ORIGINAL PAPER

DOI: 10.26794/2587-5671-2022-26-3-226-240
JEL C32, C50, G15

Price Discovery of Agri Commodities: An Integrated Approach

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ABSTRACT

The **purpose** of this paper is to examine how the introduction of the pan-India electronic trading portal (eNAM) impacted the information transmission and price discovery in informationally linked markets of India for agricultural commodities. We have applied the information share and component share **methods** using daily data of five agricultural commodities from 2005 to 2019. This paper offers two **findings**, first; evidence shows that commodity stock prices have more price discovery as compared to the market prices. Whereas market prices also generate a significant price discovery, but its volume is less. Second, market prices adjust more quickly than commodity stock prices to correct the disproportion between both markets. This scenario is more evident post eNAM era. **Conclusions** from this study can be used to understand the information flow and would be helpful to academicians, practitioners, policymakers, or business players of commodity markets.
Keywords: price discovery; agricultural commodity; information share; component share

For citation: **Mishra A., Kumar R.P. Price discovery of agri commodities: An integrated approach. *Finance: Theory and Practice*. 2022;26(3):226-240. DOI: 10.26794/2587-5671-2022-26-3-226-240**

ОРИГИНАЛЬНАЯ СТАТЬЯ

Определение цен на сельскохозяйственные товары: комплексный подход

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АННОТАЦИЯ

Цель данной работы — изучить, как внедрение общеиндийского электронного торгового портала (eNAM) повлияло на передачу информации и установление цен на информационно связанных рынках Индии для сельскохозяйственных товаров. Авторы применили **методы** доли информации и доли компонентов, используя ежедневные данные по пяти сельскохозяйственным товарам с 2005 по 2019 г. Представлены два **вывода**: во-первых, данные свидетельствуют о том, что цены на товарные акции в большей степени способствуют формированию цен по сравнению с рыночными ценами. В то же время рыночные цены также генерируют значительное ценообразование, но его объем меньше. Во-вторых, рыночные цены корректируются быстрее, чем цены на товарные акции, чтобы исправить диспропорцию между двумя рынками. Этот сценарий более очевиден после эпохи eNAM. Выводы данного исследования могут быть использованы для понимания информационного потока и будут полезны для академиков, практиков, политиков и бизнесменов, работающих на товарных рынках.
Ключевые слова: определение цен; сельскохозяйственные товары; информационная доля; доля компонентов

Для цитирования: **Mishra A., Kumar R.P. Price discovery of agri commodities: An integrated approach. *Финансы: теория и практика*. 2022;26(3):226-240. DOI: 10.26794/2587-5671-2022-26-3-226-240**

INTRODUCTION

Agriculture is one of the major sectors of the Indian economy, which has a significant role in India's GDP and employment. Any strategic decision would impact people at the grassroots level who have associated with this sector anywhere. In the Indian context, there are three main aspects of strategic agri decision-making; (1) to empower the economic status of the farmers, (2) to strengthen the associated labours, and (3) to be consistent with the international commodity prices [1, 2]. Considering the importance of transparency in trade (through better price discovery), accessibility to farmers, and quick payments, the Government of India has introduced a pan-India electronic trading portal that networks the existing APMCs (physical markets established under the provisions of the APLM India Act proposed by the Agricultural Produce & Livestock Market Committee) to create a unified national market for agricultural commodities called National agriculture Market (eNAM) in 2016.[1]

Due to the technology adaptation and requirement of transparency in trade, price discovery occurs in dynamic commodity markets [3]. In this paper, we will be considering the price discovery process of five agri commodities traded in different markets. The price discovery process is often viewed as information transmission. Price discovery is the process of impounding new information into the commodity's market price and is one of the essential products of markets [4].

In this paper, we have investigated which market provides more useful information regarding fundamental value for these commodities in India. The commodities are (1) cotton — India is one of the largest producers accounting for about 26% of the world cotton production as well as the third-largest exporter of cotton.[2]. Cotton has posted significant positive growth of 68% in exports which is US$ 923 million to US$ 1,550 million between FY 20 and FY 21,[3] (2) maize — India ranks 4th in area and 7th in production if we only consider maize growing countries. During 1950–1951 India produced 1.73 million metric tons (MT) of maize, which has increased to 27.8 million MT by 2018–2019, recording close to 16 times increase in production,[4] (3) wheat — India ranked second in wheat production after China, having a production share of 103.6 million MT in the year 2019,[5] (4) barley — is one of the four major feed grains (corn, barley, oats, and wheat) and is used commercially for animal feed, to manufacture malt, which is primarily used in beer production, for seed, and human food applications [5], (5) soybean — is the world's most crucial seed legume, contributing to approximately 25% of the world's edible oil, and about 65% of the global protein concentrate for livestock feeding. In the Indian context, the share of Soybean is approximately 40% of the total oilseeds and 25% of the edible oils [6].

Since Government in India is implementing the reforms to promote uniformity in the agriculture markets by integrating across the markets, measuring the price discovery is of particular relevance for policymaking also. The government is aiming to remove the information asymmetry between traders and farmers and promote real-time price discovery across the markets.[6] Understanding the price discovery in agriculture is important for market applicants and policymakers because it can contribute to better management decisions and more informed policy debates on market regulation [7]. It would be beneficial to study the flow of information between the markets and the commodities as it could be beneficial for traders and farmers both. The findings of this study can be used to understand the information flow and its impact on pricing to make relative trading strategies; if a commodity is being traded-in multiple markets. The farmers are trading directly at eNAM, and how far they get price discovered in commodity exchanges which a great concern for policy implications. It also regulates the public policy implication for the active participation of farmers in national-level commodity exchanges. As we proceed, the following section consists of a literature review, followed by the methodological framework, analysis and connectedness measurements, results and discussion, and lastly, conclusions.

REVIEW OF LITERATURE

Price discovery is the process by which the fundamental value of a commodity get reflects in the price [8]. Many researchers have discussed price discovery but the research work is restricted to the Future and Spot markets or prices. Man has investigated that the electronic trading system has more price discovery, and the share by the trading system depends on the volume, liquidity, and volatility [3]. Ahumada has developed a forecasting approach to test price discovery in a multivariate framework focusing on the soybeans market. They also found that future prices are the best predictors of future spot prices [9]. Dimpfl has examined eight commodities' spot and futures prices and found that efficient prices can be determined by the spot prices in the long run [10]. The results couldn't confirm the role of future markets in price discovery. They have explained that by understanding the market leadership in price discovery, we can look

[1] Department of Agriculture G of I. e-NAM Overview. URL: https://www.enam.gov.in/web/ (2021) (accessed on 02.11.2021).

[2] COCPC. National Cotton Scenario. URL: https://cotcorp.org.in/national_cotton.aspx (2020) (accessed on 02.11.2021).

[3] IBEF IBEF. Indian Agriculture and Allied Industries Report (July, 2021). URL: https://www.ibef.org/industry/agriculture-presentation (accessed on 02.11.2021).

[4] ICAR. India Maize Scenario. URL: https://iimr.icar.gov.in/india-maze-scenario/ (2020) (accessed on 02.11.2021).

[5] IBEF. Wheat production may cross 113 million tonnes: Skymet. URL: https://www.ibef.org/news/wheat-production-may-cross-113-million-tonnes-skymet (accessed on 02.11.2021).

[6] Department of Agriculture G of I. e-NAM Overview. URL: https://www.enam.gov.in/web/ (2021) (accessed on 02.11.2021).

into the potential exposure of the actual prices that may be used for speculation in the future market. Ates has found that both floor and equity trading contribute significantly to price discovery [11]. However electronic trading is superior in terms of operational efficiency and relative liquidity. Dolatabadi has applied the "fractionally cointegrated vector autoregressive" (FCVAR) model to examine the relationship between spot prices and futures prices in five commodities [12]. They concluded that less evidence of long-run backward integration as compared to the non-fractional model, which Figuerola-Ferretti and Gonzalo, 2010 applied. Ahumada & Cornejo have used the time-series cross-sectional approach to examine the price formation in the US commodity market, which is determined by the demand and supply in the long run and demand-pull from China [13]. Baffes & Ajwad have explained the price linkages and the degree to which the prices (price discovery process) are related in different markets for cotton [14]. Liu & An have examined the price discovery in the US and Chinese commodity futures markets for copper and soybean spot contracts using M-GARCH and information share models [15]. Figuerola-Ferretti & Gonzalo have established an equilibrium model of spot and futures for non-ferrous metals prices traded on the London Metal Exchange [16]. They confirm that future prices are "information dominant" in highly liquid futures markets. Baillie & Geoffrey have talked about the common factor models in the case when one commodity/asset is traded in more than one market [17]. They have compared the relationship between the two widely used common factor models; Hasbrouck (1995) [4], which considers the variance of the innovations to the common factor, and Gonzalo and Granger (1995) [18] which considers the components of the common factor and the error correction process. Karabiyik & Narayan have found that the spot market drives the price discovery as compared to future prices considering Islamic stocks from 19 markets [19]. Lien & Shrestha have proposed the Generalized Information Share (GIS) model to analyze the price discovery process in interrelated financial markets, which is found more efficient than Hasbrouck's (1995) [4] information share (IS) in their case [8]. Avino & Lazar [20] have examined multivariate GARCH models to generate a time-varying Hasbrouck (1995) [4] information share (IS) that can improve credit spread predictions. Kapar & Olmo have analyzed the price discovery process for Bitcoin spot and futures markets and found that future markets drive the price discovery [21]. Bohl & Siklos have examined price discovery for agricultural commodity markets and found that future markets contribute more to price discovery where speculation reduces the noise in future markets [22]. Grammig & Peter have examined the high-frequency data of stocks and found that contribution of the NYSE to price discovery has sharply declined from 2007 to 2012 [23]. Aggarwal & Thomas have examined the spot and futures markets for information flow and liquidity [24]. Putnins has examined three popular methods — the Hasbrouck information share, Harris-McInish-Wood component share, and information leadership share and found that ILS is correctly attributed to price discovery [25]. Narayan & Smyth have suggested the need for further research in econometric modeling integrating recent methods and empirical regularities in price discovery [26]. Recently, Hasbrouck has extended the application of his model by examining the price discovery in high-frequency data by estimating the multivariate time series models [27]. Here, *Table 1* shows the summary of some studies on price discovery for different types of commodities.

Since the risk transfer and price discovery are considered two primary functions of future markets [21], the price discovery process is well investigated in future markets. We have observed a gap where the price discovery process needs to examine for agri-commodities. These are commodities are traded in different markets. We want to understand the price discovery process for these agri-commodities in the commodity stock prices commodity market and National agriculture Market (eNAM) considering the following points:

1. To collect the evidence on the price discovery process in the agri-commodity markets.
2. To contribute to the knowledge of the relationships of the prices of the same commodity traded in different markets.
3. Understanding how the different markets are reacting to the new information share leads to price discovery specifically before and after the eNAM introduction.

METHODOLOGY

Based on the literature review, we can say that three popular techniques have been developed and are most widely used to estimate price discovery:

1. Information Share (IS), proposed by Hasbrouck (1995) [4].
2. Component Share (CS) proposed by Booth, So, and Tse (1999) [44], Chu, Hsieh, and Tse (1999) [45],

Table 1

Summary of the Studies on Price Discovery Between Commodities

Study Reference	Methods	Period	Commodity / type	Summary
T. Vollmer [7]	Partially cointegrated error correction model, IS, CS & ILS	Jan 2002 to Apr 2016	agricultural (spot and futures)	In the context of efficiency or avoidance of noise, the Paris wheat futures market dominates price discovery, but this dominance decreases if price volatility increases
H. Karabiyik [19]	VECM	1982 to 2015	Islamic stocks	Spot markets lead the price discovery process for most the countries
B. Kapar [21]	IS, CFC	Dec 2017 to May 2018	Bitcoin	Futures market dominates the price discovery and a weighted combination of the futures and spot market called the "common factor" drives the prices
M.T. Bohl [22]	IS, CS & ILS	Jan1990 to Jun 2018	Agricultural, livestock (spot and futures)	Speculation (total and excessive) im- proves futures markets' price discovery
J. Grammig [23]	IS, GG	2004 to 2012	Equity	NYSE's contribution to price discovery has sharply declined, and later was overtaken by the NASDAQ
F. Balli [28]	VECM	2007–2016	Various commodities (spots and futures)	Commodity indexes are well connected and precisely during global financial crisis and oil price collapse (2014–16).
J. Hao [29]	VECM, CFW, PT & IS	2017–2018	Soybeans	Soybean options show stronger price discovery than soybean futures and call options trading volume has a stronger impact on Soybean options' price discovery than the put options.
T. Dimpfla [30]	IS, CS & ILS	Mar to Nov 2017	Cryptocurrency	Bitfinex (trading venue) is the leader in the price discovery process
J. Yang [31]	Recursive cointegration	Various (2004 to 2019)	Agricultural	Futures markets dominate the price discovery
K. Shrestha [32]	Generalized IS, CS	Various (1979 to 2017)	Agricultural (spot and futures)	Futures markets lead the price discovery process except for cocoa
A. Fassas [33]	CFW, IS, VECM	Jan 2013 to Dec 2014	Indices / futures Contracts	Futures markets lead the price discovery process
B. Frijns [34]	Structural VAR	Jan 2004 to Aug 2017	US & Canadian stocks	US market dominates the prices & algorithmic trading is negatively related to price discovery
P.K. Narayan [35]	VECM	Various (1979 to 2012)	Agricultural (spot and futures)	Spot markets lead the price discovery for nine commodities while future markets dominate only six
J. Wright [36]	VECM, Cluster analysis	May 2001 to Oct 2016	Livestock (Cattle)	Futures markets lead the price discovery for the US cattle market
B.S. Rout [37]	Cointegration, Granger causality, and VECM	Jan 2010 to Dec 2016	Agri and metal	Derivative market leads the price discovery for metals and spot for agri commodities

Table 1 (continued)

Study Reference	Methods	Period	Commodity / type	Summary
H. Karabiyik [38]	IS, PT	Jun 2017 to Dec 2017	Energy, foodstuffs, agri, livestock & metals (spot and futures)	IS and PT measures are consistent for Panel data measures of price discovery whereas time series only support PT
S.T.G. Nair [39]	Cointegration, VECM	2008 to 2019	Metals (spot and futures)	Futures markets lead the price discovery process
R. de Blasis [40]	Multivariate Markov chain	Jan 2016 to Dec 2017	Gold (spot and futures)	The author proposes a new measure of price discovery called price leadership share (PLS)
R. Manogna [41]	VECM, EGARCH	2010 to 2020	Agricultural (spot and futures)	Future markets lead the price discovery for six commodities while spot markets dominate only three
A.P. Fassas [42]	Recursive cointegration analysis, multivariate GARCH, IS	Jan 2018 to Dec 2018	Bitcoin	Futures markets lead the price discovery
M. Li [43]	VECM, cointegration, SADF	Sep 2004 to Sep 2017	Soybean futures markets	Price discovery well exists during price bubble periods as compared to non-bubble periods

Source: compiled by the authors.

Notes: VECM — vector error correction model; CFW — Common factor weight; IS — Information Share; CS — Component shares; ILS — Information leadership shares; PT — Permanent Transitory; CFC — common factor component; VAR — vector autoregression; GG — Gonzalo-Granger measure; GARCH — generalized autoregressive conditional heteroscedasticity; EGARCH — exponential generalized autoregressive conditional heteroscedasticity; SADF — Supremum Augmented Dickey-Fuller Test.

Harris, McInish, and Wood (2002) [46], which is based on the permanent and transitory decomposition of Gonzalo and Granger (1995) [18].

3. The information leadership share (ILS) proposed by Putnins (2013) is a combination of both [25].

We would be using the first two methods to measure the price discovery.

Hasbrouck Information Share (IS) Measure: To determine the contributions to price discovery is nothing but to identify each market's contribution to the variance of the innovations in the common random walk component. Since markets' innovations are potentially serially correlated, we require to extract the idiosyncratic effect of the markets independently. Referring to the methodology suggested by Shrestha and Lee [47], Hasbrouck Information Shares rely on a vector equilibrium correction of price changes in n markets. If Y_t be an $n\times 1$ vector of unit-root series where it is assumed that there are $(n-1)$ cointegrating vectors which implies that the system consists of a single common stochastic trend. So, we can represent the data generating process by a vector error-correction (VEC) model as below:

$$\Delta Y_t = \alpha\beta^T Y_{t-1} + \sum_{i=1}^{k} A_i \Delta Y_{t-i} + \varepsilon_t. \quad (1)$$

Where β and α are the $n \times (n-1)$ matrices of rank $(n-1)$. The columns of β consists of the $(n-1)$ cointegrating vectors, and each column of α represent the adjustment coefficients. The matrix $\alpha\beta^T$ is decomposed in such a way that $\beta^T Y_t$ consists of $(n-1)$ vectors of stationary series. Let Ω denote the covariance matrix of the innovation vector, i.e., $\mathbb{E}\left[\varepsilon_t \varepsilon_t^T\right] = \Omega$. The equation (1) can be transformed into the following vector moving average (VMA)

$$\Delta Y_t = \psi(L)\varepsilon_t. \quad (2)$$

Or

$$Y_t = Y_0 + \psi(1)\sum_{i=1}^{t}\varepsilon_t + \psi^*(L)\varepsilon_t, \qquad (3)$$

where $\psi_0 = I_n$ is an identity matrix. Due to the assumed nature of the cointegrating relationship among these unit-root series, the Engle-Granger representation theorem [Engle and Granger (1987)] implies the following (De Jong (2002) and Lehmann (2002)):

$$\beta^T\psi(1) = 0 \text{ and } \psi(1)\alpha = 0. \qquad (4)$$

Based on the above representations, Hasbrouck (1995) considers $\psi(1)\varepsilon_t$ to represent the long-run impact of the reduced form innovations on the unit-root series [4]. Since Hasbrouck (1995) assumes that the cointegrating relationship is one-to-one. Therefore, if n non-stationary series to have $(n-1)$ cointegrating vectors, the cointegrating vectors represented by columns of matrix β can be written as follows

$$\beta^T_{(n-1)\times n} = \left[\iota_{(n-1)} : -I_{(n-1)}\right] = \begin{bmatrix} 1 & -1 & 0 & \cdots & 0 \\ 1 & 0 & -1 & \vdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & 0 & 0 & \cdots & -1 \end{bmatrix}, (5)$$

where $I_{(n-1)}$ = $Diag$ (1, 1,…, 1) and $\iota_{(n-1)}$ is an $(n-1)$ element column vector with all its elements equal to 1. Given the unique nature of β, equation (4) implies that $\psi(1)$ has identical rows. Let ψ = $(\psi_1, \psi_2, \ldots, \psi_n)$ denote the identical row of $\psi(1)$. Then, the information share for market i (S_i) is given by Hasbrouck (1995) [4]:

$$S_i = \frac{\left([\psi F]_j\right)^2}{\psi\Omega\psi^t},$$

where F is the Cholesky factorization of Ω and $[\psi F]_j$ represents the j^{th} element of the row vector ψF. As the Cholesky factorization depends on the ordering, the S_i computed using the above equation will depend on the particular ordering. By considering all possible orderings, we can compute the upper and lower bounds for S_i. Then, the IS of market i (IS_i) is given by the average of the upper and lower bounds for S_i.

For a two series case, the covariance matrix Ω and F are given by:

$$\Omega = \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix} \;\&\; F = \begin{bmatrix} \sigma_1 & 0 \\ \rho\sigma_2 & \sigma_2\sqrt{(1-\rho^2)} \end{bmatrix}.$$

Therefore, the two IS bounds (IS_1 and IS_1^*) for the first market are given by

$$IS_1 = \frac{(\psi_1\sigma_1 + \psi_2\rho\psi_2)^2}{\psi_1^2\sigma_1^2 + \psi_2^2\sigma_2^2 + 2\psi_1\psi_2\sigma_{12}},$$

$$\& \; IS_1^* = \frac{(\psi_1\sigma_1)^2(1-\rho^2)}{\psi_1^2\sigma_1^2 + \psi_2^2\sigma_2^2 + 2\psi_1\psi_2\sigma_{12}}. \qquad (6)$$

As the sum of the IS for the two markets is equal to 1, the IS for the second market can easily be computed. If the two elements of the reduced form innovation ε_t are independent, then a unique IS measure exists for each market. The IS for market i (IS_i) is given by

$$IS_i = \frac{\psi_i^2\sigma_i^2}{\psi_1^2\sigma_1^2 + \psi_2^2\sigma_2^2} \quad i = 1, 2. \qquad (7)$$

Component Share (CS) Measure:

Gonzalo and Granger (1995) propose a way of decomposing the vector of non-stationary series Y_t into permanent component f_t (non-stationary series) and transitory (stationary) component $\widehat{Y}_t$ where the identification of these components is achieved by assuming that (*i*) the permanent component is a linear function of the original series and that (*ii*) the transitory component does not Granger cause the permanent component in the long run. The permanent component f_t (under linearity condition) can be written as

$$f_t = \mu^T Y_t, \qquad (8)$$

where μ is an $n \times 1$ permanent coefficient vector which can be shown to be orthogonal to the adjustment coefficient vector α, i.e., $\mu = \alpha_\perp$. From equation (4), it is clear that ψ and μ differ by a scalar multiple. The CS measure depends on the elements of μ. For a two series case, the CS for market i (CS_i) can be given as follows:

$$CS_i = \frac{\psi_i}{\psi_1 + \psi_2}, \; i = 1, 2. \qquad (9)$$

There are some arguments regarding the interpretation of these measures. Grammig and Peter have used the volatility inclusions to identify a unique information share [23]. We have observed that Hasbrouck IS measure is sensitive to the variables' order and not unique when price innovations across markets are correlated. The contribution of a commodity market to price discovery is its information share. Information share (IS) is the proportion of efficient price innovation variance [4].

Research Design

1. Our analysis begins with performing the augmented Dickey-Fuller (ADF) to examine the price series' unit root.
2. It is essential to check the cointegration assumption for both the price series. We have used the Johansen Cointegration Test in our analysis.
3. After confirming that unit root exists in each price series and also that the two series are cointegrated, we set up a VAR model for both the price series and use AIC to determine the AR order in the model.
4. Based on the estimated VECM model, we compute the information share measures. For the Hasbrouck measure, upper and lower bounds are calculated along with the component shares, which will measure the price discovery.

Data

We have collected the commodity price time series from NCDEX (commodity market index) — which is commodity market data from NCDEX (will refer as "Commodity stock Price") and another is from Agmarknet data — which is wholesale market data for eNAM or Agmarknet (will refer as "Market Price"). We have used daily data of prices for all five commodities — cotton, maize, wheat, barley, and soybean from 2005 to 2019. Our criteria for selecting the commodity are (1) commodity should be listed in more than one market, (2) Volume or quantity of trade in the last ten years for that commodity, and (3) food grain is being selected considering their importance in the food basket, (4) we have not considering the storable or non-storable categories of the commodities and last (5) also, not categorizing based on the "seasonal" and "non-seasonal" commodity. As an assumption for the study, we assume that the APMC mandi location, the operational cost, and the commissions do not impact commodity prices. However, these may influence the decision of farmers for choosing a marketplace for trade. India electronic trading portal (eNAM) was introduced on 14th April 2016, hence we are calling these periods pre-eNAM and post-eNAM. Later from the analysis perspective, we have converted these time series into log returns. We have not used the 2020 data to exclude the impact of the COVID-19 pandemic as it has a significant effect on various monetary aspects.

Data Analysis and Results

1. In our analysis, we have used the following tests
2. Unit Root Test and Lag Length Selection
3. Johansen Cointegration Test
4. Vector Error Correction Model (VECM)
5. Information Share (IS)
6. Component Share (CS)

Regarding stationary, a time series is called stationary if it doesn't have a trend or seasonal effects. Statistically, we need to check the mean and variance to identify if a series is stationary. As the first step for the commodity stock and market prices, the standard t-test fails to reject the null hypothesis that the differenced price series has a zero mean. Then we performed the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests listed in *Table 2*.

Later, we used the Johansen cointegration test to check the existence of the cointegrating relationship. We apply log-transformed prices in this test and the results are summarized in *Table 3*. Now we conclude that there exists a single cointegrating relationship between the commodity stock price and market prices as the hypothesis of having no cointegration is rejected at a 5% significance level and the hypothesis that there is one cointegration vector cannot be rejected.

Now, we applied the Hasbrouck method to get the information shared (IS) [4]. This method gives upper and lower bounds. The upper and lower bound of IS can be calculated by doing all the permutations for one or multiple markets. To get the upper bound of IS, we can place that's market price first and lower the last. Here, we automatically calculated the number of lags by referring to the Akaike information criterion (AIC). *Table 4* summarizes the results of Hasbrouck information share (IS) and component share (CS).

The results show that the commodity stock prices lead the price discovery for all the markets except cotton. This trend is visible in both pre and post eNAM time frames. Maize and soybean commodity stock prices dominates the price discovery during post eNAM, more precisely.

We also checked the importance of various trading components summarized in *Table 5* and respective regression results are shown in *Table A1* (*APPENDIX*).

We can see that max price on that day is the most significant component of trade across the commodities.

Table 2

Unit-Root Test Results

	ADF (first difference)		PP (first difference)	
Commodity	**Intercept**	**Intercept & trend**	**Intercept**	**Intercept & trend**
Barley MP	−2.060	−3.700**	−2.790	−14.283***
Barley CSP	−1.902	−4.267***	−1.783	−5.843***
Cotton MP	−1.001	−46.920***	−1.809	−3.636**
Cotton CSP	−1.451	−59.069***	−1.990	−59.068***
Maize MP	−1.642	−44.215***	−2.124	−4.179***
Maize CSP	−1.466	−54.039***	−2.004	−54.962***
Soybean MP	−1.786	−44.262***	−2.094	−81.267***
Soybean CSP	−2.768	−55.693***	−1.991	−56.037***
Wheat MP	−0.997	−29.792***	−2.354	−39.818***
Wheat CSP	−0.668	−15.768***	−2.293	−19.674***
Critical values				
1% level	−3.960635			
5% level	−3.411076			
10% level	−3.127359			

Source: author's analysis.

Note: MP – market price; CSP – commodity stock price. The table contains the t-statistics of the ADF & PP tests results, where *** and ** indicate the significance of t-statistics at 1% and 5% level of significance, respectively.

Table 3

Johansen's Cointegration Test Results

	Number of Cointegrating Vectors			
	None		**At most one**	
	Max. Eigenvalue	**Trace**	**Max. Eigenvalue**	**Trace**
Barley	22.342*	23.338*	0.996	0.996
Cotton	24.884*	25.934*	1.050	1.050
Maize	32.800*	36.151*	3.351	3.351
Soybean	65.275*	66.436*	1.161	1.161
Wheat	51.829*	53.612*	1.783	1.783

Source: author's analysis.

Note: MP– market price; CSP – commodity stock price. Trace test indicates 1 cointegrating eqn(s) at the 0.05 level. Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level. ** MacKinnon-Haug-Michelis (1999) p-values.

Table 4

Results of information share measure

			Hasbrouck Information Share (IS)		Component Share (CS)
			Original ordering	Reversed ordering	
Barley	Overall	MP	0.347	0.092	0.181
		CSP	0.653	0.908	0.819
	Pre eNAM	MP	0.321	0.065	0.158
		CSP	0.679	0.935	0.842
	Post eNAM	MP	0.012	0.001	0.012
		CSP	0.988	0.999	0.988
Cotton	Overall	MP	0.656	0.656	0.787
		CSP	0.344	0.344	0.213
	Pre eNAM	MP	0.901	0.901	0.893
		CSP	0.099	0.099	0.107
	Post eNAM	MP	0.753	0.760	0.769
		CSP	0.247	0.240	0.231
Maize	Overall	MP	0.317	0.282	0.270
		CSP	0.683	0.718	0.730
	Pre eNAM	MP	0.046	0.036	0.101
		CSP	0.954	0.964	0.899
	Post eNAM	MP	0.847	0.787	0.561
		CSP	0.153	0.213	0.439
Soybean	Overall	MP	0.055	0.212	0.216
		CSP	0.945	0.789	0.784
	Pre eNAM	MP	0.056	0.215	0.221
		CSP	0.944	0.785	0.779
	Post eNAM	MP	0.020	0.010	0.050
		CSP	0.980	0.990	0.950
Wheat	Overall	MP	0.342	0.002	0.056
		CSP	0.658	0.998	0.944
	Pre eNAM	MP	0.725	0.105	0.398
		CSP	0.275	0.895	0.602
	Post eNAM	MP	0.015	0.043	0.142
		CSP	0.985	0.957	0.858

Source: author's analysis.
Note: MP – market price; CSP – commodity stock price.

Table 5

Importance of trading components

Commodity	Price series	Quantity Traded on that day	Traded Value (INR-In lacs)	Number of trades	Quantity Arrivals on that day	Min Price on that day	Max Price on that day	Closing Price on that day
Barley	MP	13.1%	2.3%	16.9%	5.6%	2.1%	25.8%	34.1%
	CSP	28.0%	24.0%	7.0%	1.4%	16.5%	5.4%	17.6%
Maize	MP	1.9%	3.5%	1.2%	0.1%	48.3%	43.2%	1.9%
	CSP	11.6%	4.7%	8.6%	1.1%	11.5%	54.7%	7.9%
Soybean	MP	0.8%	0.7%	0.3%	0.5%	26.6%	69.8%	1.4%
	CSP	2.1%	5.3%	3.0%	5.2%	4.4%	61.2%	18.7%
Wheat	MP	9.7%	13.3%	7.0%	2.3%	5.9%	36.4%	25.4%
	CSP	7.1%	12.8%	6.0%	0.9%	30.9%	22.5%	19.8%
Cotton	MP	1.7%	1.3%	0.6%	0.2%	35.1%	60.9%	0.2%
	CSP	31.1%	11.5%	15.4%	0.3%	7.3%	22.0%	12.4%

Source: author's analysis.
Note: MP — market price; CSP — commodity stock price.

It is a component of market prices but also has a significant impact on commodity stock prices. Overall there is no significant impact of commodity stock price on market prices but min price of wheat from market prices has some impact on commodity stock price. We also checked the Granger causality for the selected agricultural commodities and found that all the commodities have a bidirectional causality relationship.

CONCLUSION

Overall, the commodity index market dominates the price discovery for all agri commodities except cotton. For cotton, market prices lead to price discovery, which is the same for pre and post eNAM periods. Although all three measures are showing similar outcomes, CS shows that the price discovery by commodity stock prices compared to IS is significantly higher for barley and wheat. For cotton, market prices are leading the price discovery significantly. Considering the pre-eNAM period, all the commodities follow similar trends except wheat & cotton. For this period only, with the original order (market price commodity stock price), the market price is leading the price discovery while commodity stock prices are taking the lead in reversing the order. CS shows the commodity markets taking the lead. For post eNAM, market prices lead the price discovery for maize and cotton. This domination of commodity stock prices is significant for IS. To summarize the results, the commodity stock prices are leading the price discovery for all the five commodities except cotton based on all measures of information flow used. But the strength of this dominance has been varying during pre eNAM and post eNAM. It is interesting to see that maize is leading post eNAM. As one of the prime objectives, eNAM generates some price discovery, and maize is one of the examples. In contrast to maize, soybean price discovery is dominated by commodity stock prices during post-eNAM, which is significantly higher as suggested by the CS measure. One important thing which needs to consider here is that commodity stock prices are represented at the overall national level. Still, market prices are more particular to the state or domestic markets. Conclusions from this study can be used to understand the information flow and would be helpful to academicians, practitioners, policymakers, or business players of commodity markets.

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APPENDIX

Table A1

Regerssion results for selected agricultural commodities

	Pre eNAM				Post eNAM			
Barley	**Coefficients**	**Std. Error**	***t***	**Sig.**	**Coefficients**	**Std. Error**	***t***	**Sig.**
(Constant)		7.968	47.491	0.000		11.420	0.792	0.428
Quantity Traded on that day	−0.899	0.002	−20.263	0.000	0.215	0.002	4.600	0.000
Traded Value (INR–In lacs)	0.772	0.012	20.734	0.000	−0.037	0.015	−0.945	0.345
Number of trades	0.225	0.020	6.784	0.000	−0.276	0.022	−8.411	0.000
Quantity Arrivals on that day	0.046	0.000	7.047	0.000	−0.091	0.000	−14.442	0.000
Min Price on that day	0.529	0.079	5.938	0.000	−0.034	0.088	−0.382	0.702
Max Price on that day	−0.175	0.075	−1.960	0.050	0.422	0.083	4.771	0.000
Closing Price on that day	0.564	0.013	38.839	0.000	0.557	0.016	38.839	0.000
Maize	**Coefficients**	**Std. Error**	***t***	**Sig.**	**Coefficients**	**Std. Error**	***t***	**Sig.**
(Constant)		6.117	14.559	0.000		1.964	3.250	0.001
Quantity Traded on that day	−0.307	0.001	−12.614	0.000	−0.021	0.000	−2.667	0.008
Traded Value (INR–In lacs)	0.124	0.004	7.022	0.000	0.038	0.001	6.907	0.000
Number of trades	0.228	0.009	8.930	0.000	−0.013	0.003	−1.611	0.107
Quantity Arrivals on that day	0.028	0.000	5.669	0.000	0.002	0.000	1.019	0.308
Min Price on that day	−0.304	0.075	−4.409	0.000	0.534	0.021	26.956	0.000
Max Price on that day	1.447	0.067	21.547	0.000	0.478	0.021	22.751	0.000
Closing Price on that day	−0.208	0.054	−3.902	0.000	−0.021	0.005	−3.902	0.000
Soybean	**Coefficients**	**Std. Error**	***t***	**Sig.**	**Coefficients**	**Std. Error**	***t***	**Sig.**
(Constant)		13.499	12.975	0.000		3.232	3.388	0.001
Quantity Traded on that day	−0.026	0.000	−1.428	0.153	0.008	0.000	1.720	0.085
Traded Value (INR–In lacs)	0.068	0.000	5.419	0.000	−0.007	0.000	−2.337	0.020
Number of trades	−0.038	0.003	−1.876	0.061	−0.003	0.001	−0.560	0.575
Quantity Arrivals on that day	0.066	0.000	21.713	0.000	−0.005	0.000	−6.201	0.000
Min Price on that day	−0.056	0.030	−2.122	0.034	0.273	0.005	60.418	0.000
Max Price on that day	0.778	0.053	14.489	0.000	0.717	0.006	116.03	0.000
Closing Price on that day	0.238	0.072	3.476	0.001	0.014	0.004	3.476	0.001

Wheat	Coefficients	Std. Error	*t*	Sig.	Coefficients	Std. Error	*t*	Sig.
(Constant)		8.467	10.843	0.000		6.104	19.378	0.000
Quantity Traded on that day	−0.242	0.000	−8.147	0.000	−0.170	0.000	−7.029	0.000
Traded Value (INR–In lacs)	0.435	0.004	10.773	0.000	0.232	0.003	6.987	0.000
Number of trades	−0.204	0.006	−7.196	0.000	−0.123	0.004	−5.294	0.000
Quantity Arrivals on that day	0.029	0.000	7.540	0.000	−0.041	0.000	−13.326	0.000
Min Price on that day	1.050	0.038	29.995	0.000	−0.102	0.032	−3.169	0.002
Max Price on that day	−0.763	0.036	−22.205	0.000	0.634	0.027	22.827	0.000
Closing Price on that day	0.673	0.020	36.192	0.000	0.443	0.011	36.192	0.000
Cotton	**Coefficients**	**Std. Error**	***t***	**Sig.**	**Coefficients**	**Std. Error**	***t***	**Sig.**
(Constant)		306.94	41.971	0.000		4.821	−10.084	0.000
Quantity Traded on that day	−1.826	0.007	−20.824	0.000	−0.018	0.000	−3.647	0.000
Traded Value (INR–In lacs)	0.676	0.026	12.944	0.000	0.014	0.000	4.962	0.000
Number of trades	0.906	0.132	10.759	0.000	0.007	0.002	1.481	0.139
Quantity Arrivals on that day	−0.019	0.003	−1.094	0.274	−0.002	0.000	−2.754	0.006
Min Price on that day	0.431	0.675	2.754	0.006	0.365	0.006	68.152	0.000
Max Price on that day	−1.294	0.885	−5.685	0.000	0.633	0.005	120.73	0.000
Closing Price on that day	0.729	1.291	2.254	0.024	0.002	0.000	2.254	0.024

Source: author's analysis.

Note: MP — market price; CSP — commodity stock price.

Table A2

Granger causality tests statistics for selected agricultural commodities

	Null Hypothesis	F-Statistic	Prob.	Direction	Relationship
Barley	CSP does not Granger Cause MP	17.2323	7.00E-17	Bi-directional	MP ↔ CSP
	MP does not Granger Cause CSP	16.5151	4.00E-16	Bi-directional	
Cotton	CSP does not Granger Cause MP	0.89476	0.04835	Bi-directional	MP ↔ CSP
	MP does not Granger Cause CSP	1.04827	0.03873	Bi-directional	
Maize	CSP does not Granger Cause MP	16.9235	1.00E-16	Bi-directional	MP ↔ CSP
	MP does not Granger Cause CSP	2.52123	0.0276	Bi-directional	
Soybean	CSP does not Granger Cause MP	102.032	9E-101	Bi-directional	MP ↔ CSP
	MP does not Granger Cause CSP	5.46742	5.00E-05	Bi-directional	
Wheat	CSP does not Granger Cause MP	9.83574	2.00E-09	Bi-directional	MP ↔ CSP
	MP does not Granger Cause CSP	10.0031	2.00E-09	Bi-directional	

Source: author's analysis.

Note: MP — market price; CSP — commodity stock price.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.
Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

The article was submitted on 02.11.2021; revised on 20.11.2021 and accepted for publication on 17.12.2021.
The authors read and approved the final version of the manuscript.
Статья поступила в редакцию 02.11.2021; после рецензирования 20.11.2021; принята к публикации 17.12.2021.
Авторы прочитали и одобрили окончательный вариант рукописи.