**PERFORMANCE OF GROUNDNUT MARKETS IN KARNATAKA – AN ECONOMIC ANALYSIS**

**ABSTRACT**

The present study aims to evaluate the spatial price linkages between groundnut markets in Karnataka using monthly price data of groundnut (2002- 2022). The required secondary data were collected from published reports of APMC’s, Krishimaratavahini etc. For the study top ten groundnut markets such as Yadgir, Laxmeshwar, Raichur, Ballari, Challakere, Hubbali, Gadag, Mundargi, Chitradurga and Kottur were selected based on groundnut arrivals. The study uses Augmented Dickey Fuller, Johansen co-integration, Granger causality test and Vector error correction model (VECM) to fulfil the objectives of the study. The study concluded that all the price series of the groundnut market were found to be non-stationery at level and stationery at first difference except Kottur market. There is a bidirectional causation relationship in price transmission among all chosen groundnut markets except Yadgir-Raichur, Ballari-Raichur, Challakere-Raichur, Gadag-Raichur, Mundargi-Raichur, Kottur-Raichur, Challakere-Ballari where prices influenced unidirectional. Five out of the ten markets were cointegrated at a significance level of 5 per cent indicating that the chosen groundnut markets had long-run equilibrium relationships. The results from the VECM Model showed that the rate at which error correction coefficient restored deviation from equilibrium was high in Yadgir market, moderate in Mundargi and in other groundnut markets shown less.

Key words: Markets, Johnson cointegration test, Granger causality test, ADF, VECM.

**Introduction:**

Price is the amount of money that has to be paid to acquire a given product. It can be called as an indicator of economic growth. The market price is the price prevailing in the market. The price fluctuates in the market with the time may be within a day, within a week, within a month or within a season. The price of agricultural produce in the market influenced by its arrivals (supply) to the market (Kolageri and Banakar, 2018). Spatial market integration refers to a situation in which the price of the commodity in spatially separated markets move together and price signals and information are transmitted smoothly(Ghosh, 2010)**.** Spatial price linkage is the linkage between regional markets through prices of agricultural commodities. Spatially price behaviour in regional market may be used to measure the degree of integration of markets. Groundnut is a major oilseed crop contributing around 25.14 per cent of the total oilseeds production in the country during 2021-22. Among the states, Gujarat, Rajasthan and Tamil Nadu together account for close to 80 per cent of the annual output of groundnut in the country (Anon, 2022). In Karnataka, area under groundnut crop was about 5.90 lakh hectares and stands in fifth position contributing seven per cent to total production of groundnut in India (Anon, 2023). the present study was undertaken in the Karnataka state with the objective to assess the spatial price linkages in major groundnut markets.

**Data and Methodology:**

The study was conducted in the Karnataka state. The top ten groundnut markets for the study were selected based on the triennium average (2019-20, 2020-21 and 2021-22) of market arrivals. The secondary data related to market arrivals and prices of groundnut crops at district level was obtained from respective APMC’s district statistical officer and various reports published by DES, Bangalore. Among the agricultural markets in the state, the top ten major groundnut markets were selected based on highest market arrivals viz, Yadgir, Laxmeshwar, Raichur, Ballari, Challakere, Hubballi, Gadag, Mundargi, Chitradurga and Kottur to determine the spatial price linkages in the groundnut markets. The analytical techniques used in the study are described below.

1. **Unit root test: Augmented Dickey Fuller (ADF) test**

A stationary series or series with no unit root is one with a mean value which will not vary with the sampling period. In contrast, a non-stationary series will exhibit a time varying mean (Juselius, 2006). Before examining integration relationships between or among markets, it is essential to test for unit root and identify the order of stationarity, denoted as I (0) or I (1). This is necessary to avoid spurious and misleading regression estimates. The framework of ADF methods is based on analysis of the following model

Here, pt is the groundnut price series being investigated for stationarity, ∆ is first difference operator, T is time trend variable, μt represents zero-mean, serially uncorrelated, random disturbances, k is the lag length; α, β, γ and δk are the coefficient vectors. Unit root tests were conducted on the β parameters to determine whether or not each of the groundnut market series is more closely identified as being I (1) or I (0) process (Dickey & Fuller, 1979).

1. **Johansen’s cointegration method**

Cointegration depicts a long-term relationship between variables; even if two or more series are non-stationary, they are said to be cointegrated if there exists a stationary linear combination of them. After establishing that the price series are stationary at the level or same order of differences, the maximum likelihood method of cointegration is applied to check the number of cointegrating vectors (Johansen 1988; Johansen and Juselius 1990). The null hypothesis of at most ‘r’ cointegrating vectors against a general alternative hypothesis of ‘r+1’ cointegrating vectors is tested by trace statistics. The number of cointegrating vectors indicated by the tests is an important indicator of the extent of the co-movement of prices. An increase in the number of cointegrating vectors implies an increase in the strength and stability of price linkages.

1. **Vector Error Correction Model**

The cointegration analysis reflects the long-run movement of two or more series, although they may drift apart in the short run. Once the series is found to be cointegrated, the next step is to find out the short run relationship along with the speed of adjustment towards equilibrium using an error correction model, represented by the equations:

Where,

ECTt-1 is the lagged error correction term

Xt and Yt are the variables under consideration transformed through natural logarithm

Xt-i and Yt-i are the lagged values of variables X and Y

The γ is the error correction coefficient that measures the response of the regressor in each period to departures from equilibrium. The negative and statistically significant values of γ depict the speed of adjustment in restoring equilibrium after disequilibrium, and if it is positive and zero, the series diverges from equilibrium.

1. **Granger causality test**

After undertaking the cointegration analysis of the long-run linkages of the various variables, and after identifying how they will be linked, the causal relationship between the prices series in the selected groundnut markets will be approached through Granger’s causality technique. If a variable Y is Granger-caused by variable X, it means that the values of variable X helps to predict the values of variable Y and vice versa. The Granger causality test conducted within the framework of a vector auto regression (VAR) model was used to test the existence of a long-run causal price relationship between markets and the direction of that relationship. The F-test was used to check whether the significance of changes in one price series affects another price series. This test also identifies the key market, i.e., the market that influences the price of all other markets (price leader). The causality relationship between two price series, based on the following pairs of ordinary least square (OLS) regression equations through a bivariate VAR, is given by the equations below:

Where

X and Y are two different market prices series

ln stands for price series in logarithm form t is the time trend variable

The subscript stands for the number of lags of both variables in the system

The null hypothesis in both equations is a test that ln Xt does not Granger-cause ln Yt. In each case, a rejection of the null hypothesis will imply that there is Granger causality between the variables.

**Result and Discussion:**

1. **Unit root test of groundnut markets in Karnataka**

The results of the ADF test for groundnut markets at level and at first difference are represented in Table 1. It could be seen from the table that the price series of groundnut for all markets accepted the null hypothesis of nonstationary compared at their level except Kottur market as the probability values (0.09) were higher compared to t-statistics values at 5 per cent significance level. The t-statistics of ADF test was found to be smaller in all markets than compared to probability values which signify that the groundnut price series were nonstationary in nature at level. The table results showed that the groundnut price series in all selected markets rejected the null hypothesis of having unit root at first difference I(1) which signifies that the underlying price series are stationary in nature at 5 per cent level of significance. These findings are in line with the findings of Ikudayisi and Salman (2014), who showed that the Ho of unit root for all the time series were rejected at their first difference. The results are also similar to Burark *et al*. (2015) on soybean that at least four cointegrating equations at 5 per cent level of significance.

**Table 1.** **Stationarity of groundnut markets**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Markets** | **Level** | | | **First difference** | | |
| **t-statistics** | **Probability** | **Stationarity** | **t-statistics** | **Probability** | **Stationarity** |
| Yadgir | 0.09 | 0.96 | Nonstationary | -10.62 | 0.00 | Stationary |
| Laxmeshwar | -1.30 | 0.63 | Nonstationary | -15.66 | 0.00 | Stationary |
| Raichur | -1.61 | 0.47 | Nonstationary | -4.67 | 0.00 | Stationary |
| Ballari | -0.84 | 0.80 | Nonstationary | -11.30 | 0.00 | Stationary |
| Challakere | -1.16 | 0.69 | Nonstationary | -11.21 | 0.00 | Stationary |
| Hubballi | -1.55 | 0.51 | Nonstationary | -19.12 | 0.00 | Stationary |
| Gadag | -1.54 | 0.51 | Nonstationary | -15.68 | 0.00 | Stationary |
| Mundargi | -1.66 | 0.45 | Nonstationary | -13.48 | 0.00 | Stationary |
| Chitradurga | -1.72 | 0.42 | Nonstationary | -22.62 | 0.00 | Stationary |
| Kotturu | -2.81 | 0.06 | Stationary | - | - | - |

Note: 5% Critical value: 2.873

1. **Johansen’s cointegration test for groundnut markets**

The Johansen co-integration test results for groundnut markets are presented in Table 2. It could be seen from the results that, both maximum eigenvalue and trace statistics rejected the null hypothesis of number of co-integration equation among selected groundnut markets and accepted the alternative hypothesis of having presence of five co-integrating equations among groundnut markets in the study area. The presence of number of co-integration equations were decided based on either maximum Eigenvalue or Trace statistics. The results of the table revealed that the trace statistics values of groundnut markets viz, 361.49, 267.84, 196.54, 146.72 and 101.41 were found to be higher than compared to critical values indicating the existence of five co-integrating equations between selected groundnut markets. Similarly, maximum eigen test statistics values 93.64 and 71.31 were found to be higher than compared to critical values which showed that there was existence of two cointegrating equations among the selected groundnut markets. So, both the tests showed that the selected groundnut markets had long-run relationships and were cointegrated among themselves. This might be indicating their effective integration and the transmission of price signals from one market to another market. The study concluded that the Johnson cointegration test had shown that despite being geographically separated and spatially segmented, the selected groundnut markets in Karnataka were well-connected in terms of price movements/signals, proving that there was long-term price linkage between the selected groundnut markets in the state. These results are in line with the results of Nayak *et al*. (2020) and Pant and Sharma (2022) who also reported the presence of co-integrating equations among the selected markets.

**Table 2. Co-integration of groundnut markets**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | | | **Maximum Eigen value** | | |
| **Trace Statistic** | **Critical Value** | **Prob.\*\*** | **Max-Eigen Statistics** | **Critical value** | **Prob.\*\*** |
| None \* | 0.32 | 361.49 | 239.24 | 0.00 | 93.64 | 64.50 | 0.00 |
| At most 1 \* | 0.25 | 267.85 | 197.37 | 0.00 | 71.31 | 58.43 | 0.00 |
| At most 2 \* | 0.18 | 196.54 | 159.53 | 0.00 | 49.82 | 52.36 | 0.09 |
| At most 3 \* | 0.17 | 146.72 | 125.62 | 0.00 | 45.30 | 46.23 | 0.06 |
| At most 4 \* | 0.13 | 101.42 | 95.75 | 0.02 | 34.06 | 40.08 | 0.20 |
| At most 5 | 0.10 | 67.36 | 69.82 | 0.08 | 26.18 | 33.88 | 0.31 |
| At most 6 | 0.07 | 41.17 | 47.86 | 0.18 | 17.11 | 27.58 | 0.57 |
| At most 7 | 0.06 | 24.06 | 29.80 | 0.20 | 14.88 | 21.13 | 0.30 |
| At most 8 | 0.04 | 9.19 | 15.50 | 0.35 | 8.71 | 14.26 | 0.31 |
| At most 9 | 0.00 | 0.48 | 3.84 | 0.49 | 0.47 | 3.84 | 0.49 |

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

1. **Granger causal relationship among groundnut markets**

The Granger Causality technique was used to determine the direction of causation or causal relationship between the price series of groundnut markets and results were presented in Table 3. It could be seen from the results of the table that there was a bidirectional causation relationship in price transmission among the chosen groundnut markets in study area except market pairs such as Yadgir- Raichur, Ballari-Raichur, Challakere-Raichur, Gadag-Raichur, Mundargi-Raichur, Kottur-Raichur and Challakere-Ballari where market prices influenced unidirectionally. In case of bidirectional causation, the study showed that price changes in former market in each pair have impact on the price of the groundnut in the latter market, but the latter market price change was supported by the price change in the former market, whereas in case of unidirectional causation, a price change of former groundnut market causes the impact of price change in latter market, whereas as the price change in the latter market was not have any impact on the price of the groundnut in former market.

**Table 3.** **Pair-wise causality of groundnut markets in Karnataka**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Null hypothesis** | **F-statistic** | **Probability** | **Granger cause** | **Direction** |
| LAX does not Granger Cause YAD  YAD does not Granger Cause LAX | 21.360  14.246 | 3.E-09  1.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| RAI does not Granger Cause YAD  YAD does not Granger Cause RAI | 30.920  2.258 | 1.E-12  0.106 | Yes  No | Bidirectional  Unidirectional |
| BAL does not Granger Cause YAD  YAD does not Granger Cause BAL | 11.698  12.507 | 1.E-05  7.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| CHAL does not Granger Cause YAD  YAD does not Granger Cause CHAL | 12.032  15.133 | 1.E-05  6.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| HUB does not Granger Cause YAD  YAD does not Granger Cause HUB | 29.136  6.139 | 4.E-12  0.0025 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause YAD  YAD does not Granger Cause GAD | 14.310  10.918 | 1.E-06  3.E-05 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause YAD  YAD does not Granger Cause MUND | 14.633  30.304 | 1.E-06  2.E-12 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause YAD  YAD does not Granger Cause CHITR | 28.763  5.888 | 6.E-12  0.0032 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause YAD  YAD does not Granger Cause KOTT | 20.102  13.135 | 8.E-09  4.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| RAI does not Granger Cause LAX  LAX does not Granger Cause RAI | 26.309  5.257 | 4.E-11  0.0058 | Yes  Yes | Bidirectional  Bidirectional |
| BAL does not Granger Cause LAX  LAX does not Granger Cause BAL | 52.682  14.818 | 9.E-20  8.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| CHAL does not Granger Cause LAX  LAX does not Granger Cause CHAL | 33.404  6.657 | 1.E-13  0.0015 | Yes  Yes | Bidirectional  Bidirectional |
| HUB does not Granger Cause LAX  LAX does not Granger Cause HUB | 4.513  8.379 | 0.0119  0.0003 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause LAX  LAX does not Granger Cause GAD | 13.178  6.234 | 4.E-06  0.0023 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause LAX  LAX does not Granger Cause MUND | 33.411  11.224 | 1.E-13  2.E-05 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause LAX  LAX does not Granger Cause CHITR | 9.765  15.658 | 8.E-05  4.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause LAX  LAX does not Granger Cause KOTT | 12.117  15.0868 | 1.E-05  7.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| BAL does not Granger Cause RAI  RAI does not Granger Cause BAL | 2.707  12.832 | 0.0687  5.E-06 | No  Yes | Unidirectional  Bidirectional |
| CHAL does not Granger Cause RAI  RAI does not Granger Cause CHAL | 0.960  23.568 | 0.3842  4.E-10 | No  Yes | Unidirectional  Bidirectional |
| HUB does not Granger Cause RAI  RAI does not Granger Cause HUB | 13.020  8.248 | 4.E-06  0.0003 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause RAI  RAI does not Granger Cause GAD | 3.001  13.748 | 0.0516  2.E-06 | No  Yes | Unidirectional  Bidirectional |
| MUND does not Granger Cause RAI  RAI does not Granger Cause MUND | 1.279  32.111 | 0.2799  4.E-13 | No  Yes | Unidirectional  Bidirectional |
| CHITR does not Granger Cause RAI  RAI does not Granger Cause CHITR | 10.432  13.526 | 4.E-05  3.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause RAI  RAI does not Granger Cause KOTT | 1.766  28.739 | 0.173  6.E-12 | No  Yes | Unidirectional  Bidirectional |
| CHAL does not Granger Cause BAL  BAL does not Granger Cause CHAL | 0.608  18.369 | 0.5448  4.E-08 | No  Yes | Unidirectional  Bidirectional |
| HUB does not Granger Cause BAL  BAL does not Granger Cause HUB | 12.962  34.697 | 4.E-06  5.E-14 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause BAL  BAL does not Granger Cause GAD | 14.123  23.450 | 2.E-06  5.E-10 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause BAL  BAL does not Granger Cause MUND | 7.895  30.045 | 0.0005  2.E-12 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause BAL  BAL does not Granger Cause CHITR | 12.328  17.205 | 8.E-06  1.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause BAL  BAL does not Granger Cause KOTT | 6.386  29.319 | 0.002  4.E-12 | Yes  Yes | Bidirectional  Bidirectional |
| HUB does not Granger Cause CHAL  CHAL does not Granger Cause HUB | 11.188  18.545 | 2.E-05  3.E-08 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause CHAL  CHAL does not Granger Cause GAD | 11.741  7.567 | 1.E-05  0.0006 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause CHAL  CHAL does not Granger Cause MUND | 13.802  11.799 | 2.E-06  1.E-05 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause CHAL  CHAL does not Granger Cause CHITR | 13.258  14.664 | 3.E-06  1.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause CHAL  CHAL does not Granger Cause KOTT | 10.167  20.085 | 6.E-05  8.E-09 | Yes  Yes | Bidirectional  Bidirectional |
| GAD does not Granger Cause HUB  HUB does not Granger Cause GAD | 14.959  4.295 | 7.E-07  0.0147 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause HUB  HUB does not Granger Cause MUND | 19.678  7.372 | 1.E-08  0.0008 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause HUB  HUB does not Granger Cause CHITR | 4.282  18.09 | 0.0149  5.E-08 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause HUB  HUB does not Granger Cause KOTT | 5.742  20.514 | 0.0037  6.E-09 | Yes  Yes | Bidirectional  Bidirectional |
| MUND does not Granger Cause GAD  GAD does not Granger Cause MUND | 22.069  15.545 | 2.E-09  4.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause GAD  GAD does not Granger Cause CHITR | 8.014  15.522 | 0.0004  4.E-07 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause GAD  GAD does not Granger Cause KOTT | 5.844  12.314 | 0.0033  8.E-06 | Yes  Yes | Bidirectional  Bidirectional |
| CHITR does not Granger Cause MUND  MUND does not Granger Cause CHITR | 14.400  19.826 | 1.E-06  1.E-08 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause MUND  MUND does not Granger Cause KOTT | 8.044  20.553 | 0.0004  6.E-09 | Yes  Yes | Bidirectional  Bidirectional |
| KOTT does not Granger Cause CHITR  CHITR does not Granger Cause KOTT | 11.471  14.259 | 2.E-05  1.E-06 | Yes  Yes | Bidirectional  Bidirectional |

**Price series:** Yad- Yadgir, Lax- Laxmeshwar, Rai- Raichur, Bal- Ballari, Chal- Challakere, Hub- Hubballi, Gad- Gadag, Mund- Mundargi, Chitr- Chitradurga, Kott-Kottur

1. **Vector error correction model showing the long-run effects**:

The Vector Error Correction model results for groundnut markets are presented in Table 4. The error correction term (ECT) indicated the speed of adjustment towards long-run equilibrium of groundnut markets in the study area but this ECT term should significant and sign must be negative in nature. The error correction term of groundnut markets indicated that, the Error Correction terms of Yadgir, Raichur, Ballari and Kottur markets were found to be significant and negative. Whereas, the ECT of Laxmeshwar, Challakere, Hubballi, Gadag, Mundargi and Chitradurga markets were positive and significant in nature. The above said results of the study depicted that the change in price of groundnut in Yadgir, Raichur, Ballari and Kottur market have influenced and have impact on the price of other groundnut markets in the long run period, whereas change in price of groundnut in Laxmeshwar, Challakere, Hubballi, Gadag, Mundargi and Chitradurga will not have any impact on the price of other groundnut markets on the long run.

It could be seen from the results of the table that the information flow was more in Yadgir market which was 68 per cent followed by Mundargi (32.00 %), Hubballi (19.00 %) and Raichur (10.00 %) markets whereas the remaining markets such as Laxmeshwar (9.00 %), Ballari (0.30%), Challakere (2.50 %), Gadag (2.40 %), Kottur (3.00 %) and Chitradurga (1.00 %) were having very less information flow in the markets. The study showed that the price adjustment occurs more quickly in Yadgir followed by Mundargi, Hubballi and Raichur markets.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Error Correction:**  **Table 4. Long -term relationship between the selected groundnut markets in Karnataka** | **D (YAD)** | **D (LAX)** | **D (RAI)** | **D (BAL)** | **D (CHAL)** | **D (HUB)** | **D (GAD)** | **D (MUND)** | **D (CHITR)** | **D (KOTT)** |
| **CointEq1** | -0.68  (-0.08)  [-8.51] | 0.09  (-0.05)  [ 1.70] | -0.10  (-0.06)  [-1.75] | -0.003  (-0.05)  [-0.06] | 0.03  (-0.05)  [ 0.51] | 0.19  (-0.06)  [ 3.14] | 0.02  (-0.04)  [0.55] | 0.32  (-0.06)  [5.67] | 0.01  (-0.09)  [0.10] | -0.03  (-0.09)  [-0.30] |
| **D (YAD (-1))** | 0.19  (-0.08)  **[ 2.53]** | -0.13  (-0.05)  **[-2.59]** | 0.12  (-0.06)  **[ 2.26]** | 0.05  (-0.05)  [ 0.93] | 0.02  (-0.05)  [ 0.45] | -0.20  (-0.06)  **[-3.43]** | -0.06  (-0.04)  [-1.52] | -0.20  (-0.05)  **[-3.78]** | -0.04  (-0.09)  [-0.44] | -0.08  (-0.09)  [-0.87] |
| **D (YAD (-2))** | 0.21  (-0.07)  **[ 3.11]** | -0.05  (-0.05)  [-1.13] | 0.17  (-0.05)  **[ 3.31]** | 0.14  (-0.05)  **[ 3.04]** | 0.10  (-0.04)  **[ 2.19]** | -0.23  (-0.05)  **[-4.41]** | 0.01  (-0.04)  [0.38] | -0.05  (-0.05)  [-1.02] | -0.03  (-0.08)  [-0.38] | -0.03  (-0.08)  [-0.33] |
| **D (LAX (-1))** | -0.09  (-0.11)  [-0.87] | -0.54  (-0.07)  **[-7.43]** | -0.07  (-0.08)  [-0.89] | -0.28  (-0.07)  **[-3.82]** | -0.14  (-0.07)  **[-2.07]** | 0.05  (-0.08)  [ 0.58] | 0.02  (-0.06)  [0.27] | -0.05  (-0.08)  [-0.59] | 0.10  (-0.13)  [0.76] | -0.22  (-0.13)  [-1.72] |
| **D (LAX (-2))** | 0.03  (-0.11)  [ 0.25] | -0.37  (-0.07)  **[-5.05]** | 0.00  (-0.08)  [ 0.02] | -0.18  (-0.07)  **[-2.39]** | -0.20  (-0.07)  **[-2.92]** | 0.00  (-0.08)  [ 0.04] | -0.21  (-0.06)  **[-3.47]** | 0.05  (-0.08)  [0.61] | 0.08  (-0.13)  [0.60] | -0.24  (-0.13)  [-1.92] |
| **D (RAI (-1))** | 0.04  (-0.11)  [ 0.39] | 0.22  (-0.07)  **[ 3.09]** | -0.12  (-0.08)  [-1.48] | 0.15  (-0.07)  **[ 2.05]** | 0.11  (-0.07)  [ 1.56] | 0.04  (-0.08)  [0.46] | 0.02  (-0.06)  [0.37] | 0.19  (-0.08)  **[2.50]** | 0.17  (-0.13)  [1.33] | 0.27  (-0.13)  **[2.19]** |
| **D (RAI (-2))** | 0.21  (-0.11)  [ 1.95] | 0.06  (-0.07)  [ 0.80] | -0.05  (-0.08)  [-0.57] | -0.01  (-0.07)  [-0.08] | -0.01  (-0.07)  [-0.12] | 0.14  (-0.08)  [1.65] | 0.08  (-0.06)  [1.31] | 0.32  (-0.08)  **[4.14]** | -0.02  (-0.13)  [-0.15] | 0.41  (-0.13)  **[3.21]** |
| **D (BAL (-1))** | 0.48  (-0.14)  **[ 3.36]** | 0.10  (-0.10)  [ 1.08] | 0.27  (-0.11)  **[ 2.53]** | 0.04  (-0.10)  [ 0.44] | 0.31  (-0.09)  **[ 3.44]** | 0.24  (-0.11)  **[ 2.24]** | 0.20  (-0.08)  **[2.50]** | 0.16  (-0.10)  [1.55] | 0.05  (-0.17)  [0.28] | 0.30  (-0.17)  [1.82] |
| **D (BAL (-2))** | 0.13  (-0.14)  [ 0.93] | 0.08  (-0.09)  [ 0.86] | -0.01  (-0.10)  [-0.11] | 0.00  (-0.10)  [ 0.01] | 0.24  (-0.09)  **[ 2.66]** | 0.07  (-0.11)  [ 0.66] | -0.02  (-0.08)  [-0.27] | -0.17  (-0.10)  [-1.69] | -0.06  (-0.17)  [-0.36] | 0.14  (-0.16)  [0.85] |
| **D (CHAL (-1))** | -0.32  (-0.13)  **[-2.45]** | 0.18  (-0.09)  **[ 2.10]** | -0.09  (-0.10)  [-0.97] | -0.06  (-0.09)  [-0.74] | -0.33  (-0.08)  **[-3.99]** | 0.08  (-0.10)  [ 0.77] | -0.07  (-0.07)  [-0.95] | -0.05  (-0.09)  [-0.57] | 0.11  (-0.15)  [0.75] | -0.08  (-0.15)  [-0.55] |
| **D (CHAL (-2))** | -0.40  (-0.13)  **[-3.13]** | 0.11  (-0.09)  [ 1.35] | -0.28  (-0.09)  **[-3.00]** | -0.38  (-0.09)  **[-4.47]** | -0.53  (-0.08)  **[-6.48]** | 0.03  (-0.10)  [ 0.28] | -0.11  (-0.07)  [-1.60] | -0.03  (-0.09)  [-0.37] | -0.22  (-0.15)  [-1.49] | -0.28  (-0.15)  [-1.92] |
| **D (HUB (-1))** | -0.34  (-0.10)  **[-3.34]** | -0.01  (-0.07)  [-0.14] | -0.01  (-0.08)  [-0.10] | -0.01  (-0.07)  [-0.19] | -0.06  (-0.07)  [-0.87] | -0.21  (-0.08)  **[-2.63]** | 0.03  (-0.06)  [0.47] | 0.23  (-0.07)  **[3.15]** | 0.21  (-0.12)  [1.71] | 0.32  (-0.12)  **[2.66]** |
| **D (HUB (-2))** | -0.23  (-0.10)  **[-2.30]** | 0.03  (-0.07)  [ 0.45] | 0.06  (-0.07)  [ 0.83] | 0.02  (-0.07)  [ 0.24] | 0.03  (-0.06)  [ 0.45] | 0.09  (-0.08)  [ 1.17] | 0.09  (-0.06)  [1.68] | 0.08  (-0.07)  [1.11] | 0.13  (-0.12)  [1.14] | 0.27  (-0.11)  **[2.36]** |
| **D (GAD (-1))** | 0.34  (-0.14)  **[ 2.48]** | -0.04  (-0.09)  [-0.43] | 0.14  (-0.10)  [ 1.39] | 0.44  (-0.09)  **[ 4.77]** | 0.35  (-0.09)  **[ 4.02]** | -0.11  (-0.10)  [-1.06] | -0.17  (-0.08)  **[-2.23]** | 0.10  (-0.10)  [0.98] | 0.00  (-0.16)  [0.01] | 0.15  (-0.16)  [0.98] |
| **D (GAD (-2))** | 0.11  (-0.13)  [ 0.86] | -0.04  (-0.09)  [-0.40] | -0.08  (-0.10)  [-0.77] | 0.24  (-0.09)  **[ 2.77]** | 0.20  (-0.08)  **[ 2.41]** | -0.10  (-0.10)  [-0.98] | -0.09  (-0.07)  [-1.22] | 0.01  (-0.09)  [0.07] | -0.04  (-0.15)  [-0.25] | 0.04  (-0.15)  [0.28] |
| **D (MUND (-1))** | -0.32  (-0.10)  **[-3.18]** | 0.29  (-0.07)  **[ 4.27]** | 0.04  (-0.08)  [ 0.58] | 0.19  (-0.07)  **[ 2.75]** | 0.19  (-0.07)  **[ 2.96]** | 0.17  (-0.08)  **[ 2.14]** | 0.20  (-0.06)  **[3.53]** | 0.13  (-0.07)  [1.82] | 0.20  (-0.12)  [1.66] | 0.24  (-0.12)  **[2.07]** |
| **D (MUND (-2))** | -0.21  (-0.10)  **[-2.01]** | 0.08  (-0.07)  [ 1.10] | -0.12  (-0.08)  [-1.60] | -0.03  (-0.07)  [-0.39] | -0.07  (-0.07)  [-0.99] | -0.01  (-0.08)  [-0.18] | 0.06  (-0.06)  [0.99] | -0.31  (-0.07)  **[-4.20]** | 0.06  (-0.12)  [0.48] | -0.11  (-0.12)  [-0.90] |
| **D (CHITR (-1))** | 0.05  (-0.06)  [ 0.77] | 0.01  (-0.04)  [ 0.16] | 0.02  (-0.04)  [ 0.35] | -0.00  (-0.04)  [-0.10] | -0.01  (-0.04)  [-0.14] | 0.01  (-0.05)  [ 0.29] | -0.01  (-0.03)  [-0.18] | 0.02  (-0.04)  [0.38] | -0.52  (-0.07)  **[-7.54]** | 0.04  (-0.07)  [0.54] |
| **D (CHITR (-2))** | 0.13  (-0.06)  **[ 2.18]** | 0.04  (-0.04)  [ 1.01] | 0.12  (-0.04)  **[ 2.71]** | 0.09  (-0.04)  **[ 2.26]** | 0.09  (-0.04)  **[ 2.34]** | -0.01  (-0.05)  [-0.17] | 0.05  (-0.03)  [1.54] | 0.08  (-0.04)  [1.88] | -0.18  (-0.07)  **[-2.55]** | 0.07  (-0.07)  [0.96] |
| **D (KOTT (-1))** | 0.16  (-0.06)  **[ 2.63]** | -0.06  (-0.04)  [-1.54] | 0.01  (-0.05)  [ 0.27] | -0.02  (-0.04)  [-0.38] | 0.02  (-0.04)  [ 0.38] | -0.08  (-0.05)  **[-1.81]** | 0.02  (-0.03)  [0.68] | -0.03  (-0.04)  [-0.80] | 0.04  (-0.07)  [0.62] | -0.61  (-0.07)  **[-8.75]** |
| **D (KOTT (-2))** | 0.13  (-0.06)  **[ 2.20]** | -0.02  (-0.04)  [-0.52] | -0.01  (-0.04)  [-0.24] | 0.03  (-0.04)  [ 0.76] | 0.03  (-0.04)  [ 0.79] | -0.05  (-0.05)  [-1.12] | 0.04  (-0.03)  [1.14] | 0.01  (-0.04)  [0.30] | 0.06  (-0.07)  [0.86] | -0.28  (-0.07)  **[-4.11]** |
| **C** | 16.21  (-27.48)  [ 0.59] | 15.47  (-18.25)  [ 0.85] | 15.48  (-20.16)  [ 0.77] | 14.69  (-18.35)  [ 0.80] | 14.23  (-17.54)  [ 0.81] | 19.72  (-20.89)  [ 0.94] | 14.80  (-15.17)  [0.98] | 9.45  (-19.55)  [0.48] | 19.31  (-32.18)  [0.60] | 17.56  (-31.70)  [0.55] |
| **R-squared** | **0.37** | **0.41** | **0.20** | **0.37** | **0.43** | **0.26** | **0.28** | **0.40** | **0.25** | **0.34** |

**Note:** Standard errors in ( ) & t-statistics in [ ]

**Conclusion:**

The study has examined cointegration, causality and price transmission in major groundnut markets in Karnataka. The results of overall cointegration test have indicated that different groundnut markets in Karnataka are well-integrated and have long-run price association across them. The market pair-wise cointegration test has confirmed that there was a bidirectional causation relationship in price transmission among the chosen groundnut markets in study area except market pairs such as Yadgir- Raichur, Ballari-Raichur, Challakere-Raichur, Gadag-Raichur, Mundargi-Raichur, Kottur-Raichur and Challakere-Ballari where market prices influenced unidirectionally. The error correction term (ECT) indicated the speed of adjustment towards long-run equilibrium of groundnut markets in the study area. The error correction term of groundnut markets indicated that, the Error Correction terms of Yadgir, Raichur, Ballari and Kottur markets were found to be significant and negative depicted that the change in price of groundnut in Yadgir, Raichur, Ballari and Kottur market have influenced and have impact on the price of other groundnut markets in the long run period.

**Reference:**

Anonymous, 2022, Agricultural statistics at a glance 2022, Department of Agriculture & Farmers Welfare Economics & Statistics Division. 48-57.

Anonymous, 2023, Final estimates of district wise area, production and yield of principal crops in Karnataka for the year 2021-22, Directorate of Economics and Statistics, Bengaluru, Karnataka: 23

Bannor R K and Sharma M, 2015, Spatial price transmission in groundnut markets of Rajasthan. *Indian Journal of Economics and Development*, *11*(4):851-860.

Burark S, Sharma H and Meena G, 2015, Co-integration and causality analysis in major soybean markets of Rajasthan and Madhya Pradesh*. The Journal of Rural and Agricultural Research,* 15(2): 5-7.

Dickey D A and Fuller W A, 1979, Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74:427–31.

Ghosh M, 2010, Spatial price linkages in regional food grain markets in India. *MARGIN: The Journal of Applied Economic Research*, 4(4):495-516.

Ikudayisi A A and Salman K K, 2014, Spatial integration of maize market in Nigeria–a vector error correction model. *International Journal of Food and Agricultural Economics*, *2*(3):71-80.

Johansen S and Juselius K, 1990, Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics,* 52(2):169-210.

Johansen S, 1988, Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2-3):231-254.

Juselius K, 2006, The co-integrated VAR model: methodology and applications. Oxford University Press, London.

Kolageri N R and Banakar B, 2018, Instability in market arrivals and modal price of selected commodities in agriculture produce markets of Karnataka. *Journal of Pharmacognosy and Phytochemistry*, *7*(5):3375-3378.

Kumari R V, Gundu R, Panasa V and Akula S, 2022, Co-integration and causality analysis of castor markets in Telangana state. *Journal of Oilseeds Research*, 39(1):39-45

Mahalle S L, Shastri S and Kumar S, 2015, Integration of wheat markets in Maharashtra*. Agricultural Economics Research Review,* *28*(1):179-187.

Nayak A, Lokesha H and Gracy C P, 2020, Co-integration of groundnut markets in India with special reference to Karnataka. *Current Applied Science and Technology,* *39*(18):14-22.

Pant D K and Sharma M L, 2022, Market integration of major sunflower oil markets of India. *International Journal of Agriculture Sciences,* 4(7):0975-3710.

Richard B K, Madhu S and Surjeet D, 2016, Integration of cumin markets in Rajasthan*. International Journal of Agricultural Sciences, 8(52)*:2516-2520.

Venujayakanth B, Dudhat A S, Swaminathan B and Ardeshana N J, 2017, Price integration analysis of major groundnut domestic markets in India. *Economic Affairs*, *62*(2):233-241.