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An empirical study on the cointegration between major domestic market prices and imported redgram prices in India

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Abstract

The main objective of the study is to assess cointegration of major redgram markets and price movement in major markets in India using important econometric tools like Augmented Dickey-Fuller (ADF), Johansen's cointegration test, Granger causality test and Vector Error Correction Model (VECM). The present study examines the price behavior and market integration of redgram across major domestic markets Gulbarga, Mumbai, Indore, Vijayawada, and Tandur along with imported prices. Stationarity analysis using the Augmented Dickey-Fuller (ADF) test revealed that all price series were non-stationary at their levels but became stationary after first differencing, confirming the presence of unit roots and enabling further cointegration and causality analyses. Granger causality results indicated both bidirectional and unidirectional causal relationships among markets. A notable bidirectional causality between Mumbai and Vijayawada reflected strong mutual price influence, while multiple unidirectional causal flows toward Indore highlighted its role as a price-receiving market dependent on Gulbarga, Mumbai, Tandur, and imported prices. The Vector Error Correction Model (VECM) demonstrated significant long-run adjustments and short-run dynamics, with lagged prices of Mumbai and Tandur exerting considerable influence on current prices across all major markets. Vijayawada's lagged prices also affected Mumbai, underscoring inter-market linkages between southern and western regions. Overall, the findings confirm strong market integration and dynamic price transmission among redgram markets, offering valuable insights for price forecasting, market intelligence, and policy formulation aimed at enhancing efficiency in redgram marketing and procurement.

Keywords: Redgram prices, market integration, cointegration analysis

Introduction

Redgram is commonly known as Tur or Arhar in India and is the second important pulse crop in the country after gram (chana). The ability of redgram to produce high economic yields under soil moisture deficit makes it an important crop in rainfed and dry land agriculture. World major redgram producing countries are India (42.20 lakh tonnes), Malawi (4.47 lakh tonnes), Myanmar (3.27 lakh tonnes), Tanzania (1.64 lakh tonnes) and Kenya (0.83 lakh tonnes).

Area under redgram reported during 2025-26 was 42.42 lakh ha (104.82 lakh acres) as against 46.50 lakh ha (114.90 lakh acres) during the same period in 2024-25. In India, major redgram cultivating states are Karnataka 12.62 lakh ha (31.18 lakh acres), Maharashtra 10.83 lakh ha (26.76 lakh acres), Madhya Pradesh 3.70 lakh ha (9.14 lakh acres), Uttar Pradesh 3.33 lakh ha (8.23 lakh acres), Telangana 1.99 lakh ha (4.92 lakh acres) and Gujarat 1.94 lakh ha (4.79 lakh acres) According to Government 3rd advance estimates, all India redgram production in 2024-25 is at 3.56 million tonnes.

Review of Literature

Goletti and Babu (1994) ^[9] studied the extent of market integration of maize markets in Malawi in order to understand how it had been affected by market

liberalization. Several measures of integration were used to analyze both the co movement of prices and the price adjustment process over time using monthly retail prices of maize at eight main locations over the period between January 1984 to December 1991. The study concluded that liberalization increased market integration. Afolami (2001) ^[1] investigated the degree of cowpea market integration in Uganda using such measures as bi variate correlation coefficients, co-integration and Granger-Causality. Campiche *et al.* (2007) ^[4] studied the relation between crude oil prices and variation of agricultural commodities using a vector error correction model. Co integration results showed that corn and soybean prices were co integrated with crude oil price during 2006-2007. Awal and Sabur (2009) ^[2] 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 VEC model and Granger test on the monthly data from 1989 to 2008 and reported that there was no long run and short-run causality between the fuel (oil, gasoline and ethanol) and agricultural commodity (corn, soybeans, wheat, sugar and rice) prices. Nazlioglu *et al.*, (2013) ^[14] 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)^[7] investigating on national and international markets observed that trade policy regime had an important role in price transmission mechanisms and they put forward a trade policy intervention to mitigate the impact of price exuberance. The authors analyzed agricultural price transmission during price bubbles, in particular, considering Italian and international weekly spot (cash) price data over years 2006–2010. Kumari *et al.*, (2019)^[13] examined cointegration of major redgram markets and price movement in major markets in India using econometric tools like Augmented dickey-fuller (ADF), Johansen's cointegration test, granger causality test and vector error correction model (VECM). Kumari *et al.*, (2022)^[12] studied Co-integration and causality analysis of castor markets in Telangana state, the results showed that Devarakadra market influenced the prices in the other three major markets *i.e.*, Badepalli, Gadwal and Narayanpet.

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. However, this method clearly has some limitations, as it cannot measure the direction of price integration between two markets. The co-integration 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 does, 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.* $v_{it} (=P_{it} \otimes \beta P_{it}) \sim I(0)$.

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)^[6] 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)^[8]. 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) is 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)^[5]. The number of the appropriate lag for ADF is 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.

$$\Delta \ln P_t = \alpha_0 + \delta_1 t + \gamma \ln P_{t-1} + \sum_{j=1}^q \theta_j \Delta \ln P_{t-j} + \varepsilon_t \quad (1)$$

Where, P the price in each market, Δ is the difference parameters (*i.e.*, $\Delta P_1 = P_t - P_{t-1}$, $P_{t-1} = P_{t-1} - P_{t-2}$ 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 or error term.

Johansen Cointegration

The maximum likelihood (ML) method of cointegration is applied to check long-run wholesale prices relation between the selected Sesamum markets of India (Johansen, 1988; Johansen and Juselius, 1990)^[10]. The starting point of the ML method is vector autoregressive model of order (k) and may be written as:

$$P_t = \sum_{i=1}^k A_i P_{t-i} + \mu + \beta_t + \varepsilon_t; (t=1, 2, 3 \dots T) \quad (2)$$

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:

$$\Delta P_t = \prod P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \beta \mu_t + \varepsilon_t \quad (3)$$

Where,

$$\Gamma_i = -(I - \Pi_i, \dots, T); i=1, 2, \dots, k-1$$

$$\Pi = -(I - \Pi, \dots, \Pi_k)$$

Both Γ_i and Π_i are the $n \times n$ 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 are independent and identically distributed (*i.i.d.*). 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 inverting the matrix Π^{-1} for P_t and as a linear combination of stationary variable (Kirchgässner, *et al.*, 2012)^[11]. The stationary linear combination of the P_t 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 $0 < \text{rank}(\Pi) = r < n$ then there are $n \times r$ cointegrating vectors. The central point of the Johansen's procedure is simply to

decompose Π into two $n \times r$ matrices such that $\Pi = \alpha\beta'$. The decomposition of Π implies that the $\beta'Pt$ are r stationary linear combination.

Johansen and Juselius, (1990) proposed two likelihood ratio test statistics (Trace and Max Eigen test statistics) to determine the number of cointegrating vectors as follows:

$$J_{trace} = -T \sum_{i=r+1}^N \ln(1 - \hat{\lambda}_i) \quad (4)$$

$$\lambda_{max} = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (5)$$

Where, r is the number cointegrated vector, $\hat{\lambda}_1$ is the eigen value and $\hat{\lambda}_{r+1}$ is the $(r + 1)^{th}$ largest squared eigen value obtained from the matrix Π and the T is the effective number of observations. 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:

$$\Delta P_{it} = \gamma_1 + \gamma_2 \Delta P_{it} - \pi \hat{u}_{it-1} + v_{it} \quad (6)$$

In this model, γ_2 is the impact multiplier (the short-run effect) that measures the immediate impact that a change in P_{it} 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 $\hat{u}_{t-1} = P_{it-1} - \hat{p}_1 - \hat{p}_2 P_{it-1}$ 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_{it} , determine another time-series variable, say P_{it} , then there exists a Granger causality relationship between P_{it} and P_{it} , in which P_{it} is Granger caused by P_{it} . Bessler and Brandt (1982) [3] firstly introduced this test into research on market integration to determine the leading market.

From the above analysis, the model is specified as follows:

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

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

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

$$\theta_{21} = \dots = \theta_{2n} = \dots = \gamma_1 = 0 \quad (\text{No causality from } P_{it} \text{ to } P_{it})$$

$$\theta_{41} = \dots = \theta_{4n} = \dots = \gamma_2 = 0 \quad (\text{No causality from } P_{it} \text{ to } P_{it})$$

Software used for the analysis EViews

Data and Methodology

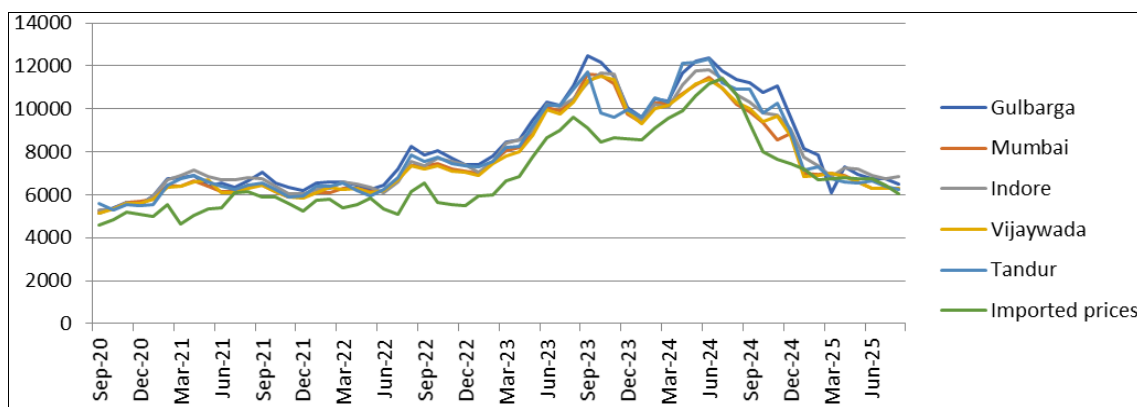
Gulbarga, Mumbai, Indore, Vijayawada and Tandur are the five domestic redgram market prices and imported prices selected for the study. The required secondary data on redgram prices in the above markets were collected for the period from September, 2020 to August, 2025 from websites www.agriwatch.com, tgmarketing and www.commerce.gov.in

The statistical analysis was carried in three steps. The first step involves testing for the order of integration, with time series data on price of redgram in each market at the levels

and first differencing, using the Augmented Dickey-Fuller (ADF). Conditional on the outcome of the tests, the second stage involves investigating pair-wise redgram market time series prices co-integration utilizing the Johansen's maximum likelihood approach. If pair-wise markets co-integration exists, however, there is no guarantee that the two markets belong to one market (the law of one price). On the basis of the pair-wise redgram market co-integration results in the third stage Vector Error Correction Model (VECM) was used to examine interaction effects, taking the error term from this co-integrating regression as a measure of the VECM term to capture the short run dynamics and causality of the model. The necessary condition for doing the co-integration analysis is to determine, whether the two price series are stationary or not.

Results and Discussion

It is evident from Figure 1 that all major markets of redgram in the country were found to be highly integrated with regard to price movement. And imported prices also integrated with domestic market prices.



Source: www.agriwatch.com, tgmarketing and www.commerce.gov.in

Fig 1: Average monthly prices of redgram in major markets of India and imported prices (Rs/q)

Testing stationarity

In order to check the stationarity of price series of redgram, the Augmented Dickey Fuller based unit root tests were used and the results are presented in Table 1.

It is observed from the table that the ADF values are below the critical value at 5% level of significance indicating the non existence of unit root. This implies that the redgram price series are non stationary at level in Gulbarga, Mumbai,

Indore, Vijayawada and Tandur markets and Imported prices which recorded lower ADF values than that of critical values at 5% level. The results of the table further showed that in first difference, the ADF values are higher than the critical value at 5% level indicated that the price series are free from the consequences of unit root. This implies that the price series are stationary at 1st difference level.

Table 1: Augmented dickey-fuller test for testing stationarity

Series	Original Series t-Statistic	1 st order differenced series t-Statistic
Gulbarga	-1.48	-6.20
Mumbai	-1.31	-5.92
Indore	-1.77	-5.31
Vijayawada	-1.64	-5.23
Tandur	-1.33	-6.96
Imported prices	-1.69	-5.21

5% critical value for ADF statistics are -2.92

Co integration among the prices of the commodity in different markets

Johansen's Co-integration test for selected redgram 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 null

hypothesis statement of existence of r co-integrated relationship against the alternative hypothesis of $r + 1$ co-integration relationship was tested. Johansen (1988) [10] and Johansen and Juselius (1990) [10] have given new technique for co integration for long run as well as short run relationships for multivariate equation.

Table 2: Results of Johansen's Multiple Co-integration Test for Redgram Prices

No. of CE(s)	Eigen value	Trace Statistic	Critical Value	Prob.	Max-Eigen Statistic	Critical Value	Prob.
None *	0.819376	289.8811	95.75366	0.0000	0.819376	97.54639	40.07757
At most 1 *	0.659675	192.3347	69.81889	0.0000	0.659675	61.43766	33.87687
At most 2 *	0.619367	130.897	47.85613	0.0000	0.619367	55.05737	27.58434
At most 3 *	0.445336	75.83967	29.79707	0.0000	0.445336	33.59543	21.13162
At most 4 *	0.407774	42.24424	15.49471	0.0000	0.407774	29.86038	14.2646
At most 5 *	0.19528	12.38386	3.841466	0.0004	0.19528	12.38386	3.841466

Johansen's Multiple Co-integration test was employed to determine the long run relationship between the price series. The test shows whether the selected redgram markets are integrated or not. The results of the test are presented in Table 2.

The results of co-integration test showed at least six co-integration equations at 5% level of significance indicating that the selected redgram markets are having long run equilibrium relationship and there exists co-integration between them.

Causality among prices

In order to know the direction of causation between the markets Granger Causality test was employed. When a co-integration relationship is present for two variables, a Granger Causality Test (Granger, 1969) can be used to analyze the direction of this co-movement relationship. Theoretically, a variable is said to Granger-cause another variable, if the current value is conditional on the past value.

Table 3: Testing for pair-wise Granger causality

Null Hypothesis	F-Statistic	Prob.	Direction
IMPORTED_PRICES does not Granger Cause GULBARGA	2.88	0.0649	
GULBARGA does not Granger Cause IMPORTED_PRICES	1.05	0.3573	
INDORE does not Granger Cause GULBARGA	0.16	0.8567	
GULBARGA does not Granger Cause INDORE	3.73	0.0307	→
MUMBAI does not Granger Cause GULBARGA	2.91	0.0634	
GULBARGA does not Granger Cause MUMBAI	5.97	0.0046	→
TANDUR does not Granger Cause GULBARGA	8.97	0.0004	→
GULBARGA does not Granger Cause TANDUR	0.39	0.6788	
VIJAYAWADA does not Granger Cause GULBARGA	0.65	0.5258	
GULBARGA does not Granger Cause VIJAYAWADA	2.70	0.0764	
INDORE does not Granger Cause IMPORTED_PRICES	2.53	0.0898	
IMPORTED_PRICES does not Granger Cause INDORE	3.69	0.0318	→
MUMBAI does not Granger Cause IMPORTED_PRICES	1.63	0.2060	
IMPORTED_PRICES does not Granger Cause MUMBAI	2.68	0.0777	
TANDUR does not Granger Cause IMPORTED_PRICES	2.20	0.1205	
IMPORTED_PRICES does not Granger Cause TANDUR	1.89	0.1620	
VIJAYAWADA does not Granger Cause IMPORTED_PRICES	1.42	0.2517	
IMPORTED_PRICES does not Granger Cause VIJAYAWADA	2.74	0.0738	
MUMBAI does not Granger Cause INDORE	6.82	0.0023	→
INDORE does not Granger Cause MUMBAI	2.74	0.0742	
TANDUR does not Granger Cause INDORE	11.82	0.0006	→
INDORE does not Granger Cause TANDUR	0.03	0.9702	
VIJAYAWADA does not Granger Cause INDORE	2.87	0.0659	
INDORE does not Granger Cause VIJAYAWADA	0.09	0.9096	
TANDUR does not Granger Cause MUMBAI	7.66	0.0012	→
MUMBAI does not Granger Cause TANDUR	1.28	0.2863	
VIJAYAWADA does not Granger Cause MUMBAI	10.31	0.0002	↔
MUMBAI does not Granger Cause VIJAYAWADA	7.08	0.0019	
VIJAYAWADA does not Granger Cause TANDUR	0.02	0.9783	
TANDUR does not Granger Cause VIJAYAWADA	6.03	0.0044	

Engle and Granger (1987) showed that if two series are individually I (1), and co-integrated, a causal relationship will exist in at least one direction. For two first order co-integrated vectors, two stages are needed to estimate error correction model. First, the pair-wise Granger Causality test approach is carried out to know how much of influence of market prices can be explained by past values of that market prices; then second, to see whether adding lagged values of another major market prices can improve the explanation of behavior of prices in the previous price behavior of another market. The Granger causality test was conducted to analyze the influence of one market on the prices of other markets. The casual relationship between the price series of selected redgram markets were approached through Granger Causality technique. The results of the analysis showing the relationship between selected redgram markets are presented in Table 3.

It was observed from Table 3 that there is bidirectional causality affected on redgram prices of Mumbai – Vijayawada. There is unidirectional causality affected on redgram prices of Gulbarga – Indore, Gulbarga – Mumbai, Tandur – Gulbarga, Imported prices – Indore, Mumbai –

Indore, Tandur – Indore and Tandur – Vijayawada. It indicates that Indore prices are depending up on Gulbarga, Imported prices, Mumbai and Tandur.

Lead/lag markets, distortions in the markets

Since the Johansen's Multiple Co-integration test results showed that the selected redgram markets have long run equilibrium relationship and there exists co-integration between them. Hence, the Vector Error Correction Model (VECM) was employed to know the speed of adjustments among the redgram markets for short run and long run equilibrium. The results of VECM are presented in Table 4. The estimates of Vector Error Correction Model revealed that Mumbai market two months lag price is affecting current prices of Gulbarga, Indore Mumbai and Vijayawada markets. Tandur market two months lag price is affecting current prices of Gulbarga, Indore Mumbai and Vijayawada markets. Vijayawada market one month lag price is affecting current prices of Mumbai market. Vijayawada market two months lag price is affecting current prices of Mumbai and Vijayawada markets.

Table 4: Speed of adjustment as measured by the Error correction term in VECM

	Gulbarga	Imported Prices	Indore	Mumbai	Tandur	Vijayawada
C	[-0.17859]	[-0.07613]	[-0.35000]	[-0.04606]	[-0.01138]	[-0.13145]
Gulbarga(-1)	[-0.45398]	[-1.32077]	[0.98369]	[1.23130]	[-0.12465]	[1.54381]
Gulbarga(-2)	[-0.65755]	[-1.09525]	[-0.22933]	[-0.28638]	[-0.70179]	[-0.51455]
Imported Prices(-1)	[0.39210]	[1.08466]	[-0.25541]	[1.12700]	[1.27699]	[0.03246]
Imported Prices(-2)	[0.45035]	[-0.48680]	[0.68906]	[1.31728]	[0.65031]	[0.26287]
Indore(-1)	[-1.43334]	[1.67781]	[-1.89123]	[-1.06023]	[0.18344]	[-1.40375]
Indore(-2)	[-1.66226]	[0.11760]	[-1.98274]	[-0.96718]	[0.13509]	[-0.38096]
Mumbai(-1)	[0.78300]	[-0.21000]	[0.61489]	[-1.58444]	[-0.84434]	[1.01811]
Mumbai(-2)	[2.86383]	[0.23016]	[2.89159]	[2.05643]	[1.03459]	[3.21249]
Tandur(-1)	[1.82807]	[0.90745]	[1.53408]	[1.71979]	[0.07664]	[1.30229]
Tandur(-2)	[2.98443]	[1.65295]	[3.54620]	[3.19613]	[1.08682]	[2.89940]
Vijayawada(-1)	[0.42243]	[-0.10839]	[1.01246]	[2.04283]	[0.67166]	[-0.09797]
Vijayawada(-2)	[-1.12821]	[-0.21126]	[-1.63461]	[-2.48751]	[-1.04967]	[-3.42657]

Conclusion

The overall analysis of redgram prices across major domestic markets and imported prices provides clear evidence of strong market integration and dynamic inter-relationships. The results of the Augmented Dickey–Fuller (ADF) test confirmed that all price series were non-stationary at their original levels but became stationary after first differencing, indicating the presence of unit roots and the suitability of further long-run and short-run integration analysis. The Granger causality results revealed both bidirectional and unidirectional causal relationships among the selected markets. A bidirectional causal flow between Mumbai and Vijayawada suggests strong mutual price influence, while several unidirectional causal relationships—particularly those directed toward Indore—indicate that price movements in Indore are significantly shaped by upstream markets such as Gulbarga, Mumbai, Tandur, and imported price trends. This highlights Indore as a price-receiving market rather than a price-leading one. The Vector Error Correction Model (VECM) further emphasized the presence of long-run equilibrium among the markets. The lagged prices of Mumbai and Tandur (especially the two-month lag) were found to significantly influence the current prices in Gulbarga, Indore, Mumbai, and Vijayawada, demonstrating their dominant role in the price formation mechanism. Additionally, the influence of Vijayawada's lagged prices on Mumbai underscores the interconnectedness of southern and western market price dynamics. Overall, the study concludes that major redgram markets in India and imported prices are highly integrated, with clear long-run and short-run causal linkages. Mumbai and Tandur emerge as influential markets in determining national price movements, while Indore acts predominantly as a price follower. These findings have important implications for market forecasting, policy planning, and designing efficient procurement and marketing strategies for redgram in India.

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