Economic Affairs, Vol. 62, No. 2, pp. 233-241, June 2017
DOI: 10.5958/0976-4666.2017.00005.5
©2017 New Delhi Publishers. All rights reserved

Price Integration Analysis of Major Groundnut Domestic Markets in India

B. Venujayakanth[1], A.S. Dudhat[2], B. Swaminathan[3] and N.J. Ardeshana[4]

[1, 2] Department of Agricultural Statistics, Junagadh Agricultural University, Gujarat, India
[3, 4] Department of Agricultural Economics, Junagadh Agricultural University, Gujarat, India

*Corresponding author: venu31415@gmail.com

ABSTRACT

Market integration is a good proxy for measuring efficiency in the marketing system, whereby the underlying infrastructure is best put to use coupled with effective resource allocation. This way, the emerging price signals from the markets can be utilized to benefit both producers and consumers alike. The present study examines the performance of major groundnut domestic markets *viz.* Kurnool (Andhra Pradesh), Rajkot (Gujarat) and Villupuram (Tamil Nadu) in terms of market integration by using Engle-Granger bivariate co-integration test and Johansen multivariate co-integration test. The findings revealed the existence of long-run equilibrium between the markets in such a way that a 1% price rise in Kurnool market leads to 1.22% price rise in Villupuram market. Similarly, for every 1% price rise in Rajkot market, price in Villupuram market increases by 1.13%. Besides, causality test indicated the existence of feedback relationship between Kurnool and Rajkot market, Kurnool and Villupuram market and the presence of unidirectional relationship between Rajkot to Villupuram market. The presence of short run disequilibria between market pairs was also captured using Vector Error Correction Model (VECM) and the findings revealed that almost 11 to 37% of the short-run fluctuations get corrected with a month. Overall, the results signified effective price transmission mechanism in the domestic markets and any further boost to the existing infrastructure will only help in improving both producer's and consumer's surpluses.

Keywords: Groundnut markets, Johansen co-integration, short-run disequilibrium, VECM

Groundnut (*Arachis hypogea*) is one of the important oilseed crops in the world with its production being largely confined to Asian and African countries alone. Asia accounts for about 50% of area and 60% of world production. Though, India occupies the largest share under groundnut acreage (20 percent) followed by China (18%), China accounts for highest share (37%) in groundnut production (DES, 2014). In India alone, groundnut accounts for over 80% of total oilseed output and around 60% of edible oil consumption (Sundaramoorthy *et al.*, 2014). Thereby, groundnut can be rightly called as the 'king of oilseeds'. Despite all the claims, the traditional problems in marketing such as information asymmetricity and inadequate infrastructural facilities continue to mar the prospects of groundnut farmers.

The proliferation and intensification of communication and infrastructure facilities in the semi-developed countries like India would lead to integration of markets which shall help both producers and consumers alike in the long run. On the other hand, poor allocation of resources as a result of inefficient infrastructure system would in-turn lead to poor integration of markets. In this study, an attempt has been made to study the spatial market integration of three major domestic groundnut markets in India *viz.* Kurnool (Andhra Pradesh), Rajkot (Gujarat) and Villupuram (Tamil Nadu). The markets were selected on the basis of their share in market arrivals and volume of transactions during the study period (i.e. April, 1996 to April, 2016).

The term spatial market integration refers to a situation in which the prices of a commodity in spatially separated markets move together and the price signals and information are transmitted smoothly across the markets. Hence, spatial market performance may be evaluated in terms of the relationship between prices of spatially separated markets and spatial price behaviour in regional markets may be used as a measure of overall market performance (Reddy, 2012).

In other words, if the price changes in one market are fully reflected in alternative market then these markets are said to be integrated. If the markets are integrated then the resources are allocated effectively, whereas poor integration leads to misallocation of resources which in-turn causes price fluctuations pronounced more particularly in one market or the other. In this context, the present study is employed with the specific objectives to comprehend the existence of market integration and to capture short-run disequilibria, if any, between the market pairs.

Database and Methodology

To analyse market integration, month-wise wholesale price data were sourced for the period between April, 1996 and April, 2016 from the official website of Directorate of Agriculture and Cooperation, Ministry of Agriculture and Farmers' Welfare, Government of India (DACNET, 2016). The data being of time-series type, it is necessary to ensure stationarity before fitting them in the model. Stationarity in the data series would reveal the order of differences and to carry out cointegration between market pairs, it is essential for both the markets to be in the same order. The methodological framework of the study is given in figure 1 which accentuates the tools used in the study along with their usage.

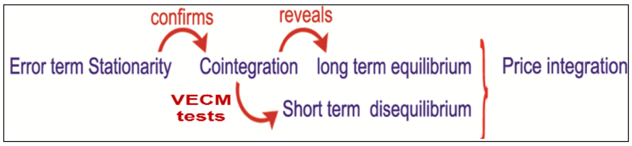

Fig. 1: Methodological Framework of the study

Unit root test

The presence of unit root (non-stationarity) in the underlying series is tested by performing Augmented Dickey-Fuller test using the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m-1} \alpha_i \Delta Y_t + \varepsilon_t \qquad (1)$$

Where, ε_t=pure white noise error term; $\Delta Y_{t-1}=(Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$ etc; and m = number of lag length and it is determined using Akaike or Schwarz information criteria or the Partial Autocorrelation function (PACF) of the first differenced series if data are under levels.

Granger causality test

The mere existence of a relationship between variables does not prove causality or the direction of influence. There is a strong connection between co-integration and causality in such a way that at least one granger cause relationship must exit in the co-integration system (Sundaramoorthy *et al.*, 2014). The price series P_{1t} can cause P_{2t} ($P_{1t} \rightarrow P_{2t}$) or the price series P_{2t} can cause P_{1t} ($P_{2t} \rightarrow P_{1t}$), and the arrows show the direction of causality. The granger causality test assumes that the information relevant to the prediction of the respective variables, P_{1t} and P_{2t}, is contained in the time series data of these variables under study. The test involves estimating the following pair of regressions:

$$P_{1t} = \alpha + \sum_{i=1}^{m} \beta_i P_{1t-i} + \sum_{j=1}^{m} \gamma_j P_{2t-j} + u_{1t} \qquad (2)$$

$$P_{2t} = \alpha' + \sum_{i=1}^{m} \theta_i P_{1t-i} + \sum_{j=1}^{m} \varphi_j P_{2t-j} + u_{2t} \qquad (3)$$

It is assumed that the disturbances u_{1t} and u_{2t} are uncorrelated and based on the significance of the lagged coefficients the causality is determined (Gujarati *et al.*, 2009).

Engle Granger Co-integration test

Bi-variate cointegration analysis between market pairs was carried out using Engle and Granger (1987) formulation test using the following regression:

$$P_{1t} = \alpha + \beta P_{2t} + \varepsilon_t \qquad (4)$$

Where, P_1 and P_2 are two price series from different regions. The residuals obtained from the equation (4) are as follows: $\varepsilon_t = P_{1t} - \alpha - \beta P_{2t}$ and the estimated ε_t becomes $\hat{\varepsilon}_t = P_{1t} - \hat{\alpha} - \hat{\beta} P_{2t}$. The residuals are considered to be temporary deviations from the long-run equilibrium. As the estimated ε_t is based on the estimated co-integration parameters β, the critical values of ADF test cannot be used for determining their significance but ADF unit root tests can be conducted on the residuals ε_t obtained from the equation (4) using the following linear equation:

$$\Delta\varepsilon_t = \delta\varepsilon_{t-1} + \sum_{i=1}^{m}\alpha_i\Delta\varepsilon_{t-i} + u_t \quad (5)$$

Where, δ and α are the estimated parameters and u_t is the error term. A co-integration test was carried out on the estimated coefficient δ. If the ADF-statistic of the coefficient exceeds the critical value reported by Engle-Yoo (1987), the residuals obtained from the co-integration equation (4) will be stationary and the price series P_1 and P_2 are said to be integrated in the long run and *vice-versa*. Similar approach was carried out by Reddy (2012) and Tahir and Muhammad (2008) to study the existence of co-integration between markets.

Johansen Co-integration test

The methodology given by Johansen and Juselius (1990) uses the restricted VAR (*p*) Vector Error Correction model to determine the number of co-integration vectors. Using that, the study has employed the following regression model to study the long run equilibrium as well as to analyze the presence of short run disequilibrium among the market pairs,

$$\Delta P_t = \mu + \sum_{i=1}^{k-1}\Gamma_i\Delta P_{t-I} + \Pi P_{t-k} + \beta_t + \varepsilon_t \quad (6)$$

Where, $\Gamma_i = -(A_{i+1} + \ldots + A_k)$ i = 1, … , k − 1, $\Pi = (I - A_1 - \ldots - A_k)$; μ = constant; ε_t~IID (0, Ω); Ω = covariance matrix; Δ = prices differenced in order to achieve stationarity; ΠP_{t-k} = long run relationship. By full rank factorisation the co-integration matrix 'Π' can be decomposed into αβ' whereby, both α and β are n×r matrices; r represents the number of cointegration relationship with 0 < r < n and β represents cointegration vectors and α refers to the short run adjustment of the disequilibrium between market pairs.

Maximum Eigen value test

Johansen test is based on the eigen values as rank (Π) refers to the number of co-integration relations. If the rank (Π) is less than *n* then there is an existence of co-integration relation. But in that case, the det (Π) = 0. Thereby, the Eigen values are useful for solving this problem as det (Π) = $\lambda_1.\lambda_2\ldots\lambda_n$. Eigen value of the Johansen test is computed by ordering the Eigen value by size $\lambda_1 > \lambda_2 > \ldots > \lambda_n$. The test of maximum Eigen value is a likelihood ratio test and the test statistic is given as follows:

$$LR(r_0, r_{0+1}) = T\ln(1-\lambda_{r0+1}) \quad (6.1)$$

Where, $LR(r_0, r_{0+1})$ is the likelihood ratio test statistic and T is the sample size or total number of usable observations. For testing whether H_0 : rank(Π) = r_0 and H_1 : rank(Π) = r_{0+1} i.e. H_0 : rank(Π) = 0 and H_1: rank(Π) = 1, likelihood ratio test LR (0,1) = T ln (1-λ_1) is used.

Trace statistic

The trace test statistic used in the study is as follows:

$$LR(r_0, n) = -T\sum_{i=r_{0+1}}^{n} \ln(1-\lambda_i) \quad (6.2)$$

The test is called trace test because the trace of matrix A is $\sum a_{ii}$ (sum of diagonal element of a matrix) since in the statistic $\sum\ln(1-\lambda_i)$, the $(1-\lambda_i)$ occupies the diagonal position and the sum of these terms leads to the term trace statistic.

Error correction model (ECM)

After confirming the existence of long-run relationship among the market pairs, the ECM was applied to investigate the short-run causality between the variables further and to establish the speed of adjustment of the short-run disequilibrium to the long-run equilibrium. The error correction model used in the study is same as given in equation (6). The vector 'α' in the equation represents the speed of adjustment towards long-run equilibrium.

RESULTS AND DISCUSSION

Graphical analysis of Market Integration

Graphical analysis is one of the crude measures to assess market integration. By performing this analysis, the pattern of price movements between the markets is revealed. The price movements of Kurnool, Rajkot and Villupuram markets are depicted in Fig. 2. As it can be seen from the figure, in long run all the three market prices are moving together albeit there is existence of certain amount of disequilibrium or fluctuations in the shorter run. This graphical analysis is a kind of a primer to further perform the formal tests of market integration.

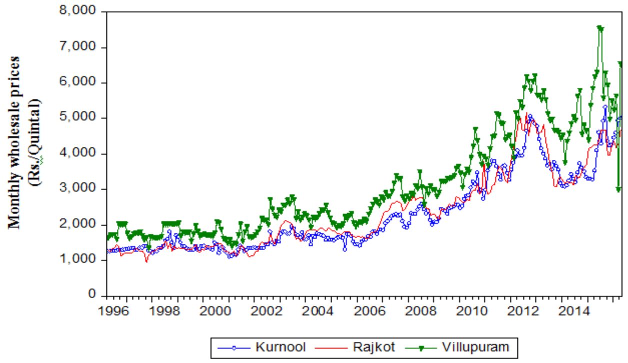

Fig. 2: Graphical analysis of domestic groundnut markets

Unit root test

In all the three price series, the unit root test on levels detected non-stationarity and only the first differences were turned out to be stationary. It indicated that all the series are integrated of order one i.e. $I(1)$. This condition is necessary to perform the bivariate and multivariate co-integration test.

Causality test

Before performing market integration test, it is necessary to know the causal relationship existing between the markets. Here causality implies Granger causality which ascertains the lead market between the market pairs.

Table 1: Unit root test for different domestic groundnut markets of the study

Market	At levels	Stationarity	At first difference	Stationarity
Kurnool	-1.85	Non-stationary	-3.81**	Stationary
Rajkot	-2.41	Non-stationary	-6.83***	Stationary
Villupuram	-2.13	Non-stationary	-10.34***	Stationary

Note: ****significant at 1% level; and ** significant at 5% level.*

Critical values: -3.99 (1%), -3.42 (5%), -3.13(10%).

There is a strong relationship between the Granger causality and co-integration i.e. there needs to be at least one market Granger to establish co-integration in the market pairs (Brooks, 2008). The test finds out which market should be regressand (dependent variable) and which should be kept as regressor (independent variable). The test was performed between six market pairs consisting of all the three markets under study and the results are furnished in table 2 and Fig. 3.

Table 2: Granger causality test for different markets

Null Hypothesis	F-statistic
Rajkot market does not Granger cause Kurnool market	22.61***
Kurnool market does not Granger cause Rajkot market	8.23***
Villupuram market does not Granger cause Kurnool market	13.46***
Kurnool market does not Granger cause Villupuram market	19.35***
Villupuram market does not Granger cause Rajkot market	0.85
Rajkot market does not Granger cause Villupuram market	64.04***

*Note: *, ** and *** indicate significance at 10 %, 5 % and 1 % levels respectively.*

From the Fig. 3 it is identified that there is bi-direction causality between Kurnool and Rajkot and also between Kurnool and Villupuram market. But as the existence of a unidirectional causality from Rajkot to Villupuram market was established, this causality test, thereby, exposed that the price changes in Rajkot market occur before the price changes in Villupuram market.

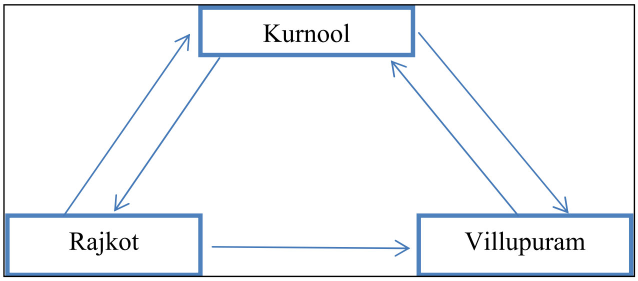

Fig. 3: Causal relationship among domestic groundnut markets under study

Engle-Granger Co-integration test

Engle-Granger co-integration is a bivariate test and is performed based on the causal relationship between the market pairs as given in Fig. 3. In the co-integration regression, the market which influences (or causes) another market is kept as an exogenous (independent) variable and estimation is done by OLS (ordinary least square) method. The residuals obtained from the co-integration regression are subjected to ADF test in order to judge whether the two series are integrated or not. Accordingly, the findings of this study revealed that the Kurnool and Rajkot market were non-stationary in levels.

In other words, both the markets were found to be integrated of order one i.e. $I(1)$. Thereby, it was considered meaningful to estimate co-integration regression between them by keeping one market as exogenous variable and the other market as endogenous variable. Since, there was existence of bidirectional causality between Kurnool and Rajkot markets, first of all Kurnool market was kept as the exogenous variable and co-integration regression was estimated as given in equation (7). The co-integration parameter was found to be highly significant.

$$\underset{(46.66)}{\text{Rajkot} = 42.29} + \underset{(0.02)}{1.02^{***}}\text{Kurnool} \quad (7.0)$$

$$\Delta\varepsilon_t = -5.84^{***}\varepsilon_{t-1} - \underset{(0.05)}{0.29^{***}}\,\Delta\,\varepsilon_{t-i} \sim I(0) \quad (7.1)$$

Where, $\hat{\varepsilon}_t = \text{Rajkot} - 42.29 - 1.02^{***}\text{Kurnool}$

$$\text{Kurnool} = \underset{(43.00)}{124.35^{***}} + \underset{(0.01)}{0.89^{***}}\text{Rajkot} \quad (8.0)$$

$$\Delta\varepsilon_t = -5.75^{***}\varepsilon_{t-1} - \underset{(0.05)}{0.29^{***}}\,\Delta\,\varepsilon_{t-i} \sim I(0) \quad (8.1)$$

Where, $\hat{\varepsilon}_t = \text{Kurnool} - 124.35^{***} - 0.89^{***}\text{Rajkot}$

$$\text{Villupuram} = \underset{(43.77)}{213.25^{***}} + \underset{(0.02)}{1.22^{***}}\,\text{Kurnool} \quad (9.0)$$

$$\Delta\varepsilon_t = -8.79^{***}\varepsilon_{t-1} - \underset{(0.06)}{0.56^{***}}\,\Delta\,\varepsilon_{t-i} \sim I(0) \quad (9.1)$$

Where, $\hat{\varepsilon}_t = \text{Villupuram} - 213.25^{***} - 1.22^{***}\text{Kurnool}$

$$\text{Kurnool} = -\underset{(36.53)}{62.66^{*}} + \underset{(0.01)}{0.77^{***}}\,\text{Villupuram} \quad (10.0)$$

$$\Delta\varepsilon_t = -8.64^{***}\varepsilon_{t-1} - \underset{(0.06)}{0.55^{***}}\,\Delta\,\varepsilon_{t-i} \sim I(0) \quad (10.1)$$

Where, $\hat{\varepsilon}_t = \text{Kurnool} + 62.66^{***} - 0.77^{***}\text{Villupuram}$

$$\text{Villupuram} = \underset{(51.33)}{294.02^{***}} + \underset{(0.02)}{1.13^{***}}\,\text{Rajkot} \quad (11.0)$$

$$\Delta\varepsilon_t = -5.05^{***}\varepsilon_{t-1} - \underset{(0.05)}{0.29^{***}}\,\Delta\,\varepsilon_{t-1} - \underset{(0.07)}{0.14^{***}}\,\Delta\,\varepsilon_{t-2} \sim I(0) \quad (11.1)$$

Where, $\hat{\varepsilon}_t = \text{Villupuram} - 294.02^{***} - 1.13^{***}\,\text{Rajkot}$

But to confirm the existence of co-integration between Kurnool and Rajkot markets, residuals were obtained from the fitted co-integration regression and the unit root test was performed on the residuals. The result of fitted ADF regression on residuals is given in the equation (7.1). It revealed that the ADF test statistic (5.84) was significant i.e. it was higher than the critical values given by the Engle and Yoo (1987), thereby, indicating stationarity of the residual series. Thus, the Kurnool and Rajkot markets were found to be co-integrated.

Subsequently, Rajkot market was kept as the exogenous variable and co-integration regression was attempted as given in equation (8). As shown in the equation, the co-integration parameter was found to be highly significant and the ADF residual regression in equation (8.1) confirmed that the residuals obtained from the co-integration regression were stationary. As the Engle-Granger test confirmed the integration of Kurnool and Rajkot markets, long-run price equilibrium between the markets was established.

Similar, to the above discussed market pair, Kurnool and Villupuram markets were also found to be integrated of order one i.e. $I(1)$ and the causality between the Kurnool and Villupuram market was also bidirectional. To estimate co-integration regression is Kurnool market was first kept as an independent variable and the Villupuram market was assumed to be influenced by the former market. The estimated co-integration regression, given in equation (9), indicated high significance of the co-integration parameter ($\hat{\beta}$) revealing that a 1% price increase in Kurnool market may lead to 1.22% price rise in Villupuram market if the two markets were integrated. The integration of two markets was confirmed by the ADF test on residuals as given in equation (9.1). Thus, the presence of long-run price movements between the two markets was established.

As there was the existence of bi-directional causality between Kurnool and Villupuram market, it was indeed necessary to estimate the second co-integration regression by keeping Villupuram market as an independent variable. The estimated parameters of the co-integration regression are given in equation (10) in which the co-integration parameter ($\hat{\beta}$) can be found to be highly significant. Though the two markets were non-stationary in levels, their residuals were found to be stationary as confirmed by the residual ADF test in the equation (10.1). This is one of the characteristic features of the integrated markets which also serves as confirmation for the long-run integration of Kurnool and Villupuram market prices.

The Rajkot and Villupuram markets were found to be integrated of order one i.e. $I(1)$, thereby co-integration regression between the two markets was attempted. The causality between these two markets was unidirectional in such a way that Villupuram market did not Granger cause the Rajkot market but the Rajkot market Granger caused Villupuram market. Thereby, Rajkot market was kept as regressor (independent variable) and Villupuram market as Regressand (dependent variable). The estimated co-integration regression, as given in equation (11), showed highly significant parameter which in turn revealed that a 1% price increase in Rajkot market may lead to 1.13% price rise in Villupuram market, provided the markets are integrated. The integration between the markets was further confirmed by performing ADF test on the residuals obtained by the co-integration regression.

The result of that test as given in equation (11.1) indicated that the residuals were stationary i.e. the two markets are integrated in the long-run. In this way, the Engle-Granger bivariate co-integration technique confirmed integration in major domestic groundnut markets. All the possible market pairs were integrated which indicated that the infrastructure facilities available in the domestic markets facilitate effective resource allocation leading to price transmission between the integrated markets. In addition, it was found that among the three markets Rajkot and Kurnool markets were the most dominant as the prices in these markets were found to cause price changes in the Villupuram groundnut wholesale market.

Johansen Co-integration Test

The weakness of the Engle-Granger co-integration test is that it can be applied only for a bivariate series and does not hold good to a multivariate series. As three markets were taken in the present study, the weakness of the Engle-Granger test was overcome by using multivariate Johansen co-integration technique. To perform this test, it was necessary to have the price series of all the three markets in the same order i.e. all the price series should be integrated in the same order of stationarity. As the findings revealed that all the three markets were stationary at $I(1)$, the test was performed. Since the Johansen test uses the restricted VAR(p) model i.e. VECM model, determining optimum lag becomes a significant step. The optimum lag was selected as 1 and 10 by the AIC and SIC. For parsimonious approach, lag 1 was selected and performed. The Eigen values were obtained from the co-integration matrix (Π) as given in table. 3. As there were three market price series, three Eigen values were obtained. The number of non-zero Eigen value indicated the rank of the co-integration matrix and the rank of that matrix in turn indicated the number of co-integration relation that is stationary (Tsay, 2016). As it is clear from table 3 that only the first two Eigen values were non-zero, thereby there are only two co-integration relations between the market pairs.

This result is supported by the determinant of the co-integration matrix which is zero; as it implies that the rank of that matrix is not three i.e. rank of matrix is less than three. Eigen value denotes the number of co-integration relation and it has been formally tested in the study using Johansen test and the results are presented in table 4. The Johansen approach consists of two tests one is Trace test and other is maximum Eigen value test (Table 4) and the latter test is more powerful than the former (Reddy, 2012). As the findings show, the trace test accepts the null hypothesis of two co-integration relation (Rank of matrix (Π) = 2) and it is supported by the maximum Eigen value test which rejects the null hypothesis of one co-integration relation and accepts the alternative hypothesis of two co-integration relationship. Since both the tests accepted the maximum co-integration relationship in the multivariate series (i.e. two), the long-run integration of the markets stand confirmed.

Table 3: Eigen value of the co-integration matrix

Eigen value	
$\lambda_1 = 0.20$	Eigen value order = 0.20 > 0.13 > 0.01
$\lambda_2 = 0.13$	$(\lambda_1 \geq \lambda_2 \geq \lambda_3)$
$\lambda_3 = 0.01$	$\mathrm{Det}(\Pi) = \lambda_1 . \lambda_2 . \lambda_3 = 0$

To obtain two co-integration relations, possible pairs of the three markets under study *viz.* Kurnool Villupuram, Rajkot Villupuram and Villupuram Rajkot were considered and the findings are presented in table 5. In the first two market pairs,

Table 4: Johansen multivariate co-integration test

$1-\lambda_i$		$\ln(1-\lambda_i)$
$1-\lambda_1 = 0.80$		$\ln(1-\lambda_1) = -0.22$
$1-\lambda_2 = 0.87$		$\ln(1-\lambda_2) = -0.13$
$1-\lambda_3 = 0.99$		$\ln(1-\lambda_3) = -0.01$
Trace co-integration test		
H_0 : Rank (Π) = m vs H_1 = Rank (Π) > m		$-(T-p)\sum_{i=m+1}^{k}\ln(1-\lambda i)$
H_0 : Rank (Π) = 0	H_1 = Rank (Π) > 0	$-(239)\sum_{i=0+1}^{3}\ln(1-\lambda_1) = 89.01^*$
H_0 : Rank (Π) = 1	H_1 = Rank (Π) > 1	$-(239)\sum_{i=1+1}^{3}\ln(1-\lambda_2) = 35.68^*$
H_0 : Rank (Π) = 2	H_1 = Rank (Π) > 2	$-(239)\sum_{i=2+1}^{3}\ln(1-\lambda_3) = 2.40$
Maximum eigen value test		
H_0 :Rank (Π) = m vs H_1 : Rank (Π) = $m+1$		$-(T-p)\ln(1-\lambda i)$
H_0 : Rank (Π) = 0	H_1: Rank (Π) = 0 + 1	$-(239)\ln(1-\lambda_1) = 53.33^*$
H_0 : Rank (Π) = 1	H_1 : Rank (Π) = 1 + 1	$-(239)\ln(1-\lambda_1) = 33.28^*$
H_0 :Rank (Π) = 2	H_1 : Rank (Π) = 1 + 1	$-(239)\ln(1-\lambda_1) = 2.40$

Note: *Critical values at 5 % level of significance are 29.79 (r = 0), 15.49 (r=1) and 3.84 (r = 2) for Trace test and 21.13 (r = 0), 14.26 (r = 1) and 3.84 (r = 2) for Max-Eigen test.*

T = Sample size which is 240 data points, p = optimum lags included which is one and

m = rank of the matrix.

former was kept as dependent variable and latter was assumed to be independent variable. But the Rajkot Villupuram market pair was not considered as there was no causality from the Villupuram market in Tamil Nadu state to the Rajkot market (Gujarat state). These relationships were based on the causal relationships that exist between the market pairs and they were also found to be stationary which indicated that the domestic groundnut markets were well integrated. The coefficients in the co-integration relationships were normalized coefficients (Table 5). This integration of markets implied that price in the spatially separated markets move together in response to changes in the demand and supply and other economic variables. This also indicated that there is common stochastic trend or one unit root for all the three markets.

Table 5: Possible co-integration relationship that is stationary

Co-integration relationship	Causality
AP_MT – 0.97 GU_MT (0.03)	Feedback
TN_MT – 1.25 GU_MT (0.05)	Unidirectional
AP_MT – 0.78 TN_MT (0.02)	Feedback

Short-run disequilibrium

Even though the markets are integrated in long-run, there may be disequilibrium in the shorter run (Sidhu *et al.*, 2012 and Selvi *et al.*, 2014). The adjustment of that disequilibrium to attain the long-run equilibrium path was estimated in the study based on error correction terms. The usually adopted Engle-Granger error correction mechanism can be applicable only for two variables. Since, the study involved three markets, the Vector Error Correction Model (VECM) was performed. To perform this test, it was necessary to know the number of co-integration relations existing between the markets under study. Since, the Johansen test ascertained the existence of two co-integration relations, thereby, in VECM model out of three market variables first two variables were considered as dependent variable and the order of estimation was done based on the Granger causality test outcomes. The market pairs considered for VECM estimation were: Kurnool–Villupuram–Rajkot, Rajkot–Villupuram–Kurnool and Kurnool–Rajkot–Villupuram.

In all the three pairs, first two markets act as dependent variables because of the presence of two co-integration relations in the vector. The last pair i.e. Kurnool–Rajkot–Villupuram is not estimated because the Villupuram market does not Granger causes Rajkot market. The estimated VECM for the pair Kurnool– Villupuram– Rajkot is given as VECM equations. Similar to the Johansen test, the lag determination is also one of the important criteria in VECM for determining the number of co-integration relations. The optimum lag was revealed as one and VECM was performed based on this lag.

The output of the Johansen test was taken as the input to VECM so as to reduce the co-integration matrix (Π) into $\alpha\beta'$ on the basis of full rank factorisation. Johansen test ascertained rank of that matrix as two i.e. two co-integration relations. Thereby, VECM was used on this information and the matrix Π was reduced by full rank factorisation into full column rank matrix α and full row rank matrix β'. The full column rank matrix was the adjustment matrix and the full row rank matrix was the long-run integration matrix. The co-integration equations obtained are similar to that of obtained in the table 5.

VECM equations:

$$\mathbf{D(Kurnool)} = \underset{(10.48)}{13.95} + \Pi P_{t-1} + \underset{(0.06)}{0.20^{***}} D\,(Kurnool(-1)) - \underset{(0.03)}{0.10^{***}} D\,(Villupuram(-1)) - \underset{(0.06)}{0.06} D\,(Rajkot(-1))$$

(10.48) (0.06)

$$\mathbf{D(Villupuram)} = \underset{(22.43)}{10.54} + \Pi P_{t-1} + \underset{(0.13)}{0.50^{***}} D\,(Kurnool(-1)) - \underset{(0.08)}{0.30^{***}} D\,(Villupuram(-1) - \underset{(0.14)}{0.29^{**}} D\,(Rajkot(-1)$$

$$\mathbf{D(Rajkot)} = \underset{(11.12)}{14.16} + \Pi P_{t-1} - \underset{(0.06)}{0.02} D(Kurnool(-1)) - \underset{(0.04)}{0.02} D\,(Villupuram(-1)) + \underset{(0.07)}{0.05} D\,(Rajkot(-1))$$

The ΠP_{t-1} is reduced into $\alpha\beta' P_{t-1}$ i.e. the short-run and long-run vector as given below and the equation is given in:

$$\alpha = \begin{pmatrix} \alpha_1 & \alpha_2 \\ \alpha_3 & \alpha_4 \\ \alpha_5 & \alpha_6 \end{pmatrix} = \begin{pmatrix} -\mathbf{0.30}^{***}\ (0.04) & 0.11^{***}\ (0.03) \\ 0.15 \quad (0.10) & \mathbf{-0.37}^{***}\ (0.07) \\ 0.11^{**}\ (0.05) & 0.01 \quad (0.03) \end{pmatrix}$$

$$\beta' = \begin{pmatrix} 1 & 0 & -0.97^{***} & (0.03) \\ 0 & 1 & -1.25^{***} & (0.05) \end{pmatrix}$$

The adjustment coefficient α_1 was related to the Kurnool market and Rajkot market and the adjustment coefficient α_4 was related Villupuram market and Rajkot market, where both the coefficients were negative and significant indicating that the adjustment leads to the equilibrium in long-run.

$$D(Kurnool) = -\underset{(0.04)}{\mathbf{0.30}^{***}}(Kurnool - 0.97\ Rajkot + 20.45) \tag{13}$$

$$D(Villupuram) = -\underset{(0.07)}{\mathbf{0.37}^{***}}(Villupuram - 1.25\ Rajkot - 112.27) \tag{14}$$

As given in equation 13, the Kurnool and Rajkot market were integrated in long-run and the disequilibrium between them in short-run was adjusted by the Kurnool market of about 30% per month in order to attain the long-run equilibrium with Rajkot market. Similarly, as given in equation 14, Villupuram market was found to adjust itself by about 37% per month in order to attain equilibrium with the Rajkot market. The adjustment estimated by the VECM indicated that the markets take some period of time to attain long-run equilibrium. The fitted VECM adequacy was tested on the multivariate portmanteau test Q(6) = 57.97 with p-value =0.15, and the findings implied the acceptance of the null hypothesis of no serial correlation of residuals.

$$D\,(Rajkot) = -\underset{(0.04)}{\mathbf{0.11}^{***}}(Rajkot - 1.02\ Kurnool - 20.95) \tag{15}$$

$$D\,(Villupuram) = -\underset{(0.07)}{\mathbf{0.37}^{***}}(Villupuram - 1.28\ Kurnool - 138.28) \tag{16}$$

The VECM was also estimated for Rajkot–Villupuram – Kurnool pair due to the presence of causality from Kurnool market to the other two markets. The adjustment coefficients α_1(– 0.11)and α_4(– 0.37) given in the equations (15) and (16) were found to be negative and significant implying that the disequilibrium between Rajkot and Kurnool market in long-run was corrected by the Rajkot market at the rate of 11% per month to attain equilibrium with the Kurnool market. This adjustment made by the Rajkot market was found to be very slow as it takes some more periods to attain long-run integration. Similarly the Villupuram market adjusts itself by 37% per month in order to attain long-run equilibrium with Kurnool market. This adjustment is quite moderate.

CONCLUSION

The present study has focused on market price integration of major wholesale market groundnut, the leading oilseed crop in India. The findings reveal that though the markets are geographically well separated, none of them acted as a separate market and there are very less market distortions. On the contrary, all of them displayed a common price movement and effective price signals of integration in the long-run and the results of the co-integration tests showed that the markets were integrated with maximum two co-integrating equations. At the same time, short-run disequilibrium in prices also tend to exist between the integrated market pairs to such an extent that almost 11 to 37% of the deviations were found to be corrected with a month. Thereby, there seems to be sluggishness in market convergence. Improving market arbitrage and efficient allocation of resources in the markets will address this issue to a huge extent. In addition, developments in transportation system, market infrastructure and rationalizing institutional constraints would further help in improving price transmission.

REFERENCES

Brooks, C. 2008. Introductory Econometrics for Finance (2nd edition). Cambridge University Press, New York, USA.

DACNET. 2016. Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers' Welfare, New Delhi, India. www.agmarkweb.dacnet.nic.in. Accessed on April, 2016.

DES. 2014. Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi. Available at: http://eands.dacnet.nic.in/APY_96_To_06.htm.

Engle, R.F. and Granger, C.W. 1987. Co-integration and error correction: representation and testing. *Econometrica,* **55**: 251-257.

Engle, R.F. and Yoo, B.S. 1987. Forecasting in a co-integrated system. *Journal of Econometrics*, **35**: 143-159.

Gujarati, D.N., Dawn, C.P. and Sangeetha, G. 2009. Basic Econometrics (5th edition). Tata McGraw Hill Education Pvt. Ltd.

Johansen, S. and Juselius, K. 1990. Maximum Likelihood Estimation and Inference on Cointegration with Application to Demand for Money. *Oxford Bulletin of Economics and Statistics,* **52**: 169-210. DOI: 10.1111/j.1468-0084.1990.mp52002003.x

Pansayarselvi, R., Muraligopal, S. and Swaminathan, B. 2014. Price dynamics of domestic and international maize markets: A vector error correction mechanism (VECM) approach. *International Research Journal of* Agricultural *Economics and Statistics,* **5**(2): 272-277.

Reddy, A. 2012. Market Integration of Grain Legumes in India: The Case of the Chickpea Market. *SAARC Journal of Agriculture,* **10**(2): 11-29.

Sidhu, R.S., Kumar, S., Vatta, K. and Singh, P. 2010. Supply Chain Analysis of Onion and Cauliflower in Punjab. *Agricultural Economics Research Review,* **23**: 445-453.

Sundaramoorthy, C., Girish, K.J., Suresh, P. and Mathur, V.C. 2014. Market Integration and Volatility in Edible Oil Sector in India. *Journal of the Indian Society of Agricultural Statistics,* **68**(1): 67-76.

Tahir, M. and Muhammad, T.J. 2008. Market Integration in Wholesale Maize Markets in Pakistan. *Regional and Sectoral Economics Studies,* **8**: 2-8.

Tsay, R.S. 2016. Analysis of Financial Time Series (3th edition). John Wiley, New York, USA.