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An econometric analysis of price transmission between major markets of maize in India

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Abstract
This study tests long-run spatial market integration between price pairs of maize in five major markets *viz.*, Davangere, Kurnool, Chhindwara, Sangli and Nizamabad of the India by adopting important econometric tools like Johansen's multivariate co integration approach, Augmented Dickey-Fuller (ADF), Granger causality test and Vector Error Correction Model (VECM). The study has confirmed the presence of co-integration, implying the six years price association among the markets. To get the additional evidence as to whether and in which direction price transmission is occurring between the market pairs, Granger causality test has been used, which has confirmed Devangare and Nizamabad to be the price-determining markets. Devengare-Nizamabad has been found comparatively more efficient as it has depicted most bidirectional causal relations with other markets. The Vector Error-Correction Model (VECM) shown the selected markets of Maize are employed to know the speed of adjustments for the prices of Maize among selected markets, for short run and long run equilibrium of prices.

Keywords: Market integration, maize, co-integration, granger causality, VECM

Introduction
Maize or corn (Zea mays) is cultivated globally being one of the most important cereal crops worldwide. USA is the largest producer of maize in the world contributing to 31% of global maize production followed by China (23%), Brazil (9%), Argentina (5%) and Ukraine (3%), the top 5 maize producing countries in 2020.

In India, maize crop standup as the third cash crop after wheat and rice. It is an important crop to India as 15 million Indian farmers are engaged in maize cultivation. States such as Karnataka, Rajasthan, Madhya Pradesh and Telangana contribute towards half of the total maize acreage in the country. India needs to plan production by productivity increase and also reorient value chain if it is to serve the basic goal of remunerative prices for farmers.

Maize is next to rice among the cereal crops and third top most crop among all the crops cultivated in Telangana with an area of 6.44 lakh hectares under cultivation. The maize production in Telangana was 17.51 lakh tonnes with an average yield of 3,057 Kg/ha during the year 2019-20. Major maize growing districts in Telangana are Warangal Rural, Khammam, Nirmal, Siddipet, Kamareddy, Mahabubabad, Nizamabad, Warangal Urban, Jagityal and Karimnagar. Area and production of maize has increased manifolds in the state during the last one decade.

Price instability, exploitation of farmers by middlemen in marketing activities and lack of market integration system, etc. are few of the pressing problems faced by the farmers cultivating maize. Keeping this in view, Telangana Government has urged the farmers not to go for maize cultivation during *kharif* 2020-21 under the Regulated farming policy. Accordingly maize acreage has reduced from 4.09 lakh hectares to 2.93 lakh hectares in Telangana State even though the agro-climatic conditions are favourable for its cultivation.

Under these circumstances, it is felt that there is need to formulate appropriate ways and means for sustenance of the crop in the state and reduce price fluctuations, such that both producer's profit and consumer's benefits will increase and lead for overall economic development of the state.

Jyothi *et al.* (2017) [9] in their study investigated the relationship between spot and future market prices of maize and analysed the nature of price discovery process in India's maize futures market. They used unit root test to find out the stationarity of data set, co-integration and Granger-Causality test to analyse the long run and short run relationship respectively between maize futures and spot market prices.

Seth and Sidhu (2018) [13] studied price discovery and volatility spillovers in Indian wheat market. Granger-Causality test confirmed the existence of bidirectional causality between wheat spot and its underlying wheat futures market. From the study, Johansen co-integration test was found to approve the long-term equilibrium relationship between wheat spot and wheat futures prices. The Vector Error Correction Method showed that wheat futures market was found to lead wheat spot market in price discovery process in the long-run. Vasudev *et al.* (2015) [14] conducted a study to assess the performance of the selected agricultural markets for maize in Telangana state. Correlation and co-integration analyses were carried out to determine the spatial market integration among the various maize markets. For co-integration analysis, the time series data were tested using the Dickey-Fuller unit root test followed by Engle-Granger test to determine the market integration. The results of analysis revealed that a moderate correlation ranging from 0.666 among Warangal - Nagarkurnool to 0.868 between Nizamabad - Siddipet for maize and all of them were significant at 1% level of significance. Goletti and Babu (1994) [5] studied the extent of market integration of maize markets in Malawi in order to understand how it has been affected by market liberalization. Several measures of integration are introduced to analyze both the co-movement of prices and the price adjustment process over time. Monthly retail prices of maize at eight main locations over the period January 1984 to December 1991 are considered. The main conclusion is that liberalization has increased market integration. Campiche *et al.* (2007) [2] studied the relation between crude oil prices and variation of agricultural commodities using a vector error correction model. Co integration results denote that corn and maize prices are co integrated with crude oil price during the 2006-2007-time frames. Awal and Sabur (2009) [1] examined the pricing efficiency of exportable fresh vegetables markets in Bangladesh and its export markets by using Engle-Granger (EG) test, Co integration Regression for Durbin Watson (CRDW) test and Error Correction Methods (ECM). Zhang *et al.* (2010) [15] used the VEC model and the Granger test on the monthly data from 1989 to 2008 and reported that there is not any long run and short-run causality between the fuel (oil, gasoline and ethanol) and agricultural commodity (corn, maize, wheat, sugar and rice) prices. Nazlioglu and Soytas (2012) [12] investigated the relationship between the world oil prices and the agricultural commodity prices by using the monthly data from 1980 to 2010 and the panel co-integration and the Granger causality techniques. The results of their study showed that the change in oil prices and the weak dollar have a strong impact on many agricultural commodity prices. Esposti and Listorti (2013) [3] investigate on national and international markets; trade policy regime has an important role in price transmission mechanisms and the trade policy intervention put forward to mitigate the impact of price exuberance is considered. The authors analyzed agricultural price transmission during price bubbles, in particular, considering Italian and international weekly spot (cash) price data over years 2006–2010.

Materials and Methods

For price integration, simple bivariate correlation coefficients measure price movements of a commodity in different markets. This is the simplest way to measure the spatial price relationships between two markets. Early inquiries on spatial market integration, for example Lele (1968) [11] and Jones (1968) [11] have used this method. However, this method clearly has some limitations, as it cannot measure the direction of price integration between two markets. The cointegration procedure measures the degree of price integration and takes into account the direction of price integration. This econometric technique provides more information than the correlation procedure, as it allows for the identification of both the integration process and its direction between two markets.

Market Integration Test

Market integration is tested using the cointegration method, which requires that

- Two variables, say P_{it} and P_{jt} are non-stationary in levels but
- Stationary in first differences i.e. $P_{it} \sim I(1)$ and $P_{jt} \sim I(1)$.

There exists a linear combination between these two series,
Which is stationary i.e. υ_{it} $(=P_{it} - \hat{\alpha} - \hat{\beta}P_{it}) \sim I(0)$.
So the first step is to test whether each of the univariate series is stationary. If they are both I (1) then we may go to the second step to test cointegration. The Engle and Granger (1987) procedure is the common way to test cointegration.

Unit root test

The regression analysis of non-stationary time series produces spurious results, which can be misleading (Ghafoor, *et al.*, 2009) [4]. The most appropriate method to deal with non-stationary time series for estimating long-run equilibrium relationships is cointegration, which necessitates that time series should be integrated of the same order. Augmented Dickey- Fuller (ADF) and Phillips-Perron test (PP) were used to verify the order of integration for each individual series. The ADF test, tests the null hypothesis of unit root for each individual time series. The rejection of the null hypothesis indicates that the series is non-stationary and *vice-versa* (Dickey and Fuller, 1981). The number of the appropriate lag for ADF was chosen for the absence of serial correlation using Akaike Information Criterion (AIC). The ADF test is based on the Ordinary Least Squares (OLS) method and requires estimating the following model.

$$\Delta lnP_t = \alpha_0 + \delta_1 t + \gamma lnP_{t-1} + \sum_{j=1}^{q} \vartheta_j \Delta lnP_{t-j} + \varepsilon_t$$

Where, P is the price in each market, Δ is the difference parameters (i.e., $\Delta P1 = P_t - P_{t-1}$, $P_{t-1} = P_{t-1} - P_{t-2}$ and $P_{n-1} = P_{n-1} - P_{n-2}$) and so on, α_0 is the constant or drift, t is the time or trend variable, q is the number of lags length and ε_t is a pure white noise error term.

Johansen Cointegration

The maximum likelihood (ML) method of cointegration is applied to check long-run wholesale prices relation between the selected markets of India (Johansen, 1988; Johansen and Juselius, 1990) [7, 8]. The starting point of the ML method is vector autoregressive model of order (k) and may be written as:

$$P_t = \sum_{i=1}^{k} A_t P_{t-1} + \mu + \beta_t + \varepsilon_t \text{: } (t=1, 2, 3 \ldots T)$$

Where, (n*1) denotes the vector of non-stationary or integrated at order one, i.e., I (1) prices series. The procedure for estimating the cointegration vectors is based on the Vector error correction model (VECM) representation given by:

$$\Delta P_t = \prod P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{t-i} + +\beta \mu_t + \varepsilon_t$$

Where,
Γ_i= -(I-Π_i-….,T); i=1,2,….k-1
Π = − (I-Π, −………Π_k)

Both Γi and Πi are the n*n matrixes of the coefficient conveying the short and long run information respectively, μ is a constant term, t is a trend, and ε_t is the n-dimensional vector of the residuals that is identical and independent distributed. The vector ΔP_t is stationary P_t is integrated at order one I(1) which will make unbalance relation as long as Π matrix has a full rank of k. In this respect, the equation can be solved by inversing the matrix Π^{-1} for Pt and as a linear combination of stationary variable (Kirchgässner, *et al.*, 2012) [10]. The stationary linear combination of the Pt determines by the rank of Π matrix. If the rank r of the matrix Π r=0 the matrix is the null and the series underlying is stationary. If the rank of the matrix Π is such that 0 < rank of (Π) = r < n then there are n × r cointegrating vectors. The central point of the Johansen's procedure is simply to decompose Π into two n × r matrices such that Π=αβ'. The decomposition of Π implies that the β'Pt are r stationary linear combination.
Johansen and Juselius, (1990) [8] proposed two likelihood ratio test statistics (Trace and Max Eigen test statistics) to determine the number of cointegrating vectors as follows:

$$J_{trace} = -T \sum_{i=r+1}^{N} \ln(1 - \widehat{\lambda}_1)$$
$$\lambda_{max} = -T ln\,(1 - \widehat{\lambda}_{r+1})$$

Where, r is the number cointegrated vector, $\widehat{\lambda}_1$ is the eigen value and $\widehat{\lambda}_{r+1}$ is the $(r+1)^{th}$ largest squared eigen value obtained from the matrix Π and the T is the effective number of observation. The trace statistics tested the null hypothesis of r cointegrating vector(s) against the alternative hypothesis of n cointegrating relations. The Max Eigen statistic tested the null hypothesis (r =0) against the alternative (*r* + 1).

Vector Error Correction Model (VECM)
If price series are *I* (1), then one could run regressions in their first differences. However, by taking first differences, we lose the long-run relationship that is stored in the data. This implies that one needs to use variables in levels as well. Advantage of the vector error correction model (ECM) is that it incorporates variables both in their levels and first differences. By doing this, VECM captures the short-run disequilibrium situations as well as the long-run equilibrium adjustments between prices. Even if one demonstrates market integration through cointegration, there could be disequilibrium in the short-run i.e., price adjustment across markets may not happen instantaneously. It may take some time for the spatial price adjustments. VECM can incorporate such short-run and long-run changes in the price movements.
A VECM formulation, which describes both the short-run and long-run behaviors of prices, can be formulated as:

$$\Delta P_{it} = \gamma_1 + \gamma_2 \Delta P_{jt} - \pi \hat{\upsilon}_{it-1} + v_{it}. \quad (4)$$

In this model, γ_2 is the impact multiplier (the short -run effect) that measures the immediate impact that a change in P_{jt} will have on a change in P_{it}. On the other hand, π is the feedback effect or the adjustment effect that shows how much of the disequilibrium is being corrected, that is the extent to which any disequilibrium in the previous period effects any adjustment in the P_{it} period of course $\hat{\upsilon}_{t-1} = P_{it-1} - \hat{p}_1 - \hat{p}_2 P_{ji-1}$ and therefore from this equation we also have ρ_2 being the long-run response.

Granger Causality Test
If a pair of series is cointegrated then there must be Granger causality in at least one direction, which reflects the direction of influence between series (in our case prices). Theoretically, if the current or lagged terms of a time-series variable, say P_{jt}, determine another time-series variable, say P_{it}, then there exists a Granger causality relationship between P_{jt} and P_{it}, in which P_{it} is Granger caused by P_{jt}. Bessler and Brandt (1982) firstly introduced this test into research on market integration to determine the leading market.

From the above analysis, the model is specified as follows

$$\Delta P_{it} = \theta_{11} \Delta P_{it-1} +.+ \theta_{1n} \Delta P_{it-n} + \theta_{21} \Delta P_{jt-1} +.\, \theta_{2n} \Delta P_{jt-n} - \gamma_1 (P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{1t}.$$

$$\Delta P_{jt} = \theta_{31} \Delta P_{jt-1} +.+ \theta_{3n} \Delta P_{it-n} + \theta_{41} \Delta P_{it-1} +.\, \theta_{4n} \Delta P_{it-n} - \gamma_2 (P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{2t}.$$

The following two assumptions are tested using the above two models to determine the Granger causality relationship between prices.

$\theta_{21} = . \ldots = \theta_{2n} = \cdots = \gamma_1 = 0$ (No causality from P_{jt} to P_{it})
$\theta_{41} = . \ldots = \theta_{4n} = \cdots = \gamma_2 = 0$ (No causality from P_{it} to P_{jt})

Results and Discussion
Our price data consist of monthly modal prices of Maize (Rs/qtl) in five major markets *viz.* Davangere, Kurnool, Chhindwara, Sangli and Nizamabad of the India using monthly Maize prices over the period from January 2016 to December 2021. The data was taken from the websites of agricultural marketing, Government of Telangana http://tsmarketing.in/ and https://agmarknet.gov.in/.

Descriptive Statistics
The Maize modal price trend of all the selected markets is presented in Fig. 1, which shows the symmetric behavior in the movement of prices in all the selected markets. The maximum modal price of Rs. 2366 /quintal prevailed in Davangere and the minimum price was found in Kurnool Rs. 931 / quintal followed by Chhindwara Rs. 998 / quintal.
Summary statistics result shows that the price of Maize remained highly volatile in Chhindwara followed by Nizamabad as measured by coefficient of variation. The highest average prices of Maize were found in Sangli market, while lowest average prices were in Kurnool, present in (Table 1).

Table 1: Summary Statistics of the monthly modal prices for Maize in major markets for India from the period January, 2016 to December, 2021 (in ₹/100 kg)

	Davangere	Kurnool	Chhindwara	Sangli	Nizamabad
Mean	1533	1374	1478	1580	1455
Median	1505	1384	1391	1518	1423
Maximum	2366	1996	2228	2105	2345
Minimum	1101	931	998	1056	1069
Std. Dev.	262.17	208.27	301.17	253.27	282.62
CV	17.11	15.16	20.38	16.03	19.43

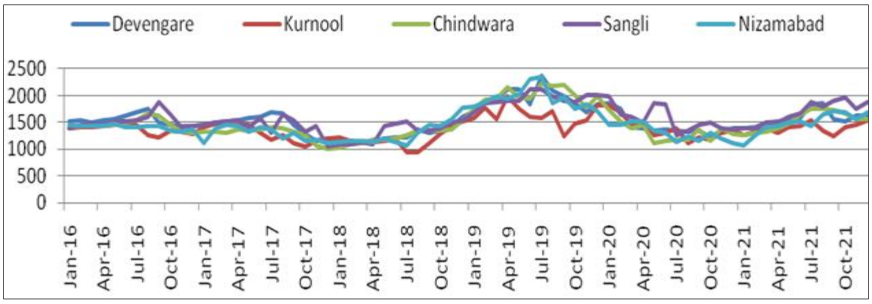

Fig 1: Price behavior (`Rs/quintal) of Maize crop in major selected markets in India

Order of the Integration

In order to check the stationarity of price series of Maize, the standard ADF and PP unit root tests, are applied to determine the order of integration. The unit root test regression implies that regressing the first difference of a series with its one period lag and several lags (as suggested by the various lag length criterion) of the first differenced series. The null hypothesis of ADF and PP tests is accepted or rejected based on the critical value and corresponding probability value. If the test statistics is smaller in absolute terms than the critical values and the corresponding probability value is greater than 5% level, the series is said to be non-stationary. The results of the ADF and PP test values are below the critical value at 5% level of significance indicating the non existence of unit root test. This implies that the Maize price series are non stationary at level in the markets Davangere, Chhindwara and Nizamabad expect Kurnool and Sangli. All the major markets i.e., Davangere, Kurnool, Chhindwara, Sangli and Nizamabad are stationary at first difference I (1).

Table 2: ADF and PP Tests for Unit Root in the modal prices of Maize

Augmented Dickey-Fuller test results at level				Phillips-Perron test results at level		
	t-Statistic	Prob.*	Remarks	t-Statistic	Prob.*	Remarks
Devengare	-2.15	0.22	Non-stationary	-2.21	0.20	Non-stationary
Kurnool	-3.00	0.03	Stationary	-2.94	0.04	Stationary
Chindwara	-1.71	0.41	Non-stationary	-2.01	0.27	Non-stationary
Sangli	-4.26	0.00	Stationary	-4.17	0.00	Stationary
Nizamabad	-1.86	0.34	Non-stationary	-1.79	0.37	Non-stationary
Augmented Dickey-Fuller test results after differencing				**Phillips-Perron test results after differencing**		
ΔDevengare	-8.94*	0.00	Stationary	-8.94*	0.00	Stationary
ΔKurnool	-10.32*	0.00	Stationary	-10.36*	0.00	Stationary
ΔChindwara	-8.27*	0.00	Stationary	-8.34*	0.00	Stationary
ΔSangli	-11.33*	0.00	Stationary	-15.18*	0.00	Stationary
ΔNizamabad	-9.30*	0.00	Stationary	-9.31*	0.00	Stationary

Notes: * denote significance at 1% levels of significance and Δ denote the first difference of the time series.

Co-integration Analysis

Johansen's Co-integration test for selected Maize markets for the long-run co-integration was performed. If two series are potentially co-integrated, at least one co-integration relationship exists. Co-integration may be affected by some facts, such as transportation cost, tariffs, and so on. The two tests, i.e., trace and max Eigen statistics of Johansen's approach based on the vector autoregressive model (VAR) were put into the application to analyze the co- integrating vectors between the selected Maize markets. The results of Johansen's maximum likelihood tests (maximum eigen-value and trace test) are reported in Table 3. The first null hypothesis of maximum eigen-value and trace test, tests the no cointegration ($r = 0$) against the alternative hypothesis ($r \geq 1$) of at least one cointegrated equation prevailed in the VAR system. Both, the maximum eigen-value and trace test reject the null hypothesis of no cointegration. The rejection/acceptance of the null hypothesis is decided by the trace max- eigen test statistic values against their critical value and corresponding probability value which is less than test statistic in the first null hypothesis. Similarly, the null hypotheses from $r \leq 1$ to $r \leq 3$ and $r \leq 4$ for both the statistics were rejected against their alternative hypotheses from the $r \geq 1$ to $r \geq 4$ and $r=5$ as their critical values are less than the test statistics and the corresponding probability values are also less than 0.05. This implies that there are five co-integrating relationships in the joint co-integration analysis of all five Maize markets.

Table 3: Johansen's co-integration test results of five major maize market prices in India

Hypothesized No. of CE(s)	H_0	H_1	Eigen value	Trace Statistics results			Max-Eigen Statistics results		
				Trace Statistics	0.05 Critical Value	p-value	Max-Eigen Statistic	0.05 Critical Value	p-value
None *	r =0	r≥1	0.64	202.77	69.81	0.000*	70.68	33.87	0.000*
At most 1*	r≤1	r≥2	0.55	132.09	47.85	0.000*	54.37	27.584	0.000*
At most 2 *	r≤2	r≥3	0.46	77.71	29.7	0.000*	42.51	21.131	0.000*
At most 3 *	r≤3	r≥4	0.32	35.20	15.49	0.000*	26.70	14.2646	0.000*
At most 4 *	r≤4	r=5	0.11	8.50	3.84	0.003*	8.50	3.8415	0.003*

Notes: in represent the natural logarithm and * denote the rejection of null hypothesis at 5% level of significance\

Granger causality test

After confirming the integration of price series, pair-wise Granger causality test was perfomed for five major Maize markets to comprehend causal relation between them. The result of the Granger causality analysis presented in Table 4 explicates that bidirectional causality market pairs is Kurnool - Davangere, Nizamabad - Davangere and Nizamabad - Chhindwara. In these cases, the former market in each pairs granger causes the modal price formation in the latter market, which in turn provides the feedback to the former market as well. A unidirectional causality markets pair is Davangere - Chhindwara, Kurnool - Chhindwara, Chhindwara - Sangli and Nizamabad - Kurnool. It means that a price change in the former market in each pair granger causes the price formation in the latter market. Whereas the remaining all markets were shown no causality. It means the price change in the latter market was not feed backed by the price change in the former market.

Tables 4: Market pair wise results of the Granger Casualty test

Lagged Periods	Markets Pairs	F-Statistic	p-value	Decision of null hypothesis	Remarks
1	Chhindwara - Davangere	1.20	0.31	Reject	No causality
	Davangere - Chhindwara	3.27*	0.02*	Do not reject	Unidirectional
2	Kurnool - Davangere	2.68*	0.05*	Do not reject	Bi-directional
	Davangere - Kurnool	2.79*	0.04*	Do not reject	
3	Nizamabad - Davangere	5.24	0.00*	Do not reject	Bi-directional
	Davangere - Nizamabad	5.11*	0.00*	Do not reject	
4	Sangli - Davangere	2.54	0.06	Reject	No causality
	Davangere - Sangli	2.21	0.09	Reject	No causality
5	Kurnool - Chhindwara	3.29*	0.02*	Do not reject	Unidirectional
	Chhindwara - Kurnool	1.29	0.28	Reject	No causality
6	Nizamabad - Chhindwara	6.45*	0.00*	Do not reject	Bi-directional
	Chhindwara - Nizamabad	3.19*	0.02*	Do not reject	
7	Sangli - Chhindwara	1.34	0.26	Reject	No causality
	Chhindwara - Sangli	2.69*	0.05*	Do not reject	Unidirectional
8	Nizamabad - Kurnool	3.92*	0.01*	Do not reject	Unidirectional
	Kurnool - Nizamabad	2.50	0.06	Reject	No causality
9	Sangli - Kurnool	1.65	0.18	Reject	No causality
	Kurnool - Sangli	0.82	0.48	Reject	No causality
10	Sangli - Nizamabad	0.59	0.62	Reject	No causality
	Nizamabad - Sangli	1.86	0.14	Reject	No causality

Note: * represents the level of significance at 5% level

Short run and long run behavior of market prices

Since the Johansen's multiple co-integration test results showed that the selected Maize markets having long run equilibrium relationship and there exists co-integration between them. Hence, the Vector Error Correction model (VECM) among the selected markets of Maize was employed to know the speed of adjustments for the prices of Maize among selected markets, for short run and long run equilibrium of prices. The results of VECM are presented in Table 5.

The estimates of Vector Error Correction Model revealed that co-integration equation value of Davangere, Kurnool, Chhindwara, and Nizamabad markets attain short run equilibrium rapidly. Davangere market one month lag price was affecting current prices of Kurnool, Chhindwara and Nizamabad. Davangere market two-month lag price was affecting current prices of Chhindwara. Kurnool market two-month lag prices was affecting current prices of Chhindwara market. Chhindwara market one month and two-month lag price was affecting current prices of itself. Sangli market one-month lag price was affecting current prices of itself and Nizamabad market. Nizamabad market one month and two-month lag price were affecting current prices of Davangere.

Table 5: vector error correction model for maize prices for major five selected markets in India

Error Correction	Davangere	Kurnool	Chhindwara	Sangli	Nizamabad
CointEq1	[6.22818]	[2.27302]	[2.98440]	[0.42990]	[-3.74522]
Davangere (-1)	[1.85013]	[2.30538]	[2.54263]	[0.42541]	[-3.78508]
Davangere (-2)	[1.60826]	[0.50587]	[3.66442]	[0.52842]	[-1.58061]
Kurnool (-1)	[1.11996]	[-1.16969]	[-1.66369]	[-0.08303]	[1.35938]
Kurnool (-2)	[1.55754]	[1.51213]	[2.17072]	[1.20281]	[-0.92977]
Chhindwara (-1)	[-1.09153]	[-1.33888]	[-5.01577]	[0.38791]	[-0.91930]
Chhindwara (-2)	[-1.31655]	[-1.09609]	[-3.02209]	[0.34926]	[-0.97239]
Sangli (-1)	[1.87754]	[1.73971]	[0.20766]	[-2.96294]	[-2.33651]
Sangli (-2)	[0.60296]	[1.07062]	[0.84646]	[-1.01620]	[-1.23118]
Nizamabad (-1)	[-3.86859]	[-0.72603]	[-0.39721]	[0.43028]	[-1.73604]
Nizamabad -2)	[-2.57613]	[0.80440]	[-0.37536]	[1.00645]	[-0.40481]
C	[-0.24270]	[-0.05887]	[-0.16521]	[0.26839]	[0.21974]

Conclusions

This study investigated the spatial market integration and price behavior of Maize markets through co integration analysis in India using January, 2016 to December, 2021 modal monthly price data. All major markets of Maize in India were found to be highly integrated with regard to price movement. Agricultural markets play an important role in agricultural marketing and production efficiency. A fundamental issue when analyzing policy reform with regards to national agricultural markets is the extent to which domestic agricultural commodity markets respond to price changes. The overall performance of agriculture depends, not only on efficiency of production or supply, but also on marketing efficiency, particularly the agricultural markets and price signal. Spatial market integration measures the extent to which markets at geographically distant locations (such as between regions) share common long-run price or trade information for a homogenous commodity.

The results of ADF unit root test indicated that Maize price series are non-stationary at level in the markets Davangere, Chhindwara and Nizamabad expect Kurnool and Sangli. All the major markets i.e., Davangere, Kurnool, Chhindwara, Sangli and Nizamabad were stationary at first difference I (1). Results of Johansen’s co integration test showed the price series as co integrated. The result of the Granger causality analysis explicates that bidirectional causality market pairs were Kurnool - Davangere, Nizamabad - Davangere and Nizamabad - Chhindwara. A unidirectional causality markets pair is Davangere - Chhindwara, Kurnool - Chhindwara, Chhindwara - Sangli and Nizamabad - Kurnool. Results of Vector Error Correction Model (VECM) showed that Davangere, Kurnool, Chhindwara, and Nizamabad markets attain short run equilibrium rapidly. Davangere market one month lag price was affecting current prices of Kurnool, Chhindwara and Nizamabad. Davangere market two month lag price was affecting current prices of Chhindwara. Kurnool market two month lag prices was affecting current prices of Chhindwara market. Chhindwara market one month and two month lag prices were affecting current prices of itself. Sangli market one month lag price was affecting current prices of itself and Nizamabad market. Nizamabad market one month and two month lag prices were affecting current prices of Davangere.

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