Journal of Commerce and Accounting Research
13 (2) 2024, 77-86
http://publishingindia.com/jcar/
doi: https://doi.org/10.21863/jcar/2024.13.2.007

Submitted: 14 February, 2023
Accepted: 02 June, 2023

PRICE DISCOVERY AND VOLATILITY SPILLOVER: AN EMPIRICAL ANALYSIS OF INDIAN FUTURES-SPOT CARDAMOM MARKETS

Sonia Garg*, Karam Pal Narwal**

Abstract *Price discovery and its related volatility spillover effect are significant indicators in commodity derivatives market to hedge the risk against sharp price fluctuations. This study empirically analyses the price discovery and volatility spillover using vector error correction model, Granger causality and bivariate exponential GARCH model (EGARCH) in Indian cardamom spot-futures markets. Daily time series data of spot market and near month futures contracts spanning the period from January 2009 to December 2020 have been used for the study. These price series data are based on the authenticated sources of Multi Commodity Exchange. The results of vector error correction model supported by Granger causality test indicates that spot market plays the role of leader as it is more efficient in reflecting the new information to prices. The results of bivariate EGARCH (1,1) model show that volatility spillover from cardamom spot market to futures market is dominant.*

Keywords: *Volatility Spillover, Price Discovery, Cardamom, MCX*

INTRODUCTION

The phenomenon of price discovery and its related volatility spillover effect for various commodities have received much attention from investors, economists, financial analysts and market regulators because commodities have high price fluctuations. These price fluctuations threaten about the price risk and drive the demand for hedging this risk in various commodities markets. Derivatives are those specialised instruments which help in hedging the risk against such sharp price fluctuations. The introduction of the derivative market segment was done to increase market liquidity (Kumar & Kasilingam, 2012). That's why, the use of derivative products like futures, forward and options have grown rapidly over the globe. Futures are most used derivatives instrument in commodities markets due to the pivotal role performed by it such as risk transfer and price discovery (Inani, 2018). A futures contract is an agreement to deliver a certain standardised commodity of pre-determined amount at a pre-agreed future date, at a pre-determined price. The price discovery includes the meaning that a price in one market (say futures market) will help in predicting the price of other market (spot market) (Kim & Lim, 2019). The essence of the price discovery process depends on whether the new information is reflected first in changes of spot prices or changes of futures prices (Srinivasan & Ibrahim, 2012). According to efficient market hypothesis, any new piece of information is impounded in both futures market as well as spot market simultaneously. But, in reality, due to some market imperfections (like higher transaction cost, liquidity, short selling and margin requirements), one market may react more quickly to new information than the other market establishing lead lag relationship (Tse, 1999). Tan and Lim (2001) and Daigler (1990) also explained, through infrequent trading hypothesis and liquidity factor, one market leads the other market.

Apart from price discovery, volatility is also a significant source of information. Due to the growing importance of financial markets in the global economy, volatility spillover has recently attained a high level of significance (Desai & Joshi, 2021). Ross (1989) also argued that rate of flow of information is directly related to the volatility. The increase in the flow of information in a particular market causes the increase in the volatility which further initiates the arbitrage

* Haryana School of Business, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, India.
Email: soniagarg569@gmail.com
** Professor, Haryana School of Business, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, India.
Email: karampalhsb@gmail.com

process leading to spillover of volatility in the other related market as well (Malhotra & Sharma, 2016). Thus, the study of volatility spillover between two markets, the process through which volatility of one market impacts that of other market, furthers the understanding of information dissemination in financial markets. Further, if there is spillover of volatility between the markets, then the market which transmits the volatility may be employed by market agents to cover the risk exposure that they face (Kavussanos & Visvikis, 2004).

Most studies on price discovery and spillover effect have been conducted in developed markets and shown that futures markets dominate the price discovery and volatility spillover mechanism by assimilating new information more quickly than the spot market. However, in emerging markets like India where commodity futures market are in their nascent stage, have somewhat different characteristics as compared to developed countries. Emerging markets are distinguished from developed markets by small sample size, thin trading volume, lower liquidity, higher volatility of returns, policy restrictions, less developed spot markets and other market frictions.

Thus far, the work on the issue of price discovery and volatility spillover in emerging economies like India is limited especially in agricultural commodities (Parsa & Mallikarjunappa, 2014; Manogna & Mishra, 2020). Further, the emphasis of the previous work on agricultural commodity market in India is mainly on food crops and to the best of our knowledge, there is hardly any attempt to analyse the price discovery and volatility spillover in cardamom which belongs to plantation sector. There are few agricultural commodities that have a trading frequency with satisfactory trading volume trading on national exchanges. The cardamom futures contract is one such contract and has been traded on the Multi Commodity Exchange since 2006. Cardamom is popularly referred as queen of spices because of its sweet and pleasant aroma. Cardamom is one of the most highly valued and exotic spice in the world. Cardamom finds its place in every kitchen of the world. It also finds a significant usage in medical properties both Ayurveda and Allopathy, as it has healing properties in dental infections and digestive disorders, etc. It is a perennial, herbaceous and rhizomatous plant and cultivated in the evergreen forests on the Western Ghats of South India. Two types of cardamom are grown in India, namely, large and small cardamom. Small green cardamom which is also known as Elettaria cardamom is traded on MCX.

India was the world's largest producer till 2000. Now, Gautemala is the world's largest producer of cardamom followed by India. India's total production was around 20640 MT and it exported 5680 MT in 2017–18. Gautemala is the world leader in cardamom export followed by India. Saudi Arabia is the largest importer for the Indian cardamom with a share of about 55% followed by UAE, Kuwait and USA. Cardamom has remarkable influence in the international market.

Cardamom crop is subjected to high price fluctuations and highly sensitive to weather (www.mcx.com) which threatens its stakeholders (planters, growers, traders, exporters and retailers) about price risk. They want to hedge their risk using futures markets. Therefore, present study attempts to analyse price discovery and volatility spillover in Indian cardamom market. This study has five major motivations. First, there is hardly any attempt to analyse the price discovery process and volatility spillover in Indian cardamom. Second, the market structure and price discovery mechanism of cardamom is entirely different. The effectiveness of futures market in price discovery can very accordingly (across different products depending upon product characteristics). Third, the available studies on this phenomenon have shown mixed and contradictory results. Fourth, employing a combination of both vector error correction model (VECM) and bivariate exponential GARCH (EGARCH) models, while most of the studies on price discovery and volatility spillover in Indian context, have been individually on the price discovery and volatility spillover. Fifth, the present study considers a fairly longer study period as compared to the prior research of the subject. This study analyses the price discovery process and volatility spillovers in Indian cardamom spot and futures market by addressing the following research questions: (1) Is futures markets are useful in price discovery of spot markets?; and (2) Is there exist a volatility spillover from futures to spot market and vice-versa?

The empirical results show that spot market leads the price discovery process and also spills over the volatility to the futures market. The findings of the study have significant implications for investors, traders, exporters, retailers, consumers, financial economist and policymakers. They may use spot prices to formulate efficient hedging strategies. Besides, it gives useful insights to the arbitrageurs, who are formulating their trading strategies based on market imperfections.

This paper is structured as follows: Second section briefly explains the reviewed literature. The third section describes the data sources and research methodology. Fourth section discusses the results. Conclusion and policy implications are presented in Fifth section.

LITERATURE REVIEW

Issue of price discovery and volatility has been studied mainly in either developed countries or equity market. Studies on this issue in emerging economies like India are limited especially in agricultural commodities (Parsa & Mallikarjunappa, 2014). Some of the studies from developed countries and equity markets are briefly reviewed in the following section. Garbade and Silber (1983) is one of the most cited studies that has developed a model of simultaneous price dynamics to examine the price discovery process for seven storable commodities including four agricultural commodities traded on CBOT and COMEX. Using daily futures and spot prices of selected commodities, they observed that futures drive the spot markets for majority of commodities. Further, the same model is re-examined by Moosa (2002) to examine the price discovery function in crude oil market. Using daily prices, he revealed that 60% function of price discovery is performed by the futures market. Moreover, Yang et al. (2001) applied VECM to study the price discovery process of futures market in USA for six storable and three non-storable commodities and showed that futures markets lead the spot markets. Also, Liu and Zhang (2006) studied price discovery process and volatility spillovers in futures and spot market of China. They found that price discovery is dominates by futures market. Besides, EGARCH model showed that volatility spillovers from futures market to spot market is more significant than vice versa. Ferretti and Gonzalo (2010) modeled and measured the price discovery in non-ferrous metals traded on London Metal Exchange (LME) and suggested that price discovery takes place in highly liquid futures markets. Very recently, Kim and Lim (2019) examined price discovery and spillover effect in steel-related commodities in China using VECM and EGARCH model. The results proved that futures prices play lead role in the price discovery. The results also confirmed that volatility spillovers from futures to spot market. However, rebar market is an exception to this finding. Studies related to developed countries and markets tend to show that futures markets play a lead role in price discovery and volatility spillover.

Empirical studies related to price discovery is very scant in India. Further, the studies conducted on price discovery in India have shown mixed results. In this framework, Kumar (2004) has analysed the price discovery and efficiency in five agricultural commodities traded on six different commodity exchanges in India. By applying ratio of standard deviations and Johansen cointegration technique on daily prices, the author found that Indian agriculture futures markets are inefficient to fully incorporate the fundamental information. Further, Chopra and Bessler (2005) explored the price discovery for black pepper traded on India Pepper and Spice Trade Association (IPSTA). To detect the market where the price takes place, authors have utilised the cointegration model, vector error correction model, forecast error variance decompositions and directed acyclic graph. They found that prices of pepper are discovered in futures market. Further, they concluded that directed acyclic graph are new and useful to study the causal pattern in the economics. To assess the price discovery in Indian agricultural commodity market for pepper, chana and guar seed, Elumalai et al. (2009) applied cointegration test and VECM model. The results of the study revealed that futures prices influence the spot prices of these agricultural commodities and hence, price discovery takes place in futures market. It was also found that futures prices indicate a better hedging efficiency for producers. Moreover, Sehgal et al. (2012) examined the price discovery in ten agriculture commodities by applying cointegration test, Variance decomposition analysis and Granger causality test for the period from 2003 to 2012. Their findings ensure the lead role of futures in price discovery of all selected commodities except turmeric. For turmeric, the results are different as no cointegration is revealed in this market. By using the same methods, Dey and Maitra (2012) explored the price discovery in pepper traded on National Multi Commodity Exchange. Using the daily observations from 2006 to 2010, authors arrived at the conclusion that pepper futures market contained informational and operational efficiency. The above mentioned studies suggest that futures market plays a dominant role in price discovery.

There is also an evidence of spot market plays the lead role in price discovery. Quan (1992), in his research, investigated the role of futures prices in price discovery of crude oil by following a two-step procedure. The study has analysed the data ranging from 1984 to 1989 using cointegration test, Granger causality test, Garbade and Silber approach and error correction model. Cointegration relationship between the price series is revealed in the first step and direction of causality is tested in the second step. The study found that spot prices and one-month and three-month ahead futures prices are cointegrated. Therefore, the further analysis was done for the three price series. He found that futures market is dominated by spot market. Further, Thenmozhi and Thomas (2007) studied price discovery in spot and S&PCNX Nifty futures market analysing the data from 2000 to 2005 using VECM-SURE model, impulse response analysis and information share. The results of the study showed that price discovery happens in the spot market. Srinivasan and Ibrahim (2012) studied the process price discovery in Indian gold market using daily spot and futures prices extracted from the NCDEX. They showed that gold's spot market dominate the price discovery process of Indian gold market. Additionally, the study reveal that gold's futures market is not yet matures and efficient. Vijyakumar et al. (2012) analysed the relationship between futures and spot market for five agricultural commodities using cointegration test and VECM over a period from 2008 to 2010. Their results showed that spot market drive the futures market for most of the commodities. The above discussed studies found a lead in the spot market which implies that price is being discovered first in that market. However, another set of researchers observed bidirectional relationship between futures and spot markets (Shakeel & Purankar, 2014; Purohit et al., 2016).

As discussed earlier, most studies on the price discovery and volatility spillover have focused on either developed countries or equity market (Liu & Zhong, 2006; Thenmozhi & Thomas, 2007; Srinivasan, 2011). Literature for volatility spillover in commodity market in Indian context is inadequate. Moreover, almost studies have centered on nonagricultural commodity markets (Behmiri & Manera, 2015). Srinivasan (2011) studied the price discovery and volatility spillover in four commodity indices of MCX for the period from 2005 to 2010. By employing bivariate EGARCH model, he found that spillover of volatility from spot to futures market is dominant for all indices. Sehgal et al. (2013) studied the twelve commodities and four indices traded on MCX to know the effect of introduction of futures on the spot market volatility. They employed bivariate EGARCH model for the empirical analysis of data ranging from 2003 to 2011 and confirmed that volatility spillover exist for three commodities only. Further, the study confirmed that no volatility spillover is observed for indices. Mahalik et al. (2014) also investigated the price discovery and volatility spillover for four indices of MCX using EGARCH model. Analysing the data from 2005 to 2008, they revealed that volatility spillover from futures to spot market is dominant in aggregate commodity index and energy index but not that of agriculture price index. Further, they showed that no cointegration relationship is found between metal's spot price index and futures price index. Bahera (2016) investigated the price discovery and spillover impact in futures and spot market of gold, silver and copper for the period from 2005 to 2016 using multivariate GARCH (BEKK) model. It was empirically observed that there exist bidirectional spillover impact for gold and silver and copper. Arora and Chander (2017) examined the price efficiency and volatility for four agricultural commodities (Chana, Kapas, Castor Seed and Turmeric) traded on NCDEX and showed that spillovers of volatility occur from futures markets to spot markets. Rout et al. (2019) examined volatility spillover effect in Indian commodity market focusing on agriculture and metal commodity segment during the period from 2010 to 2015. By using impulse response analysis, the study found that there exist bidirectional volatility spillover in both agricultural and metal commodities. Further, the study showed that though there exist bidirectional volatility spillover but the magnitude of spillover of volatility from futures to spot is more in agricultural commodities while the magnitude of volatility spillover from spot to futures is more for metal commodities. Furthermore, Manogna and Mishra (2020) empirically investigated the price discovery and volatility spillover in nine most liquid agricultural commodities which are traded on NCDEX and revealed the existence of mutual spillover effect on spot and futures markets. Thus, there are a very few studies that have made an attempt to study the price discovery and volatility spillovers in Indian commodity market especially in agricultural commodities.

An extensive literature review reveal that studies on the issue of price discovery and volatility spillover in commodity market in India are still limited. Moreover, the available studies have shown mixed and contradictory results; for example, Thenmozhi and Thomas (2007) and Srinivasan (2011) showed that volatility spillovers from spot to futures market. On the contrary, Mahalik et al. (2014), Bahera (2016), Arora and Chander (2017) and Manogna and Mishra (2020) found that volatility spillovers from futures to spot market. Owing to the importance of cardamom to the Indian economy and contradictory findings regarding price discovery and volatility spillover, there is a need to revisit the debate on the price discovery and volatility spillovers in Indian cardamom market. Most of the studies on price discovery and volatility spillover in Indian context have been individually on the price discovery and volatility spillover. This study has used a combination of both VECM and EGARCH model.

DATA SOURCE AND RESEARCH METHODOLOGY

This study has considered the spot and near month futures contracts of cardamom traded on Multi Commodity exchange of India Ltd. to explore the price discovery and volatility spillover. Time series data ranging from January 2009 to December 2020 have been obtained from the official website of MCX. Data has been analysed with the help of Microsoft Excel 2007 and E-views 2010 econometric software package. This section is subdivided into four categories to analyze the price discovery and volatility spillover between futures and spot markets. Firstly, price series are converted into log returns and tested for the stationarity. After stationarity, we check for possible cointegration between futures and spot price series to understand the long run association between them. After cointegration test, we proceed to model the prices applying a VECM and Granger causality test. At last EGARCH model is used to study the volatility spillovers between the markets.

Stationary Test

Regressing non stationary time series may produce spurious results. Hence, it is mandatory to check the stationarity of the futures and spot price series. Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) test have been conducted to check the stationarity of price series. They also help to determine the order of integration of the price series of selected commodity. These tests are based on the null hypothesis that the given price series has unit root (non-stationary). The ADF test equation is presented as:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

The PP test equation is specified as

$$\Delta Y_t = \delta Y_{t-1} + \beta_i D_{t-I} + \varepsilon_t \quad (2)$$

On the basis of these test, if the price series are found to be non-stationary at levels, then the series are transformed to make them stationary. The series are transformed by taking their first difference or log returns.

Cointegration Test

Given that futures and spot price series of cardamom are integrated of order one, that is, I(1), then the Johansen cointegration test proposed by Johansen and Juselius (1990) and Johansen (1991) can be applied to perform the cointegration analysis. This test is very sensitive to lag length selection. For lag selection VAR test has been applied. The optimal lag length is determined as per Akaike information criterion (AIC). This test is used to study the long run relationship between the price series of commodities. Johansen and Juselius (1990) have suggested the two likelihood ratio tests, that is, trace test and maximum eigenvalue test which are used to test the cointegration between series.

The null hypothesis of 'at most r cointegrating vectors' is tested against the alternative hypothesis of 'more than r cointegrating vectors' by trace test statistic:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (3)$$

the null hypothesis of 'r cointegrating vector' is tested against the alternative hypothesis of 'r + 1' by maximum eigenvalue test statistic :

$$\lambda_{max} = T \ln(1 - \hat{\lambda}_{r+1}) \quad (4)$$

If r=0, then in case of trace test statistic, the null hypothesis cannot be rejected. In this case, it can be conclude that there is no cointegration. In case of maximum eigenvalue statistic, if r=1 then the null hypothesis is not rejected. If r=0 then the null hypothesis for maximum eigenvalue statistic is rejected. In this case, we can conclude that there exists a cointegration relationship.

Vector Error Correction Model and Granger Causality Test

After confirming that spot and futures price series are cointegrated as per cost-of-carrying relationship, this study used the vector error correction model (VECM) to examine the lead lag dynamics. According to cost-of-carrying relationship, spot and futures prices are cointegrated with a common stochastic trend that is, cointegrated with one cointegrating vector (Koutmos & Tucker, 1996). This common stochastic trend is described as the common efficient price in the cointegrating system by Hasbrouck (1995). The bivariate cointegrated series, Pt = (St, Ft), have the following VECM representation:

$$\Delta S_t = \alpha_S + \lambda_S Z_{t-1} + \sum_{i=1}^{m} \beta_{Si} \Delta S_{t-i} + \sum_{i=1}^{m} \gamma_{Si} \Delta F_{t-i} + \varepsilon_{St} \quad (5)$$

$$\Delta F_t = \alpha_F + \lambda_F Z_{t-1} + \sum_{i=1}^{m} \beta_{Fi} \Delta F_{t-i} + \sum_{i=1}^{m} \gamma_{Fi} \Delta S_{t-i} + \varepsilon_{Ft} \quad (6)$$

$$Z_{t-1} = S_{t-1} - b_i F_{t-1} \quad (7)$$

Where, S_t and F_t are the daily prices of spot and futures markets, α_S and α_F are the intercepts in VECM and β_{Si}, γ_{Fi}, β_{Fi}, γ_{Si} are short run coefficients. λ_S and λ_F are speed of adjustment coefficients of spot and futures markets and the magnitude of the coefficients determine the speed at which discrepancy from long run relationship is corrected through the short run adjustments in futures and spot prices. Z_{t-1} is the error correction term. Vector error correction model helps to understand the characteristics of long run equilibrium relationship and short run adjustment process. For ECM model, at least one of the coefficient, that is, either λ_S or λ_F must be non-zero.

Granger causality test is also used to investigate whether futures (spot) prices can be better predicted with the past values of both futures and spot prices than those of only futures (spot) prices.

EGARCH Model

An attempt has been made to examine the pattern of the volatility of daily returns of cardamom spot and futures market in the Indian context. Bivariate EGARCH (1,1) model is used to know how information from one market affects the volatility behaviour of another market. Although the GARCH-type models are popular for modeling the volatility process in financial series, the empirical results investigated provide evidence that the EGARCH model can more accurately explain the volatility dynamics (Srinivasan, 2012). A negative condition variation is generally suggested by a simple GARCH model which is not suitable for further inferences. These weaknesses of GARCH model can be overcome by using Nelson's (1991) EGARCH model. Thus, the bivariate EGARCH (1,1) model is used to examine the spillover of volatility between spot and futures prices of cardamom.

This model can be represented as follows:

$$\ln\left(\sigma_{f,t}^{2}\right) = \sigma_f + \omega_f \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right| + \gamma_f \ln\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \alpha_f \ln\left(\sigma_{2,t-1}^{2}\right) + \nu_f \ln\left(\varepsilon_{s,t-1}^{2}\right) \qquad (8)$$

$$\ln\left(\sigma_{s,t}^{2}\right) = \sigma_s + \omega_s \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right| + \gamma_s \ln\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \alpha_s \ln\left(\sigma_{2,t-1}^{2}\right) + \nu_s \ln\left(\varepsilon_{f,t-1}^{2}\right) \qquad (9)$$

Where, the uncorrelated residuals $\varepsilon_{f,t-1}$ and $\varepsilon_{s,t-1}$ are obtained from equation (5) and (6). The existence of spillover of volatility is showed by the statistical significance of the coefficient of ν_f and ν_s. The coefficients of γ_f and γ_s captures the leverage effect, which indicates that volatility has a greater impact of bad news than good news.

EMPIRICAL RESULTS AND FINDINGS

Descriptive Statistic

The futures and spot prices of cardamom over the study period have been graphically plotted in Fig. 1. It shows that both futures and spot prices are moving together and hence, they seem to be cointegrated. Table 1 reports the descriptive statistics of spot and futures price and return series of cardamom. Here spot and futures returns stand for logarithmic differences of spot and futures prices. Mean return of spot and futures market is same. But futures return series is positively skewed whereas the spot return series is negatively skewed. Negative skewness of spot return series explains the high probability of earning a negative return. Jarque Bera test is applied to check the normality of data. The null hypothesis for Jarque-Bera is that the series are normally distributed. This null hypothesis is rejected because the value of probability for cardamom is significant at 1% significance level. Thus, the spot and futures prices of cardamom are not normally distributed. High leptokurtic also signifies non normality of price and return series.

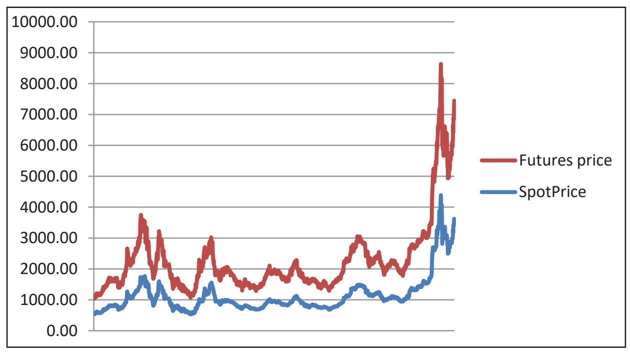

Fig. 1: Futures and Spot Price of Cardamom

Table 1: Descriptive Statistic

	Futures Price	Spot Price	Futures Return	Spot Return
Mean	1095.14	1090.95	0.0005	0.0005
Median	959.60	956.60	0.0000	0.0000
Maximum	4246.70	4390.00	0.3340	0.1628
Minimum	498.50	533.70	-0.2151	-0.1488
Std. Dev.	500.40	525.52	0.0314	0.0175
Skewness	2.76	2.93	1.3640	-0.0158
Kurtosis	12.76	13.60	19.7615	14.8178
Jarque-Bera	15096.03	17646.32	34666.94	16788.59
Probability	0.00	0.00	0.0000	0.0000

Source: Author's estimation.

Stationarity Test Results

To test the stationarity of spot and futures prices of cardamom, ADF and PP tests have been used. Table 2 reports the results of stationarity tests. ADF is a parametric approach whereas PP test is a nonparametric approach. The results of these tests show that both futures and spot prices are non-stationary at level, but become stationary after first differencing even at 1% significant level in both methods. The outcomes are consistent with (Joshi & Mehta, 2023). Both spot and futures prices are integrated of order one, that is, I (1). The confirmation that spot and futures price series are integrated at I (1) allows us to proceed further for cointegration test.

Table 2: ADF and PP Results

	Level	First Difference
Panel A. ADF	T- statistic	T- statistic
Futures prices	-1.849814(0.3565)	53.41268*(0.0001)
Spot prices	-0.986266(0.7602)	-22.47578*(0.0000)
Panel B. PP		
Futures prices	-1.601437(0.4817)	-53.72048*(0.0001)
Spot prices	-1.153407(0.6964)	-47.95140*(0.0001)

Note: *indicates the significance at 1% level. The values in the brackets are probability values.

Source: Author's computations.

Cointegration Test

Table 3 reports the results of Johansen cointegration test. This study has used the Johansen cointegration test on spot and futures prices of cardamom as per the AIC lag length. This test is used to evaluate the long term relationship between variables. The results of trace statistics and maximal eigenvalue statistics show that both tests reject the null hypothesis of no cointegration ($r = 0$) at 1% level of significance. Rejection of null hypothesis indicates the presence of cointegration between spot and futures price series of cardamom. The null hypothesis of at most one cointegration equation ($r \leq 1$) is not rejected for both statistics trace and maximal eigenvalue at 1% level of significance. This indicates that futures and spot price series are cointegrated with one cointegration equation (vector). As futures and spot price series are cointegrated, then there must be a valid error correction term between these series.

Table 3: Johansen Cointegration Test Results

Commodities	Trace Statistics		Trace Statistics	
	λ_{trace}	p-value	λ_{trace}	p-value
Cardamom				
H: r=0	98.678*	0.0001	97.138*	0.0000
H0: r1	1.540	0.2146	1.540	0.2146

Note: * shows the significance at 1% significant level.

Source: Author's Computation.

Vector Error Correction Model (VECM)

Since there is a long run relationship between the spot and futures prices, VECM is used to identify the market that where price discovery occurs. The results of VECM have been reported in Table 4. The results of VECM model show that the coefficients of error correction term (speed of adjustment) in equations (5) and (6) are negative and significant at 5% level of significance. This indicates that both spot and futures prices adjust to the previous period's deviation that arises from the long run equilibrium. The error correction term (in absolute terms) in futures equation (λ_F) is greater than the spot equation (λ_S) which implies that when there is disequilibrium between spot and futures prices in the short run, it is the futures prices that would respond this rapidly. The speed of adjustment is slow for spot prices and it becomes the place for price discovery. Therefore, the price discovery occurs in spot market.

Granger causality test is used to measure the short run lead-lag relationship between spot and futures markets. Table 5 presents the results of Granger causality test. The Granger causality test results indicate that there exists unidirectional causality from spot market to futures market. Therefore, spot market leads to the futures market. The results of both tests confirm that there is an information flow from spot market to futures market of cardamom and spot market has the capability to reflect all the new information.

Table 4: Vector Error Correction Model

Parameter	ΔS_t	ΔF_t
λ	-0.153*(-5.279)	-1.292*(-22.150)
β_1	-0.067*(-2.285)	0.266*(5.075)
β_2	-0.037(-1.446)	0.205*(4.481)
β_3	-0.031(-1.467)	0.148*(3.859)
β_4	-0.017(-1.018)	0.109*(3.626)
β_5	-0.018(-1.615)	0.049*(2.409)
γ_1	-0.659*(-21.347)	-0.891*(-16.080)
γ_2	-0.613*(-20.070)	-0.760*(-13.857)
γ_3	-0.444*(-15.230)	-0.509*(-9.723)
γ_4	-0.272*(-10.792)	-0.305*(-6.740)
γ_5	-0.128*(-6.625)	-0.134*(-3.870)
α	-1.06E-05*(-0.222)-1.06E-05*(-0.222)	-1.65E-06*(-0.019)

Note: *shows level of significance at 5%.

Source: Author's estimations.

Table 5: Granger Causality Test Results

	Test Statistic Value	df	Probability	Inference
Futures to spot	1.701511	(6,2812)	0.1166	S→F
	10.20906	6	0.1166	
Spot to futures	46.09903*	(6,2812)	0.0000	
	184.3961*	6	0.0000	

Source: Author's calculations.

Volatility Spillover in Cardamom Market

An attempt has been made to examine the pattern of the volatility of daily returns of cardamom spot and futures market in the Indian context by applying bivariate EGARCH (1,1) model. Before applying the bivariate EGARCH (1,1) model, diagnostic tests has been performed and it is found that all are significant at 1% significance level. In the EGARCH (1,1) results, the coefficients of ν_s and ν_f are important and describes the spillover of volatility between spot and futures market. Table 6 reports the results of bivariate EGARCH (1,1) model. It can be seen from the results that the coefficient of ν_f is significant at 1% significance level which shows that volatility spillovers from spot market to futures market and no volatility spillovers from futures market to spot market. The volatility spillovers are asymmetric in case of cardamom and hence the effect of bad news is more than that of good news from spot to futures market. The results also found that as information flow increases in the spot market, volatility in the futures market also increases. The results of EGARCH (1,1) model supports to the price discovery results. To check the robustness of bivariate EGARCH (1,1) estimates, diagnostic checking of residuals of spot return and futures return has been done. The results of diagnostic tests have been shown in Table 7. It is found that there is no ARCH effect in the residuals of spot return and futures return as the results were statistically insignificant. Hence, it could be concluded that the bivariate EGARCH (1,1) model was well specified and most appropriate model to eliminate the ARCH effect in case of cardamom.

Table 6: Results of Bivariate EGARCH for Cardamom

Parameters	Spot	Futures
Σ	-0.343868*(-16.5495)	-2.964909*(-25.9926)
Ꮚ	0.231286*(34.4154)	0.396841*(30.91624)
Γ	0.002324(0.486114)	-0.220821*(-17.79317)
A	0.978014*(444.8873)	0.621290*(39.43307)
N	0.000171(0.979188)	-0.001476*(-2.844754)

Notes: The values in the brackets are z statistics. * shows the significance at 1% level.

Source: Author's calculation.

Table 7: Results of Diagnostic Test

	Spot Return	Futures Return
LB^2 (16)	21.808	6.4598
ARCH-LM(12)	1.443168	0.490631

Source: Author's calculation.

CONCLUSION AND POLICY IMPLICATIONS

This study analyses the price discovery and volatility spillover in cardamom market in Indian context as the studies on this issue are still limited and have mixed and contradictory results. The cardamom's spot and futures market has been analysed by employing VECM, Granger causality and bivariate EGARCH (1,1) model. The statistical analysis found the existence of a long run relationship between spot and futures markets with the help of Johansen cointegration test. The findings of analysing price discovery using VECM reveal that price discovery exist in cardamom market with spot market leads to the futures market as it is more efficient in reflecting the new information to prices and serves as effective price discovery vehicle. The results of VECM are further supported by the results of Granger causality test revealing that spot market has the capability to reflect all the new information in its prices. The results of bivariate EGARCH (1,1) model indicates that spillover of volatility takes place from spot market to futures market. The results of our study are consistent with the study of Vijayakumar et al. (2012). The theoretical findings of Dey and Maitra (2012), Gupta and Verma (2016) referring the role of futures markets in price discovery of plantation crops are not found in case of cardamom. The findings of the study have significant implications for investors, traders, exporters, retailers, consumers, financial economist and policymakers. They may use spot prices to formulate efficient hedging strategies. Besides, it gives useful insights to the arbitrageurs, who are formulating their trading strategies based on market imperfections. This study is restricted only to cardamom. The same study could be extended to other commodities as well.

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