheat		Spot Price	Level	Intercept	-18.8574	0.0000	-4.5773	-3.4363	-2.8641	-2.5682
				Trend & intercept	-18.8493	0.0000	-4.5777	-3.9667	-3.4141	-3.1291
				None	-18.8406	0.0000	-4.5680	-2.5671	-1.9411	-1.6165
	PP- Test	Futures Price	Level	Intercept	-33.1899	0.0000	-1.0182	-3.4363	-2.8640	-2.5681
				Trend & intercept	-33.1824	0.0000	-1.0184	-3.9667	-3.4140	-3.1291
				None	-33.1855	0.0000	-1.0174	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-240.43	0.0001	-1.4996	-3.4363	-2.8641	-2.5682
				Trend & intercept	-243.40	0.0001	-1.4996	-3.9667	-3.4141	-3.1291
				None	-221.85	0.0001	-1.4995	-2.5671	-1.9411	-1.6165

Table 6. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Barley

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Barley	ADF- test	Futures Price	Level	Intercept	-20.1806	0.0000	-3.2210	-3.4363	-2.8640	-2.5682
				Trend & intercept	-20.1776	0.0000	-3.2224	-3.9667	-3.4140	-3.1291
				None	-20.1855	0.0000	-3.2200	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-28.0134	0.0000	-0.8466	-3.4363	-2.8640	-2.5681
				Trend & intercept	-28.0231	0.0000	-0.8475	-3.9667	-3.4140	-3.1291
				None	-28.0041	0.0000	-0.8458	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-150.3530	0.0001	-1.4803	-3.4363	-2.8640	-2.5681
				Trend & intercept	-151.5467	0.0001	-1.4803	-3.9667	-3.4140	-3.1291
				None	-149.4526	0.0001	-1.4803	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-27.8324	0.0000	-0.8466	-3.4363	-2.8640	-2.5681
				Trend & intercept	-28.0231	0.0000	-0.8475	-3.9667	-3.4140	-3.1291
				None	-27.8119	0.0000	-0.8458	-2.5671	-1.9411	-1.6165

(in absolute terms, that is, ignoring negative signs) and if the *p* - value is less than 5% at the 5% level of significance, then the null hypothesis (H01) should be rejected, and hence, we can accept the alternative hypothesis, that is, Ha1. The null hypothesis (H01) in the present case for the ADF test is that there is no stationarity in the returns of the futures prices of wheat. The Table 5 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of wheat are stationary as per the Augmented Dickey Fuller (ADF) Test. The Phillips - Perron (PP) test also proves stationarity in the data because *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices

of wheat are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship.

The Table 6 shows the values of ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and if the *p* - value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses H01 and H02 in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of barley, respectively. The Table 6 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses H01 and H02 are rejected. Therefore, the returns of the spot and futures prices of barley are stationary as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of barley are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 7 shows the values of ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* -value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of sugar, respectively. The Table 7 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (i.e. H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of sugar are stationary as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices

Table 7. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Sugar

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Sugar	ADF- test	Futures Price	Level	Intercept	-33.464	0.000	-1.024	-3.436	-2.864	-2.568
				Trend & intercept	-33.551	0.000	-1.027	-3.967	-3.414	-3.129
				None	-33.474	0.000	-1.024	-2.567	-1.941	-1.617
		Spot Price	Level	Intercept	-26.984	0.000	-1.953	-3.436	-2.864	-2.568
				Trend & intercept	-26.971	0.000	-1.953	-3.967	-3.414	-3.129
				None	-26.996	0.000	-1.953	-2.567	-1.941	-1.617
	PP- test	Futures Price	Level	Intercept	-33.465	0.000	-1.024	-3.436	-2.864	-2.568
				Trend & intercept	-33.562	0.000	-1.027	-3.967	-3.414	-3.129
				None	-33.474	0.000	-1.024	-2.567	-1.941	-1.617
		Spot Price	Level	Intercept	-61.139	0.000	-1.416	-3.436	-2.864	-2.568
				Trend & intercept	-61.103	0.000	-1.416	-3.967	-3.414	-3.129
				None	-61.174	0.000	-1.416	-2.567	-1.941	-1.617

Table 8. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Chili

Commodity	Test	Contracts	Model	Variables	*t*-test	*P*-value	Coefficient	1% level	5% level	10% level
Chilli	ADF- test	Futures Price	Level	Intercept	-28.786	0.000	-0.874	-3.436	-2.864	-2.568
				Trend & intercept	-28.773	0.000	-0.874	-3.967	-3.414	-3.129
				None	-28.784	0.000	-0.874	-2.567	-1.941	-1.617
		Spot Price	Level	Intercept	-24.916	0.000	-0.735	-3.436	-2.864	-2.568
				Trend & intercept	-24.911	0.000	-0.736	-3.967	-3.414	-3.129
				None	-24.908	0.000	-0.735	-2.567	-1.941	-1.617
	PP- test	Futures Price	Level	Intercept	-29.054	0.000	-0.874	-3.436	-2.864	-2.568
				Trend & intercept	-29.041	0.000	-0.874	-3.967	-3.414	-3.129
				None	-29.056	0.000	-0.874	-2.567	-1.941	-1.617
		Spot Price	Level	Intercept	-24.953	0.000	-0.735	-3.436	-2.864	-2.568
				Trend & intercept	-24.946	0.000	-0.736	-3.967	-3.414	-3.129
				None	-24.987	0.000	-0.735	-2.567	-1.941	-1.617

Table 9. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Maize

Commodity	Test	Contracts	Model	Variables	*t*-test	*P*-value	Coefficient	1% level	5% level	10% level
Maize	ADF- test	Futures Price	Level	Intercept	-31.4511	0.0000	-0.9632	-3.4363	-2.8640	-2.5682
				Trend & intercept	-31.4528	0.0000	-0.9637	-3.9667	-3.4140	-3.1291
				None	-31.4578	0.0000	-0.9629	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-37.6615	0.0000	-1.1411	-3.4363	-2.8640	-2.5681
				Trend & intercept	-37.7021	0.0000	-1.1427	-3.9667	-3.4140	-3.1291
				None	-37.6075	0.0000	-1.1392	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-31.5296	0.0000	-0.9632	-3.4363	-2.8640	-2.5682
				Trend & intercept	-31.5278	0.0000	-0.9637	-3.9667	-3.4140	-3.1291
				None	-31.5378	0.0000	-0.9629	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-37.3109	0.0000	-1.1411	-3.4363	-2.8640	-2.5681
				Trend & intercept	-37.3316	0.0000	-1.1427	-3.9667	-3.4140	-3.1291
				None	-37.2821	0.0000	-1.1392	-2.5671	-1.9411	-1.6165

of sugar are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 8 shows the values of ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and if the *p* -value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of chili, respectively. The Table 8 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of chili are stationary as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of chili are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 9 shows the values of the ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* -value is less than 5% at 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of maize, respectively. The Table 9 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of maize are stationary (Ha1 and Ha2 are accepted) as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in PP Test are less than 0.05 in both returns of the prices of the spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of maize are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 10 shows the values of the ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p*- value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected. Hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of pepper, respectively. The Table 10 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (H01 and H02) are rejected. Therefore, both the alternative hypotheses (H01 and H02) are accepted, and hence, the returns of the spot and futures prices of pepper are stationary as per the Augmented Dickey Fuller (ADF) Test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

Table 10. Unit Root Tests (ADF and PP test) on Returns of Spot and Futures Prices of Pepper

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Pepper	ADF- test	Futures Price	Level	Intercept	-30.1089	0.0000	-0.9187	-3.4363	-2.8640	-2.5681
				Trend & intercept	-30.1721	0.0000	-0.9212	-3.9667	-3.4140	-3.1291
				None	-30.0731	0.0000	-0.9170	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-27.4152	0.0000	-0.8250	-3.4363	-2.8640	-2.5681
				Trend & intercept	-27.4255	0.0000	-0.8261	-3.9667	-3.4140	-3.1291
				None	-19.1728	0.0000	-0.7460	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-30.0932	0.0000	-0.9187	-3.4363	-2.8640	-2.5681
				Trend & intercept	-30.1425	0.0000	-0.9212	-3.9667	-3.4140	-3.1291
				None	-30.0659	0.0000	-0.9170	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-29.2440	0.0000	-0.8250	-3.4363	-2.8640	-2.5681
				Trend & intercept	-29.2249	0.0000	-0.8261	-3.9667	-3.4140	-3.1291
				None	-29.4531	0.0000	-0.7460	-2.5671	-1.9411	-1.6165

Table 11. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Soybean

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Soybean	ADF- test	Futures Price	Level	Intercept	-30.1089	0.0000	-0.9187	-3.4363	-2.8640	-2.5681
				Trend & intercept	-30.1721	0.0000	-0.9212	-3.9667	-3.4140	-3.1291
				None	-30.0731	0.0000	-0.9170	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-27.4152	0.0000	-0.8250	-3.4363	-2.8640	-2.5681
				Trend & intercept	-27.4255	0.0000	-0.8261	-3.9667	-3.4140	-3.1291
				None	-19.1728	0.0000	-0.7460	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-30.0932	0.0000	-0.9187	-3.4363	-2.8640	-2.5681
				Trend & intercept	-30.1425	0.0000	-0.9212	-3.9667	-3.4140	-3.1291
				None	-30.0659	0.0000	-0.9170	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-29.2440	0.0000	-0.8250	-3.4363	-2.8640	-2.5681
				Trend & intercept	-29.2249	0.0000	-0.8261	-3.9667	-3.4140	-3.1291
				None	-29.4531	0.0000	-0.7460	-2.5671	-1.9411	-1.6165

Table 12. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Mustard-seed

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Mustard Seed	ADF- test	Futures Price	Level	Intercept	-32.1301	0.0000	-0.9835	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.1297	0.0000	-0.9839	-3.9667	-3.4140	-3.1291
				None	-32.1314	0.0000	-0.9830	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-32.9616	0.0000	-1.0090	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.9789	0.0000	-1.0100	-3.9667	-3.4140	-3.1291
				None	-32.9294	0.0000	-1.0076	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-32.1298	0.0000	-0.9835	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.1294	0.0000	-0.9839	-3.9667	-3.4140	-3.1291
				None	-32.1310	0.0000	-0.9830	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-32.9616	0.0000	-1.0090	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.9789	0.0000	-1.0100	-3.9667	-3.4140	-3.1291
				None	-32.9294	0.0000	-1.0076	-2.5671	-1.9411	-1.6165

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of pepper are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 11 shows the values of ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* -value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of soybean, respectively. The Table 11 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of soybean are stationary as per the Augmented Dickey Fuller (ADF) Test. The Phillips - Perron (PP) test also proves stationarity in the data because

the *p* - values in the PP Test are less than 0.05 in both returns of the prices of the spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that series are co-integrated. Given that the spot and futures prices of soybean are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 12 shows the values of ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* - value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of mustard seed, respectively. The Table 12 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses are rejected. Therefore, the alternative hypotheses (H01 and H02) are accepted ; hence, the returns of the spot and futures prices of mustard seed are stationary as per the Augmented Dickey Fuller (ADF) Test. The Phillips - Perron (PP) test also proves stationarity in the data because *p* - values in the PP Test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of mustard seed are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 13 shows the values of the ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* -value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of turmeric, respectively. The Table 13 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of turmeric are stationary as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because

Table 13. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Turmeric

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Turmeric	ADF- test	Futures Price	Level	Intercept	-32.2614	0.0000	-0.9866	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.2811	0.0000	-0.9876	-3.9667	-3.4140	-3.1291
				None	-32.2676	0.0000	-0.9863	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-24.3770	0.0000	-0.7155	-3.4363	-2.8640	-2.5681
				Trend & intercept	-24.4363	0.0000	-0.7182	-3.9667	-3.4140	-3.1291
				None	-24.3756	0.0000	-0.7150	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-32.2614	0.0000	-0.9866	-3.4363	-2.8640	-2.5681
				Trend & intercept	-32.2839	0.0000	-0.9876	-3.9667	-3.4140	-3.1291
				None	-32.2675	0.0000	-0.9863	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-25.7107	0.0000	-0.7155	-3.4363	-2.8640	-2.5681
				Trend & intercept	-25.7074	0.0000	-0.7182	-3.9667	-3.4140	-3.1291
				None	-25.7174	0.0000	-0.7150	-2.5671	-1.9411	-1.6165

Table 14. Unit Root Tests (ADF and PP Test) on Returns of Spot and Futures Prices of Chana

Commodity	Test	Contracts	Model	Variables	*t*-test	*p*-value	Coefficient	1% level	5% level	10% level
Chana	ADF- test	Futures Price	Level	Intercept	-33.1962	0.0000	-1.0161	-3.4363	-2.8640	-2.5681
				Trend & intercept	-33.1847	0.0000	-1.0162	-3.9667	-3.4140	-3.1291
				None	-33.2103	0.0000	-1.0161	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-24.3278	0.0000	-1.0103	-3.4363	-2.8640	-2.5682
				Trend & intercept	-24.4183	0.0000	-1.0154	-3.9667	-3.4140	-3.1291
				None	-24.3265	0.0000	-1.0096	-2.5671	-1.9411	-1.6165
	PP- test	Futures Price	Level	Intercept	-33.1980	0.0000	-1.0161	-3.4363	-2.8640	-2.5681
				Trend & intercept	-33.1865	0.0000	-1.0162	-3.9667	-3.4140	-3.1291
				None	-33.2121	0.0000	-1.0161	-2.5671	-1.9411	-1.6165
		Spot Price	Level	Intercept	-30.4836	0.0000	-0.9300	-3.4363	-2.8640	-2.5681
				Trend & intercept	-30.5007	0.0000	-0.9324	-3.9667	-3.4140	-3.1291
				None	-30.4999	0.0000	-0.9297	-2.5671	-1.9411	-1.6165

Table 15. Johansen's Co-integration Test of All Selected Agricultural Commodities

Commodities	Test	Trace Statistic	Critical Value	*p* - value
Wheat	Trace- test	665.24	15.49	0.0001
	Max Eigen- test	480.47	14.26	0.0001
Sugar	Trace- test	519.91	15.49	0.0001
	Max Eigen- test	303.32	14.26	0.0001
Barley	Trace- test	625.47	15.49	0.0001
	Max Eigen- test	421.73	14.26	0.0001
Chili	Trace- test	354.40	15.49	0.0001
	Max Eigen- test	217.79	14.26	0.0001
Turmeric	Trace- test	335.48	15.49	0.0001
	Max Eigen- test	192.93	14.26	0.0001
Pepper	Trace- test	318.08	15.49	0.0001
	Max Eigen- test	197.56	14.26	0.0001
Maize	Trace- test	319.17	15.49	0.0001
	Max Eigen- test	165.56	14.26	0.0001
Soybean	Trace- test	328.95	15.49	0.0001
	Max Eigen- test	199.22	14.26	0.0001
Mustard-seed	Trace- test	395.00	15.49	0.0001
	Max Eigen- test	208.61	14.26	0.0001
Chana	Trace- test	374.86	15.49	0.0001
	Max Eigen- test	195.12	14.26	0.0001

the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of turmeric are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 14 shows the values of the ADF and PP test statistic. If the *t* - test statistic is more than the critical values (in absolute terms, that is, ignoring negative signs) and the *p* -value is less than 5% at the 5% level of significance, then the null hypothesis should be rejected and hence, we can accept the alternative hypothesis. The null hypotheses (H01 and H02) in the present case for the ADF test are that there is no stationarity in the returns of the futures and spot prices of chana, respectively. The Table 14 exhibits that the *p* - values in case of returns of both the futures and spot prices are less than 5% at the 5% level of significance. Hence, both the null hypotheses (H01 and H02) are rejected. Therefore, the returns of the spot and futures prices of chana are stationary as per the Augmented Dickey Fuller (ADF) test. The Phillips - Perron (PP) test also proves stationarity in the data because the *p* - values in the PP test are less than 0.05 in both returns of the prices of spot and futures market. Hence, our results of stationarity are robust.

As per the theory of co-integration, if there are two non-stationary time series and these become stationary when differenced, then it can be concluded that the series are co-integrated. Given that the spot and futures prices of chana are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship. Hence, the Johansen test can be used.

The Table 15 summarizes the results of Johansen co-integration test. The null hypothesis H03 states that there is no co-integration equation among the returns of the spot and futures prices of the selected commodities. The Table 15 first exhibits that the *p* - value in case of all the commodities is 0.0001 at the 5% level of significance, which is less than 0.05. Hence, the null hypothesis H03 for all the commodities must be rejected. Hence, the alternative hypothesis Ha3 is accepted. Therefore, there is a co-integration between the spot and futures prices of all the commodities. Second, trace statistic and Max Eigen values are more than the critical value. The trace test also indicates that two co-integration equations at the 5 % level of significance show long run equilibrium between futures and spot prices of the all commodities. The results of max-eigen statistic point out the rejection of H03 at 0.05 critical values, which shows that there are co-integration vectors. Another way of examining whether the futures prices of selected agricultural commodities have a long-run relationship with spot prices of commodities. is by using the Max- Eigen statistic. The Max- Eigen statistic also indicates that there are two co-integration equations at the 5% level of significance, and it tells about the long run stability between futures and spot prices of commodities. In their study, Babu and Srinivasan (2014) also concluded that spot prices of the selected 10 commodities had no influence on their futures prices. Johansen's co-integration test results revealed that the spot prices of the selected sample commodities had no influence on their futures prices (Babu & Srinivasan, 2014).

The Table 16 depicts the results of the Granger causality test. This test depends upon the *p* - value. If the *p*-value is less than 5%, it shows that there is uni-directional relationship between futures and spot prices of the commodities including wheat, chili, turmeric, and mustard-seed. The Table 16 shows that Granger causality exits between the futures and spot prices of commodities like sugar, barley, pepper, maize, soybean, and chana. Hence, there is no bi-directional relationship between spot and futures prices of commodities.

Discussion, Conclusion, and Implications

We focused on investigating the dynamic linkage between futures and spot prices of the commodities including wheat, barley, sugar, chili, maize, pepper, soybean, mustard-seed, and chana. This study analyzes the long run relationship between futures and spot prices of commodities. The volatility of futures prices of the commodities in

Table 16. Paired Granger Causality Test of All Selected Agricultural Commodities

Commodity	Null Hypothesis:	Observations	*F*-Statistic	Prob.
Wheat	SPOT does not Granger Cause FUTURES	2130	3.5210	0.0299
	FUTURES does not Granger Cause SPOT		0.0438	0.9571
Sugar	SPOT does not Granger Cause FUTURES	2130	0.1202	0.8867
	FUTURES does not Granger Cause SPOT		0.3429	0.7098
Barley	SPOT does not Granger Cause FUTURES	2130	0.5874	0.5559
	FUTURES does not Granger Cause SPOT		1.1318	0.3229
Chili	SPOT does not Granger Cause FUTURES	2130	12.0260	0.0000
	FUTURES does not Granger Cause SPOT		1.9737	0.1395
Turmeric	SPOT does not Granger Cause FUTURES	2130	3.5355	0.0295
	FUTURES does not Granger Cause SPOT		1.4519	0.2346
Pepper	SPOT does not Granger Cause FUTURES	2130	0.0733	0.9294
	FUTURES does not Granger Cause SPOT		0.5698	0.5658
Maize	SPOT does not Granger Cause FUTURES	2130	0.0738	0.9289
	FUTURES does not Granger Cause SPOT		0.8070	0.4465
Soybean	SPOT does not Granger Cause FUTURES	2130	0.0953	0.9091
	FUTURES does not Granger Cause SPOT		0.6568	0.5187
Mustard-seed	SPOT does not Granger Cause FUTURES	2130	0.0504	0.9509
	FUTURES does not Granger Cause SPOT		3.9500	0.0195
Chana	SPOT does not Granger Cause FUTURES	2130	0.5599	0.5715
	FUTURES does not Granger Cause SPOT		0.1284	0.8795

terms of standard deviation *(SD)* as percentage (%) of means is highest in case of barley (9.9%) and is lowest in case of sugar (0.93%), which means in case of barley, prices are highly volatile in comparison to the other nine agricultural commodities. The volatility of spot prices of commodities in terms of standard deviation *(SD)* as percentage (%) of means is highest in case of wheat (10.15%) and lowest in case of pepper (0.94%), which means that in the spot market, wheat prices are highly volatile in comparison to the remaining nine agricultural commodities.

The analysis reveals that futures prices of wheat have the most efficient relationship as compared to nine other commodities, in which most of the commodities have a positive relationship except maize and chana. Spot prices of sugar have the most efficient relationship out of all spot prices of commodities. The ADF and PP test enabled us to check the stationarity of the data. We checked the data on level and first difference to check the time series data of stationarity. There are two co-integration relationships between futures and spot prices of all the 10 commodities. It means that in the long run, the movements in the futures prices are tied to spot prices. The results of the Granger causality test show that there is unidirectional relationship between futures and spot prices of commodities including wheat, chili, turmeric, and mustard-seed. Rest of the commodities do not Granger cause the spot and futures prices including those of sugar, barley, pepper, maize, soybean, and chana.

The futures prices of the commodities have some price discovery function in the spot market of the agricultural commodities in India. Although there is a difference between the spot and futures prices of the commodities, still both are related to each other in the long term. Therefore, farmers can use futures to manage the risk of price movement. But the difficulty in this process is that most of the farmers do not have the knowledge of this market. Therefore, it will be beneficial to make them aware about the market along with the promotion of the market

makers who can trade on behalf of the farmers and improve the price discovery process in the Indian commodities market.

The findings of the study have important policy and regulatory implications for the Indian commodity futures market because there is a significant change in the demand and supply of the commodities under consideration, especially due to rising demand from emerging economies, alternative uses of commodities, supply constraints, and low productivity and weather conditions. Besides these changes, the number of financial investors are also increasing in emerging markets like India (because of financial literacy and many more factors), and all these factors have changed the commodity derivatives market structure. In this way, the findings of the study will be useful to know more about the functioning of the Indian commodity futures market by providing an efficient price discovery mechanism and the ability of the market to mitigate the unexpected price movements. The study will also be helpful to the investors and other market participants to understand the mechanism of the Indian commodity futures market.

Limitations of the Study and Scope for Future Research

The present study is limited to only 10 selected agricultural commodities. This can be further extended to more agricultural commodities and also to non - agricultural commodities. Secondly, the data used in the present study is the daily closing prices of the commodities, which can be extended to high frequency data. The inter market co-integration relationships can also be tested - like commodities market volatility vis-a-vis the volatility of stock market can be a subject of future research. FMCs (futures market contract) must plan for a long term investor education strategy as a well-informed investor base can create greater trading liquidity and can help in avoiding price manipulations. That is why the FMC must make a plan for investor education.

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