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Review Paper

# Spatial and Temporal Relationship between Coriander Prices in India

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**ABSTRACT**

Coriander is among the major seed spices grown in the country. Madhya Pradesh followed by Rajasthan and Gujarat together accounts for 85-90 percent of total coriander production in the country. Present study investigated the dynamics of spatial (both intra-state and inter-state) as well as temporal relationship between coriander prices in India. The Kota and Baran markets from Rajasthan were selected to study the intra-state whereas Guna market from Madhya Pradesh and Kota market from Rajasthan was selected to examine the inter-state price relationship. The temporal analysis was conducted between futures (with delivery centre at Kota) and spot (Kota) price series of coriander. The monthly coriander prices from August 2008 to July 2020 were collected and analyzed for the study. The Johansen cointegration test and Vector Error Correction Mechanism (VECM) were used to investigate the long and short run relationship whereas Granger causality was used to examine the direction of causality between two price series. The study confirmed spatial as well as temporal correlation between coriander prices which can be further explored in many ways to achieve and strengthen the marketing efficiency.

**HIGHLIGHTS**

- Coriander markets in the country are cointegrated spatially as well as temporally.
- Coriander markets in major growing states (Madhya Pradesh and Rajasthan) are integrated with each other. Coriander spot prices are significantly influenced by its future prices.

**Keywords**: Coriander, spot price, futures price, cointegration, VECM, Granger causality

Globally, India ranks first in the production, consumption and export of seed spices. India is the largest producer of coriander in world. Coriander is among the important seed spices in India which contributes to approximately 73.60 percent of total world production during 2019 (tridge.com). In India, coriander is cultivated across the entire nation. According to advanced estimates of 2020-2021, Madhya Pradesh is the largest producer (3.94 lakh tons) with maximum area (2.93 lakh ha) under coriander cultivation. Rajasthan (1.29 lakh tons) is the second largest producer followed by Gujarat (2.12 lakh tons) (Spices Board India, 2021). In Madhya Pradesh, the Guna, Rajgadh and Mandsaur are top three districts in coriander production (Department of Horticulture and Food Processing, MP, 2017-18). Whereas, in Rajasthan, three districts viz; Jhalawar, Baran and Kota holds the entire coriander production of the state which further contributes to 25 percent of total country's production (Roy *et al.* 2019).

Since past few years the acreage under crop shows declining trend in Rajasthan and other states. There are various factors which are responsible for area allocation under crops among which prices of the

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produce is an important one (Meena *et al.* 2020). The price determines, profit to producer, satisfaction to consumer, efficiency to markets and future acceptability to the product etc. If price signals along with other market information are transmitted smoothly between markets then it is called market integration and markets are called correlated or integrated (Goletti *et al*. 1995). On the basis of place, stage and time dimensions, market integration can be of are three types viz; spatial, vertical and temporal integration. Spatial integration is related with spatially distinct markets, vertical integration involves markets at different stages of marketing and processing channels and inter temporal refers to the arbitrage across different periods of time (Barrett, 2016).

The better and ensured prices of agricultural produce are two basic need of farming in India as 70 percent of its rural households depend on agriculture for their livelihood (Economic Survey 2019-20). To achieve the same futures markets has emerged as a boom as it ensures price discovery as well as risk management. Price discovery enables farmers to allocate their resources judiciously whereas, fixing prices of commodities in advance for some future date protects the farmers from the risk of low prices in the future (Trivedi and Nair, 2018). The journey of agricultural futures trading in India has gone through ups and downs since its beginning. There has been listing, delisting and relisting of various commodities since the inception of these markets as were disputed for probable cause of price volatility and inflation (Sendhil *et al*. 2014). Later on, the Abhijit Sen Committee came out with the conclusion of no evidence of causal relationship between futures trading and rising prices of commodities (Srinivasan, 2008). At present, six national and sixteen regional commodity exchanges are operating futures trading in agricultural and non agricultural commodities in India.

Out of total agricultural commodities, 12 spices are permitted for trade in futures market. Coriander, cumin, turmeric, chili and pepper are the major five contributing significant share in the total values. Among these spices, coriander alone constitutes more than 50 percent i.e. largest share in value whereas, chili and pepper shares are small in the group (Kumar, 2016). Keeping all this background in view, present study was conducted to explore the dynamics of price relationship of coriander across spatially distinct markets and also at different periods of time in India.

## MATERIALS AND METHODS

Rajasthan and Madhya Pradesh states were selected for the study as are top coriander producing states of the nation. Intra-state study was conducted within the Rajasthan between Baran and Kota markets which were selected on the basis of maximum arrival. Inter-state relationship was examined between Kota and Guna market of Rajasthan and Madhya Pradesh, respectively. The inter-temporal relationship was examined at Kota market between futures and spot prices of coriander. The daily futures prices (averaged to month for analysis) of coriander at Kota delivery centre was collected from NCDEX as the exchange contributes maximum share in the trading of agricultural commodities in India. The monthly prices at Kota, Baran and Guna was collected from an e governance portal i.e. AGMARKNET. The entire data was transformed to natural logs i.e. Ln Kota, Ln Baran, Ln Guna and Ln Futures to stabilize the variance of the prices series. The data from August 2008 to July 2020 was collected and analyzed for study. The fundamental property of time series i.e. stationarity was examined by employing the unit root test. Further, the long and short run relationship between different price series was examined by using Johansen Cointegration test and Vector Error Correction Mechanism (VECM). To investigate the direction of relationship, Granger causality test was employed (Ghosh, 2003; Singh *et al*. 2009; Wani *et al.* 2015; Rani *et al.* 2017).

### Unit Root test

A non-stationary series is characterized by having unit root. The study employed Augmented Dickey and Fuller (1981) and Phillip and Perron (1988) tests to examine the same.

### Augmented Dickey and Fuller (ADF) test

The equation for ADF test can be written as:

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \sum_{j=1}^{\rho} \alpha j \, \Delta Y_{t-j} + \varepsilon_t$$

### Phillips- Perron (PP) Test

It makes a non parametric correction to the *t* - test statistic to account for the autocorrelation and hetroscedasticity in error term (Shihabudheen and Padhi, 2010). The equation to be estimated can be expressed as:

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \varepsilon_t$$

Where, $Y_t$ is a vector to be tested for cointegration; $\Delta Y_t = Y_t - Y_{t-1}$; $t$ is time or trend variable; ρ is the lag order of the autoregressive process and $\varepsilon_t$ is the white noise. The acceptance of null hypothesis i.e. $H_0$: δ = 0, against alternate hypothesis $H_1$: δ < 0, signifies existence of unit root in both the tests.

### Johansen Cointegration Test

It allows the evaluation of all possible cointegrating equations between the time series variables. The equation for test can be written as:

$$\Delta Y_t = \mu + \sum_{i=1}^{\rho-1} \Gamma_i \Delta Y_{t-1} + \prod Y_{t-1} + \varepsilon_t$$

Where $Y_t$ is the price series, $\Delta Y_t = Y_t - Y_{t-1}$; Γ and Π are matrices of parameter Π is $n \times n$ matrix with rank $r$ which is the number of cointegrating vectors. To examine the number, the trace test and maximum eigenvalue test were proposed which can be formulated as:

$$\lambda_{\text{trace}} = -T \sum_{i=r+1}^{n} 1n\left(1 - \lambda \hat{i}\right)$$

$$\lambda_{\max} = -T 1n\left(1 - \lambda^{\wedge}{}_{r+1}\right)$$

Where, $T$ is the sample size, and $\lambda_i$^ are the Eigen values. The test examines the null hypothesis, $H_0$: rank of Π = $r$ against alternate hypothesis, $H_1$: rank of Π > $r$. Here $r$ is the number of cointegrating equations (Sendhil *et al.* 2013).

### Vector Error Correction Model (VECM)

The cointegrated time series have long run equilibrium but there may be deviation from equilibrium in short run. VECM allows for long run and short run dynamics together. The model can be written as:

$$\Delta X_t = \alpha_0 + \sum \beta_1 \Delta Y_{t-1} + \sum \beta_2 \Delta X_{t-1} + \gamma ECT_{t-1}$$
$$\Delta Y_t = \beta_0 + \sum \alpha_1 \Delta X_{t-1} + \sum \alpha_2 \Delta Y_{t-1} + \gamma ECT_{t-1}$$

Where, $X$ and Y are two variables, Δ is the first difference and $ECT_{t-1}$ is the error correction term lagged one period. The negative and significant values of ECT i.e. γ depicts the adjustment speed in regaining equilibrium in case of any disequilibrium. It also represents the long run impact whereas short run impact is given by the lagged variables (Paul *et al.* 2015).

### Granger Causality Test

The cointegration confirms the long run relationship whereas; the direction of relationship between two time series can be determined by employing Granger causality test (1969). The direction of causality could be used to explain the current value of a variable, conditional on past values of another variable (Hernandez and Torero, 2010). The model can be written as:

$$X_t = \alpha_0 + \sum_{k=1}^{\rho} \alpha_{1k} X_{t-k} + \sum_{k=1}^{\rho} \alpha_{2k} Y_{t-k} + \varepsilon_t$$
$$Y_t = \alpha_0 + \sum_{k=1}^{\rho} \alpha_{1k} Y_{t-k} + \sum_{k=1}^{\rho} \alpha_{2k} X_{t-k} + \varepsilon_t$$

Where, $X_t$ and $Y_t$ are two variables and ρ is the number of lags of variables in the system. F- test is used to test whether $Y_t$ does not Granger cause $X_t$ by examining the null hypothesis that the lagged coefficient of $Y_t$ are equal to zero. Similarly, the other case of $X_t$ does not Granger cause $Y_t$ is examined (Samal, 2017).

## RESULTS AND DISCUSSION

Firstly, to have an insight and better understanding of the dataset, descriptive statistics analysis of all the price series was done and presented in table 1. During study period, coriander prices in, Baran, Kota, Guna and future market were analyzed. Prices in study markets varied from lowest 2203 ₹ Quintal$^{-1}$ in Baran in June 2010 to highest 12529 ₹ Quintal$^{-1}$ in future market in Dec., 2014. Beginning with the mean and median, both were higher for futures prices than other prices. The average prices in future market prevailed 1122, 1109 and 1052 ₹ Quintal$^{-1}$ higher than Baran, Kota, Guna markets, respectively. The coefficient of variation was measured lowest in future market indicated that prices in future market were consistent than spot markets. Among spot markets fluctuations in coriander prices were more in Guna than Kota and Baran (Graph 1).

**Table 1:** Descriptive statistics of coriander Prices (₹/q)

| Particulars | Baran | Kota | Guna | Futures market |
|---|---|---|---|---|
| Mean | 5157.37 | 5170.50 | 5227.08 | 6279.03 |
| Standard Deviation | 1802.04 | 1746.50 | 1633.49 | 2322.35 |
| Kurtosis | -0.19 | -0.47 | -0.47 | 0.32 |
| Skewness | 0.61 | 0.48 | 0.54 | 0.91 |
| Minimum | 2202.63 | 2305.96 | 2276.44 | 2716.58 |
| Maximum | 9466.20 | 9486.96 | 8970.74 | 12528.91 |
| Coef. of variation | 286.20 | 296.05 | 320.00 | 270.37 |

Further, skewness is the measure of distribution of symmetry with reference to normal distribution (zero skewness) i.e. either to the left (positive) or to the right (negative). The table 1 revealed positive skewness for futures price series only. Kurtosis explains the peak of the curve. The table showed that all the price series was platykurtic curve (kurtosis <3) which have shorter and thinner tail with lower peak than normal curve.

### Unit Root Test Results

The results of both Augmented Dicky Fuller (ADF) and Phillips Perron (PP) unit root test are reported in table 2. The table showed that both the tests were resulted into similar inferences.

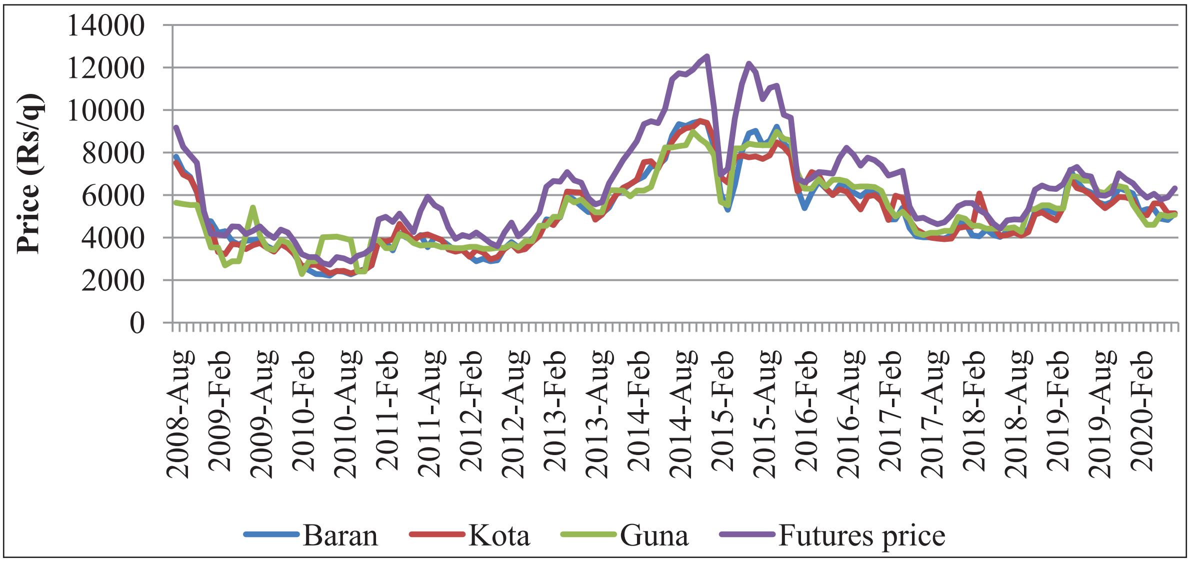
It is manifested from the table 2 that at level, all price series were non stationary as the null hypothesis of having unit root is accepted at 5 percent level of significance. Further, table displays the price series at first difference rejects the null hypothesis and accepts alternate of not having unit root. Thus, the Ln Kota, Ln Baran, Ln Guna and Ln Futures prices were stationary at first difference and were integrated of same order i.e. one.

Optimal lag length is an essential element in determining the best relationship between the model and dependent variables. Both too few lags and too large lags are not acceptable at all as the former leads to specification bias and later left with fewer degrees of freedom and possibility of multicollinearity. The optimal lag length was selected by using Schwarz Information Criterion (SC) as has been found best for large samples (Asghar and Abid, 2007). On the basis of minimum Schwarz Information Criterion the VAR model of lag order one was selected for inter-state (Ln Kota - Ln Guna) and temporal (Ln Futures -Ln spot) model whereas the lag order of two was selected for intra-spatial model (Ln Kota – Ln Baran).

### Johansen Cointegration Test Results

The results of Johansen Trace and Johansen Maximum Eigenvalue tests are presented in table 3. Here the null hypothesis of no cointegrating vector was tested against the alternate hypothesis of at most one cointegrating vectors between two price series. The perusal of table reveals that both the tests came out with similar findings.

The null hypothesis in all the conditions was




**Graph 1:** Coriander prices (₹ Quintal$^{-1}$) in study markets from 2008 to 2020

**Table 2:** Unit Root Test results

| Prices | Level/First Difference | ADF Test | | PP Test | |
|---|---|---|---|---|---|
| | | t-statistics | p value | t-statistics | p value |
| Ln Kota | Level | -0.399 | 0.539 | -0.382 | 0.545 |
| | First Difference | -9.090* | 0.000 | -10.374* | 0.000 |
| Ln Baran | Level | -0.321 | 0.568 | -0.415 | 0.532 |
| | First Difference | -8.804* | 0.000 | -9.735* | 0.000 |
| Ln Guna | Level | -0.157 | 0.628 | -0.162 | 0.626 |
| | First Difference | -9.723* | 0.000 | -11.661* | 0.000 |
| Ln Futures | Level | -0.249 | 0.595 | -0.350 | 0.558 |
| | First Difference | -8.563* | 0.000 | -8.292* | 0.000 |

**denotes rejection of null hypothesis at 5 percent level of significance; 5 % critical values of ADF and PP test is -1.943.*

**Table 3:** Johansen Cointegration Test Results

| Cointegrating vectors | Trace Test | | Maximum Eigenvalue Test | |
|---|---|---|---|---|
| | Trace statistics | 5% Critical value | Max-Eigen Statistics | 5 % Critical Value |
| **Ln Kota and Ln Bran Prices (Intra-State)** | | | | |
| None* (r = 0) | 32.169 | 12.321 | 32.083 | 11.225 |
| At most 1 (r>1) | 0.087 | 4.130 | 0.086643 | 4.130 |
| **Ln Kota and Ln Guna Prices (Inter-State)** | | | | |
| None* (r = 0) | 28.646 | 12.321 | 28.595 | 11.225 |
| At most 1 (r>1) | 0.051 | 4.130 | 0.051 | 4.130 |
| **Ln Spot and Ln Futures Prices (Inter-temporal)** | | | | |
| None* (r = 0) | 37.154 | 12.321 | 37.101 | 11.225 |
| At most 1 (r>1) | 0.054 | 4.130 | 0.054 | 4.130 |

**denotes rejection of the hypothesis at 5 percent level of significance.*

rejected as both the tests statistics was greater than critical values at 5 percent level of significance. Thus, the alternate hypothesis was accepted and all the three pairs of price series of coriander were found to be cointegrated. The Ln Kota and Ln Baran prices within the state, Ln Kota and Ln Guna prices across the state and spot and futures prices were having a long run relationship or equilibrium.

## Vector Error Correction Model (VECM) Results

Table 4 presents the results of VECM which was employed to investigate the short and long run behavior of cointregrated prices series. The negative and significant coefficient of estimated error correction term (ECT) indicates speed of adjustment at which prices returns to the equilibrium in case of any disequilibrium. In intra-state analysis, it would be prices at Baran market which adjust itself at the rate of 27.9 percent per month towards equilibrium in case of any disequilibrium. Further, the short run equilibrium is examined by diagnosing the coefficients of lagged prices. It was found to be significant which reveals that there was short run causality from lagged prices of Kota to Baran.

Table further shows the inter-state analysis results which reveal that in case of deviations from equilibrium it would be Kota prices, which adjusts itself with the speed of 17 percent per month towards equilibrium. Further, no short run causality between the markets was observed as the coefficient of lagged prices in each equation is insignificant. Table further reveals the result of inter-temporal analysis which indicates that if there is any disequilibrium between spot and futures prices in short run, it would be spot prices which adjust itself at the speed of 31.90 percent towards long run equilibrium.

## Granger Causality Results

The results of Granger causality test are presented in table 5. The table reported that in case of intra-state and inter-state analysis, the null hypothesis

**Table 4:** Vector Error Correction Model Results

| Equations | Parameter | Estimates | Std. error | t statistic | P values |
|---|---|---|---|---|---|
| | | **Ln Kota nad Ln Baran Prices (Intra-state)** | | | |
| Δ Ln Baran | ECT | -0.279* | 0.123 | -2.273 | 0.025 |
| | Δ Ln Kota (-1) | 0.168 | 0.129 | 0.130 | 0.195 |
| | Δ Ln Kota (-2) | -0.296 | 0.129 | -2.290 | 0.024 |
| | Δ Ln Baran (-1) | 0.166 | 0.135 | 0.123 | 0.221 |
| | Δ Ln Baran (-2) | 0.130 | 0.129 | 1.01 | 0.316 |
| Δ Ln Kota | ECT | 0.222 | 0.128 | 1.734 | 0.085 |
| | Δ Ln Baran (-1) | -0.154 | 0.141 | -1.100 | 0.273 |
| | Δ Ln Baran (-2) | 0.136 | 0.135 | 1.010 | 0.315 |
| | Δ Ln Kota (-1) | 0.302 | 0.135 | 2.246 | 0.026 |
| | Δ Ln Kota (-2) | -0.223 | 0.135 | -1.654 | 0.100 |
| **Ln Kota nad Ln Guna Prices (Inter-state)** | | | | | |
| ΔLn Kota | ECT | -0.170* | 0.061 | -2.773 | 0.006 |
| | Δ Ln Guna (-1) | 0.043 | 0.078 | 0.558 | 0.578 |
| | Δ Ln Kota (-1) | 0.136 | 0.091 | 1.497 | 0.137 |
| ΔLn Guna | ECT | 0.227 | 0.075 | 3.020 | 0.003 |
| | Δ Ln Guna (-1) | 0.108 | 0.096 | 1.129 | 0.261 |
| | Δ Ln Kota (-1) | 0.151 | 0.111 | 1.358 | 0.177 |
| **Ln Spot and Ln Futures Prices (Inter-temporal)** | | | | | |
| Δ Ln Spot | ECT | -0.319* | 0.098 | -3.243 | 0.002 |
| | Δ Ln spot (-1) | 0.037 | 0.122 | 0.301 | 0.764 |
| | Δ Ln Futures (-1) | 0.106 | 0.124 | 0.849 | 0.398 |
| Δ Ln Futures | ECT | 0.114 | 0.102 | 1.094 | 0.276 |
| | Δ Ln Spot (-1) | -0.009 | 0.130 | -0.068 | 0.946 |
| | Δ Ln Futures (-1) | 0.346 | 0.132 | 2.619 | 0.010 |

**Table 5:** Granger Causality Test results

| Null Hypothesis | F-Statistics | P value | Direction |
|---|---|---|---|
| Ln Kota and Ln Baran Prices (Intra-state) | | | |
| Ln Baran does not Granger Cause Ln Kota | 4.233* | 0.017 | Bi-directional |
| Ln Kota does not Granger Cause Ln Baran | 5.367* | 0.006 | |
| **Ln Kota and Ln Huna Prices (Inter-state)** | | | |
| Ln Kota does not Granger Cause Ln Guna | 8.972* | 0.003 | Bi-directional |
| Ln Guna does not Granger Cause Ln Kota | 6.573* | 0.011 | |
| **Ln futures and Ln Spot Prices (Inter-temporal)** | | | |
| Ln Futures does not Granger cause Ln Spot | 16.030* | 0.000 | Uni-directional |
| Ln Spot does not Granger cause Ln Futures | 0.347 | 0.556 | |

**denotes rejection of null hypothesis at 5 % level of significance.* denotes significant at 5 % level of significance; Δ denotes first difference*

is rejected at 5 percent which means there is bi-directional causality between prices within the Rajasthan as well as between Rajasthan and Madhya Pradesh markets. It indicates that the past values of prices in one market can be used to predict the present values of prices in another market in each pairs of intra-state and inter state's market.

Further, the null hypothesis of Ln Futures does not Granger causes Ln Spot is rejected at 5 percent level of significance. It shows that the market information transmit from futures to spot market only. Thus lagged prices of futures prices can be used to predict the current values of spot prices.

## CONCLUSION

In the present study spatial as well as temporal price relationship was examined between the prices of coriander. Spatial price relationship was examined considering the both intra-regional and inter-regional aspects. Guna market from Madhya Pradesh and Kota market from Rajasthan were selected for conducting spatial analysis as states are first and second largest producer of coriander in India, respectively. For intra-state analysis, Kota and Baran markets were selected from Rajasthan on the basis of maximum arrival in the market. Inter-temporal prices relationship was examined between spot (Kota) and futures prices of coriander. The Kota, Baran and Guna prices from AGMARKNET and futures prices from NCDEX for the period August 2008 to July 2020 were collected and converted to natural logs. The Johansen cointegration test and vector error correction model were employed to investigate the long and short run relationship, and Granger causality test was used to know the direction of relationship between integrated markets. The study reveals that the price series in each pair i.e. intra-state, inter-state and inter-temporal are cointegrated and had long run equilibrium between them. Further, study founds any kind of deviations from equilibrium will be adjusted by Baran, Kota and Spot prices at the speed of 27.9, 17 and 31.90 respectively, towards long run equilibrium in their respective pairs. The study further founds the bi-directional transmission of price signals between the markets within the state and across the state while it was unidirectional from futures to spot market. The study concluded that although, the markets were cointegrated but still the speed of price adjustment is not a satisfactory figure. It was least between inter-state markets while futures market has been performing well in comparison to others.

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