

International Journal of Agriculture Extension and Social Development

Volume 9; Issue 1; January 2026; Page No. 484-487

Received: 14-10-2025
Accepted: 22-11-2025

Indexed Journal
Peer Reviewed Journal

Co-integration and error correction modelling for prices of black pepper in Karnataka

¹Hanumanthaiah R, ²Mangala KP and ³Naveena KP

¹Department of Statistics, College of Horticulture, Bengaluru, Karnataka, India

²Departments of Agricultural Economics, College of Horticulture, Bengaluru, Karnataka, India

³Department of Agricultural Economics, College of Forestry, Ponnampet, Karnataka, India

DOI: <https://www.doi.org/10.33545/26180723.2026.v9.i1.g.2958>

Corresponding Author: Hanumanthaiah R

Abstract

An attempt was made to know the market integration on prices of major black pepper markets in Karnataka, monthly prices of black pepper from July 2015 to October 2018 of five different markets of Karnataka were used for the analysis. Unit root test, ADF test and Phillip Peron test results indicates the non Stationarity of the level series and after differencing data series becomes stationary and Johansen co-integration test was conducted as results revealed that changes in market prices of black pepper in these markets significantly affect each other in the short-run as well as in the long-run, all the markets will have equilibrium adjustment, indicating that there would be a co-integrating relationship among the different black pepper markets in Karnataka. The high degree of co-integration amongst various markets indicates that these markets are competitive and efficient at the wholesale levels.

Keywords: Co-integration, stationarity, ADF test, unit root, eigen value, trace statistics

Introduction

The uncertainty about future prices has all through been a concern for producers and consumers. It has been observed that price discovery and price risk management are the two important functions performed by advance contracts (Thomas, 2003 and Ahuja, 2006). It could, therefore, be perceived that a fairly good idea of prices at a future date would facilitate producers' rational market decisions (especially regarding choice of market(s) and quantum of produce to be dispatched) for profit maximisation. Against this backdrop, market integration and price forecasting would help in stabilising the prices by removing the market imperfections like monopolies and attain market efficiency (Mushtaq *et al.*, 2008) ^[7].

Spatial market integration "is the smooth transmission of price signals and information across spatially separated markets" (Golleti *et al.*, 1995) or is the "measure of the extent to which demand and supply in one location are transmitted to another" (Negassa *et al.*, 2003) ^[8]. If two markets are integrated, they will experience identical price shocks/changes (Barrett, 1996) ^[1]. Information flow between spot and future markets facilitates price fixation of commodity through mutual understanding between the buyer and the seller for which the price has to be paid in the pre-determined time in future. This reduces the chances of very high prices in return for protection against extremely low prices, technically called hedging, i.e. price risk management or risk transfer function.

Price stabilization at the times of extreme volatility is

another function of commodity futures. But, the issue over the past two decades is that prices of food are more volatile than of any other commodity (Chand, 2010) ^[2]. Escalating prices of food commodities question the sustainability of current economic growth as well as the efficiency of futures trading. In spite of these, growth in quantity and value of commodities traded in future markets has shown an increasing trend (Sen, 2008) ^[9]. Despite explicit growth, the active participation of farmer is also important. It helps them to hedge their produce, safeguard from price volatility and also signal the likely prices so that they can decide on their crop choices. In India, where the majority of farmers have low marketed surplus and face problem of price instability, the analysis of future trading and prescriptions become more relevant to them.

Materials and Methods

Monthly secondary data for prices of Black pepper in Major five markets (Bengaluru, Sirsi, Sakleshpura, Chikmagalur and Somwarpet) of Karnataka (2010-2018) was collected from the Agmarknet.com. Data was checked for Stationarity by Augmented Dickey Fuller test and Phillip Peron test, once data become Stationarity Johnson cointegration test was carried out to know the Cointegration between the markets.

Co-integration

To test the extent of relationship between all Black pepper markets in Karnataka both in long run and short run, Co-

integration was used. Markets are said to be integrated when the price change in one market is fully transmitted to other markets. Markets that are not integrated may convey inaccurate price information that might distort market decisions and contribute to inefficient product movement.

Augmented Dickey-Fuller (ADF) and Unit Root Test

An implicit assumption in Johansen's co-integration approach is that the variables should be non stationary at level, but stationary after first differencing. The Augmented Dickey-Fuller test is utilized to check the order of integration by using the model (1): where, $\Delta Y_t = Y_t - Y_{t-1}$, $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$, and $\Delta Y_{t-2} = Y_{t-2} - Y_{t-3}$, etc., ϵ_t is pure white noise, term, α is the constant-term, T is the time trend effect, and p is the optimal lag value which is selected on the basis of Schwartz information criterion¹ (SIC). The null hypothesis is that β_1 , the coefficient of Y_{t-1} is zero. The alternative hypothesis is: $\beta_1 < 0$. A non-rejection of the null hypothesis suggests that the time series under consideration is non-stationary.

Co-integration Analysis Using Johansen co integrating test

The Johansen procedure examines a vector auto regressive (VAR) model of Y_t , an $(n \times 1)$ vector of variables that are integrated of the order one— $I(1)$ time series. This VAR can be expressed as Equation

$$\Delta y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i y_{t-i} + \Pi y_{t-1} + \epsilon_t$$

Where, Γ and Π are matrices of parameters, p is the number of lags (selected on the basis of Schwarz information criterion), ϵ_t is an $(n \times 1)$ vector of innovations. The presence of at least one co integrating relationship is necessary for the analysis of long-run relationship of the

prices to be reasonable. To detect the number of co-integrating vectors, Johansen proposed two likelihood ratio tests (Dickey and Fuller, 1981) [3]: trace test and maximum Eigen value test, shown in Equations (3) and (4), respectively.

$$J_{trace} = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \dots \dots \dots (3)$$

$$J_{max} = -T \ln(1 - \hat{\lambda}_{r+1}) \dots \dots \dots (4)$$

Where, T is the sample size and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation. The trace test examines the null hypothesis of r co integrating vectors against the alternative hypothesis of n co integrating vectors. The maximum Eigen value test, on the other hand, tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of $r+1$ cointegrating vectors.

Results and Discussion

Co-integration of prices of Black Pepper in Different Markets of Karnataka

To test for extent of relationship between Bengaluru, Sirsi, Sakleshpura, Chikmagaluru and Somwarpet market prices both in long run also short run, co-integration was used. Figure 1. displays the Black Pepper prices for Bengaluru, Sirsi, Sakleshpura, Chikmagaluru and Somwarpet markets. Note that the Chikmagaluru market price is generally higher than the other markets during the testing period, whereas all the remaining markets prices were almost similar; difference is there because of addition of transportation cost, exchange rate difference, demand of Black pepper in world level and quality of product. In addition, as compared with the Chikmagaluru price, the other markets price has generally trend up over time with relatively low levels of volatility.

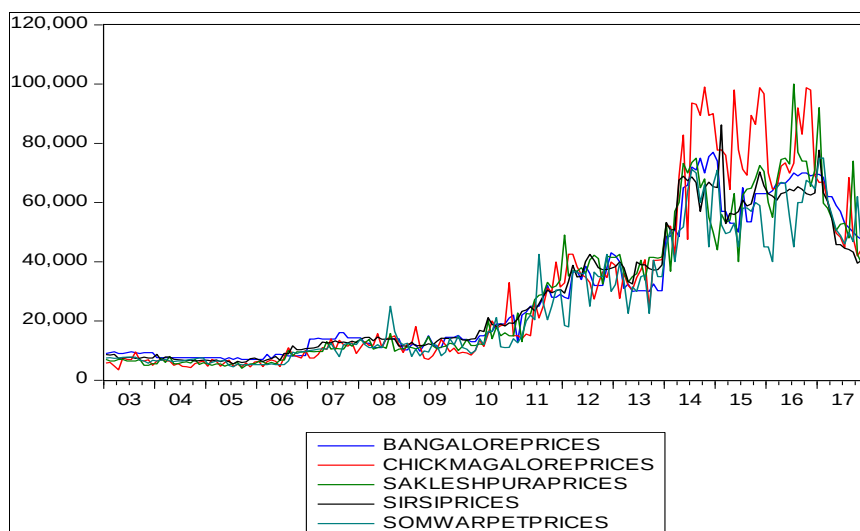


Fig 1: Monthly Black pepper prices (Rs/ql) of five markets of Karnataka

Examination of Unit root test

For testing the unit root, the null hypothesis of non-Stationarity against the alternative hypothesis of Stationarity was formulated. The results of both Augmented Dickey

Fuller and Phillip Peron tests were conducted for above mentioned market price series at their level and at first difference. The test was conducted under all assumptions i.e. trend with intercept and trend without intercept. The

results of variables for all five markets are summarized in table 1.

Augmented Dickey Fuller and Phillip Peron test showing non significance at 5 per cent level for all the five markets,

we accepted the null hypothesis. So, we can conclude all five markets price series are facing unit root problem, means all five markets price series in level are non-stationary in nature.

Table 1: Augmented Dickey Fuller and Phillip Peron Stationarity test for level series of Prices of Black Pepper

Markets	Tests	ADF test		Phillip Peron test	
		t	Prob*	t	Prob*
Bengaluru	Constant	-1.072	0.726	-1.103	0.714
	Constant trend	-2.379	0.389	-2.593	0.283
	None	-0.023	0.673	-0.049	0.6651
Chikmagaluru	Constant	-1.215	0.667	-1.576	0.492
	Constant trend	-1.883	0.658	-3.268	0.074
	None	-0.354	0.556	-0.591	0.460
Sakleshpura	Constant	-0.945	0.771	-1.176	0.684
	Constant trend	-2.539	0.308	-4.823	0.000
	None	-0.138	0.725	0.127	0.721
Sirsi	Constant	-1.084	0.721	-1.128	0.704
	Constant trend	-1.936	0.631	-2.407	0.374
	None	-0.044	0.666	-0.083	0.653
Somwarpet	Constant	-1.322	0.619	-1.858	0.351
	Constant trend	-4.697	0.001	-4.426	0.002
	None	-0.323	0.567	-0.773	0.380

If there is non stationary in the data it has to bring it to the stationary, thus series is subjected to first differencing to make the data stationary. The results of differenced series in table 2 indicated that the test statistic obtained for the entire five markets price is significant and less than at 1 percent level. So, we rejected the null hypothesis of stationary series and no unit root is true. The data series become stationary at one differencing and indicate that all the variables are integrated at order one.

Table 2: Augmented Dickey Fuller and Phillip Peron Stationarity test for Differenced series of Prices of Black Pepper

Markets	Tests	ADF test		Phillip Peron test	
		t	Prob*	t	Prob*
Bengaluru	Constant	-15.220	0.000	-15.089	0.000
	Constant trend	-15.176	0.000	-15.051	0.000
	None	-15.199	0.000	-15.070	0.000
Chikmagaluru	Constant	-13.942	0.000	-20.634	0.000
	Constant trend	-13.909	0.000	-20.590	0.000
	None	-13.951	0.000	-20.612	0.000
Sakleshpura	Constant	-14.098	0.000	-23.087	0.000
	Constant trend	-14.052	0.000	-23.015	0.000
	None	-14.070	0.000	-22.771	0.000
Sirsi	Constant	-18.067	0.000	-18.181	0.000
	Constant trend	-18.022	0.000	-18.136	0.000
	None	-18.070	0.000	-18.180	0.000
Somwarpet	Constant	-11.805	0.000	-23.454	0.000
	Constant trend	-11.787	0.000	-22.969	0.000
	None	-11.787	0.000	-21.279	0.000

Co integration test for Prices of all five Markets

Further when variables are stationary at same level I (1), check variables for long term relationship. Thus after unit root, Co integration test can be carried out to check for long term relationship.

The Johansen's Co-integration test was carried out between all the five markets and the results are given in Table 3. The study has found number of Co-integrated equations using trace statistics and maximum Eigen value statistics. In this

case, the number of co-integrating vectors can be at most four, as there are five series. According to probabilities given in table 3, the analysis rejects the null hypothesis that there is no Co-integrated vector (None), and accepts the null hypothesis that there are at most 2 Co-integrated vectors in both trace statistics and maximum eigenvalue statistics. It shows long run association between all the five markets price used in current study.

Table 3: Johansen Co-integration Test for Black pepper prices of all five markets

Unrestricted Co-integration Rank Test Trace Statistics			
Hypothesized No. of CE(s)	Trace Statistic	Critical value (0.05)	Prob*.
None*	134.451	69.818	0.000*
At most 1*	78.010	47.856	0.000*
At most 2*	43.171	29.797	0.000*
At most 3	11.825	15.494	0.165
At most 4	2.415	3.841	0.120
Unrestricted Co-integration Rank Test Eigenvalue Statistics			
Hypothesized No. of CE(s)	Max-Eigen Statistic	Critical value (0.05)	Prob*.
None*	56.440	33.876	0.000*
At most 1*	34.839	27.584	0.004*
At most 2*	31.345	21.131	0.001*
At most 3	9.409	14.264	0.253
At most 4	2.415	3.841	0.120

Conclusion

The high volatility in prices of agricultural commodities is a matter of concern for farmers and policy makers. With futures markets being blamed for food price inflation, the present study has found the efficiency of agricultural commodity futures in terms of price transmission, price discovery and degree of volatility in spot markets. Johansen's co integration test was used to know the co integration between the different markets of black pepper in Karnataka. The study has confirmed the presence of co-integration, implying the long-run price association among

the markets.

References

1. Barrett CB. Market analysis methods: are our enriched tool kits well suited to enlivened markets? *Am J Agric Econ.* 1996;78:825-829.
2. Chand R. Understanding the nature and causes of food inflation. *Econ Polit Wkly.* 2010;45(9):10-13.
3. Dickey DA, Fuller WA. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica.* 1981;49:1057-1072.
4. Goletti F, Raisuddin A, Farid N. Structural determinants of market integration: the case of rice markets in Bangladesh. *Dev Econ.* 1995;33(2):185-202.
5. Ghosh M. Cointegration tests and spatial integration of rice markets in India. *Indian J Agric Econ.* 2000;55:616-626.
6. Gulati A, Kähkönen S, Sharma PK. The Food Corporation of India: successes and failures in Indian food grain marketing. In: Kähkönen S, Lanyi A, editors. *Institutions, incentives and economic reform in India.* New Delhi: Sage Publications India Pvt Ltd; 2000. p.10.
7. Mushtaq K, Gafoor A, Dad M. Apple market integration: implications for sustainable agricultural development. *Lahore J Econ.* 2008;13:129-138.
8. Negassa A, Meyers R, Maldhin EG. Analysing the grain market efficiency in developing countries: review of existing methods and extensions to the parity bound model. Discussion paper no. 63. Washington (DC): International Food Policy Research Institute; 2003.
9. Sen A. Report of the expert committee to study the impact of futures trading on agricultural commodity prices. New Delhi: Ministry of Consumer Affairs, Government of India; 2008.