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Co-integration of Groundnut Markets in India

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A B S T R A C T

The present study was undertaken to analyze groundnut market integration in six major regional markets located in Gujarat (Junagadh and Rajkot), Rajasthan (Bikaner and Jaipur) and Karnataka (Hubballi and Raichur) states of India were selected based on major arrivals of commodity to respective market, using monthly wholesale prices of groundnut during 2005 to 2021. Augmented Dickey-Fuller Unit root test indicated that the price series in each location are non -stationary at their levels, and stationary at their first differences. Co-integration results showed that the regional markets have price linkages and thus are spatially integrated. Johansen's multiple co-integration tests reveals that that their existence of at least five co-integration equations for selected groundnut markets based on likelihood-ratio test. Granger causality test explain that, there is existence of mostly bidirectional causality with few unidirectional causality among selected groundnut markets. The unidirectional relationship was found for the pair of Raichur market indicates that price of Raichur market influence the price of Rajkot and Hubballi market. Similarly, Hubballi, Junagadh, Rajkot, Bikaner and Jaipur exerted bidirectional causality among them. Thus, results of the study indicated a strong integration among major groundnut markets in India. It's clearly manifest that Raichur is the independent market for groundnut prices in south India and also there bidirectional relationships exist among the domestic markets, So it is confirmed that the price of one market influence the price of other markets. The test for causality is based on F statistics. Which indicated the price transmission happening in long run adjustments and the presence of short run equilibrium existed among the groundnut markets in India. Vector error correction estimates indicates that, extent of groundnut markets integration for different lags in the current study.

***Key words*:** Unit root test, Granger causality, Independent market, Price transmission

Groundnut, popularly known as the peanut is a leguminous crop cultivated for edible purposes. It is found exclusively in tropical and subtropical regions of the world. It is sometimes considered as a grain legume because the seed can produce oil and the crop is categorized as an oil crop. The oil content in the seed is estimated to be around 44-50% [1]. The useful part or the part of economic importance within the crop grows under the ground as pods. These crops contain nitrogen fixing bacteria in their roots and that is the reason behind their low nitrogen fertilizer requirement. Major uses of groundnuts are found in soap making, cosmetics, lubricant industries, etc. The cake of groundnut is used for manufacturing artificial fiber. The green or dried leaves of the groundnut crops are called haulms and are used as livestock feed. The shell of the ground nut is used for manufacturing coarse boards, corks etc. [2-3].

Among the oilseed crops grown in India, groundnut holds the first place. The annual production of groundnuts is around 7180.5 thousand tonnes approximately and 9 states are considered to contribute more than 100 thousand tonnes each. The major groundnut producing states in India are Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh, West Bengal and Telangana. Groundnut farming in India is done in 85 lakh hectares of land approximately and highest productivity is from the state of Tamil Nadu [4]. Oil seeds in India definitely contribute to the agricultural economy, but they are only next to food grains in both value and production. The importance of edible oil in one's daily diet has resulted in increased demand for groundnut production [5]. It is estimated that there would be further increase in consumption levels owing to enhanced income and population [6]. Currently the production doesn't satisfy the demand and oil is being imported from other countries. Therefore, efforts should be made to increase the area under production for groundnuts so that many by-products manufactured from these could be made available [7]. Groundnut farming in India is also expected to improve income opportunities for the tribal population.

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MATERIALS AND METHODS

Selection of markets

In India, Gujarat, Rajasthan and Karnataka put together contributes more than 60 per cent of the country's total groundnut production, so markets from the above states were selected purposively based on major arrivals. The study is based on monthly wholesale price data for six major groundnut markets namely, Junagadh, Rajkot, Jaipur, Bikaner, Hubballi and Raichur markets for the period from January 2005 to December 2021 were analyzed. All the relevant data have been collected from Krishimaratavahini, Agmarknet and NIC.

Market integration

To maintain the growth rate, it is essential that a farmer should receive remunerative prices. They should get a better share of consumers‟ rupee paid for soybean and its value-added products. This is possible only when marketing efficiency is of high order. Market integration analysis over space and form are the major tools to verify the marketing efficiency.

Prices in spatially integrated markets are determined simultaneously in various locations, and information of any change in price in one market is transmitted to other markets. Markets that are not integrated may convey inaccurate price signal that might distort producers marketing decisions and contribute to inefficient product movement and traders may exploit the market and benefit at the cost of producers and consumers.

Price transmission analysis

The output of price transmission analysis helps to understand the following points - Is there a long-term relationship between the two markets, Do prices in market 'A' influence those in market 'B', the reverse, or do they both influence each other, If the price in one market changes how much will it cause the other price to change in short run and if the price in one market changes how much will it cause the other price to change in the long run In the context of two domestic prices, it tells us whether market 'A' is influencing market 'B', or 'B' is influencing 'A', or if both are influencing each other. This causation analysis helps in understanding and describing trends in local prices.

ADF test

Prior to testing for co-integration, the price series are first tested for their order of integration, since a necessary condition for co integration is that the series are integrated of the same order. The augmented Dickey- Fuller (ADF) test is used to test for the order of integration. To test unit root, the ADF test is conducted based on the following regression equation:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-1} + e_t$$

[t-1: 1 month lagged price and Δ: differenced series]

Y_i denoted the price series of markets (Junagadh, Rajkot, Jaipur, Bikaner, Hubballi and Raichur groundnut price series).

If the coefficient δ is not statistically different from zero, it implies that the series have a unit root, and, therefore, the series is non- stationary. To verify that the first differenced price series is indeed stationary, ADF unit root tests are used. The null hypothesis of non-stationary is tested using a t-test. The null hypothesis is rejected if the estimated variable is significantly negative. Once the variables are checked for stationary and are of the same order, integration between them can be tasted.

Testing for market integration is central to the design of any agricultural price policy in many developing countries and has been an area of abiding research interest. This literature can be divided into three broad categories. Until recently two broad approaches had been used to investigate market integration: (i) that devised prior to the use of co integration techniques (ii) those using co integration methods of the Engle- Granger variety, and (iii) those using Johansen maximum-likelihood techniques (Johansen, 1988). To the extent that agricultural prices tested are non-stationary, the latter technique is more appropriate.

Engle-granger causality

An autoregressive distributed lag (ADL) model for the Granger-causality test was developed following Engle and Granger (1987) specification provided below:

$$P_t^1 = \alpha + \beta_o T + \sum_{j-1}^{J} \beta_j P^1_{t-j} + \sum_{k-1}^{K} h_k P^2_{t-k} + \varepsilon_t$$

Where T is the time trend, εt is the error term.

Lags for the ADL model were selected to minimize the Akaike‟s Information Criterion. Granger causality tests were specified as:

$$P_t^1 = \alpha + \beta_o T + \sum_{j-1}^{J} \beta_j P^1_{t-j} + \sum_{k-1}^{K} h_k P^2_{t-k} + \varepsilon_t$$

$$H_o: h_1 = h_2 = \ldots\ldots\ldots = h_t = 0$$

$$P^2_t = \delta + \phi_o T + \sum_{j-1}^{J} \Omega_j P^1_{t-j} + \sum_{k-1}^{K} \phi_k P^2_{t-k} + v_t$$

$$H_o: \phi_1 = \phi_2 = \ldots\ldots\ldots\ldots = \phi_K = 0$$

Co-integration

Co-integration means that despite being individually non-stationary, a linear combination of two or more time series can be stationary. The series that satisfy this requirement are said to be co-integrated. Following Granger, a time series x_t which has a stationary, invertible, non-deterministic ARMA representation after differencing *d* times is integrated of order *d* and is denoted by $x_t \sim I(d)$. The components of the vector x_t are said to be co integrated of order *d*, *b*, denoted CI (d,b), if all the components of *xt* are I(d); there exists a vector ‟ x_t is 1(d-b), b>0.

The vector is then called a co integrating vector. A necessary condition for co integration is that the data series for each variable involved exhibit similar statistical properties, that is, to be integrated to the same order with evidence of some linear combination of the integrated series.

Johansen developed a multivariate system of equations approach, which allows for simultaneous adjustment of both or even more than two variables. Johansen‟s approach is also widely used in many bivariate studies as it has some advantages to the single equation approach. First, the multivariate system of equations approach is more efficient than the single equation approach, i.e., it allows estimating the co integration vector with smaller variance. The second advantage of the multivariate approach is that in the simultaneous estimation it is not necessary to presuppose exogeneity of either of the variables.

Error correction model

Although price transmission analysis is a useful tool for understanding and predicting price trends, it only tells us about the relationship between two prices over time. It does not tell us why the price transmission is strong or weak, fast or slow. This interpretation can only be done with local knowledge of transportation routes, seasonal flows in staple foods, trade and agricultural marketing policies, the availability of foreign exchange and credit, the ease of obtaining permits, and the competition for overland freight, among other factors.

RESULTS AND DISCUSSION

Market integration

To verify level and first differenced price series were indeed stationary, Augmented Dickey-Fuller (ADF) unit root

test was used. The ADF test results are presented for the period January 2005 to December 2021 (Table 1). The equations were estimated with an intercept and time trend. The results are presented in (Table 1), for ADF unit root tests for each series. The null hypothesis of non-stationary was tested based on the critical values reported by MacKinnon. All the price series appeared non stationary in the levels, but all the series were stationary after taking first differences. After confirming the price exchange rates were stationary in their first differences, co integration between the groundnut markets in futures was tested using Johansen's maximum likelihood procedure. The bivariate co-integration technique of Engle and Granger was also tested for the presence of long run relationship existing between groundnut price in different states.

Table 1 ADF Unit root test for groundnut in selected markets of India

Variable	Level	P-value	First difference	P-value
Hubballi	-2.0132	0.2381	-12.4275**	0.0000
Raichur	-2.2306	0.0560	-14.6121**	0.0000
Junagadh	-2.1251	0.2354	-14.1392**	0.0000
Rajkot	-1.7913	0.3839	-13.8479**	0.0000
Bikaner	-1.8405	0.3600	-16.2980**	0.0000
Jaipur	-1.5103	0.5262	-10.3827**	0.0000

**Significant at 1 per cent level

Table 2 Pairwise Granger causality test for groundnut markets in India

Null hypothesis	F – statistic	P –value
HUBBALLI does not Granger Cause BIKANER	10.7078**	0.0000
BIKANER does not Granger Cause HUBBALLI	5.7990*	0.0036
RAJKOT does not Granger Cause HUBBALLI	16.2750**	0.0000
HUBBALLI does not Granger Cause RAJKOT	3.6587*	0.0278
JAIPUR does not Granger Cause HUBBALLI	6.6781*	0.0016
HUBBALLI does not Granger Cause JAIPUR	5.3551*	0.0055
JUNAGADH does not Granger Cause HUBBALLI	10.5269**	0.0000
HUBBALLI does not Granger Cause JUNAGADH	7.4419**	0.0008
RAICHUR does not Granger Cause HUBBALLI	5.7341*	0.0039
HUBBALLI does not Granger Cause RAICHUR	2.0271	0.1348
RAJKOT does not Granger Cause RAICHUR	4.4467*	0.0131
RAICHUR does not Granger Cause RAJKOT	2.8294	0.0618
JAIPUR does not Granger Cause RAICHUR	7.0048*	0.0012
RAICHUR does not Granger Cause JAIPUR	6.8693*	0.0013
JUNAGADH does not Granger Cause RAICHUR	4.9316*	0.0083
RAICHUR does not Granger Cause JUNAGADH	5.1692*	0.0066
BIKANER does not Granger Cause RAICHUR	4.8729*	0.0087
RAICHUR does not Granger Cause BIKANER	8.9991**	0.0002
JAIPUR does not Granger Cause RAJKOT	3.7256*	0.0261
RAJKOT does not Granger Cause JAIPUR	9.0204**	0.0002
JUNAGADH does not Granger Cause RAJKOT	14.8102**	0.0000
RAJKOT does not Granger Cause JUNAGADH	5.240*	0.0062
BIKANER does not Granger Cause RAJKOT	8.0468**	0.0005
RAJKOT does not Granger Cause BIKANER	6.0578*	0.0029
JUNAGADH does not Granger Cause JAIPUR	5.6590*	0.0042
JAIPUR does not Granger Cause JUNAGADH	10.217**	0.0000
BIKANER does not Granger Cause JAIPUR	12.1178**	0.0000
JAIPUR does not Granger Cause BIKANER	6.0195*	0.0030
BIKANER does not Granger Cause JUNAGADH	9.6120**	0.0001
JUNAGADH does not Granger Cause BIKANER	3.9715*	0.0206

**Significant at 1 percent level;
*Significant at 5 percent level

Granger casualty test

The causal relationship among the markets price of major groundnut markets in India were approached through above technique and results are presented in (Table 2). It could be seen that existence of mostly bidirectional causality with few unidirectional causality among selected groundnut markets. The unidirectional relationship was found for the pair of Raichur market indicates that price of Raichur market influence the price of Rajkot and Hubballi market. Similarly, Hubballi, Junagadh, Rajkot, Bikaner and Jaipur exerted bidirectional causality among them (Fig 1). Thus, results of the study indicated a strong integration among major groundnut markets in India. So, it is confirmed that the price of one market influence the price of other markets. The test for causality is based on F statistics.

Results of Jahansen's multiple co-integration analysis

Since all the price series are non-stationary at level form and stationery at first difference level, Johansen co integration test can be applied to analyze the long run equilibrium among the groundnut markets. The results of the analysis showed that there exist at least five co-integrations, out of which four equations were significant at one per cent level reaming at 5 per cent level of significant (Table 3). It is concluded that long run equilibrium exists among the six major markets. Any shocks in these markets would affect the prices of the other markets.

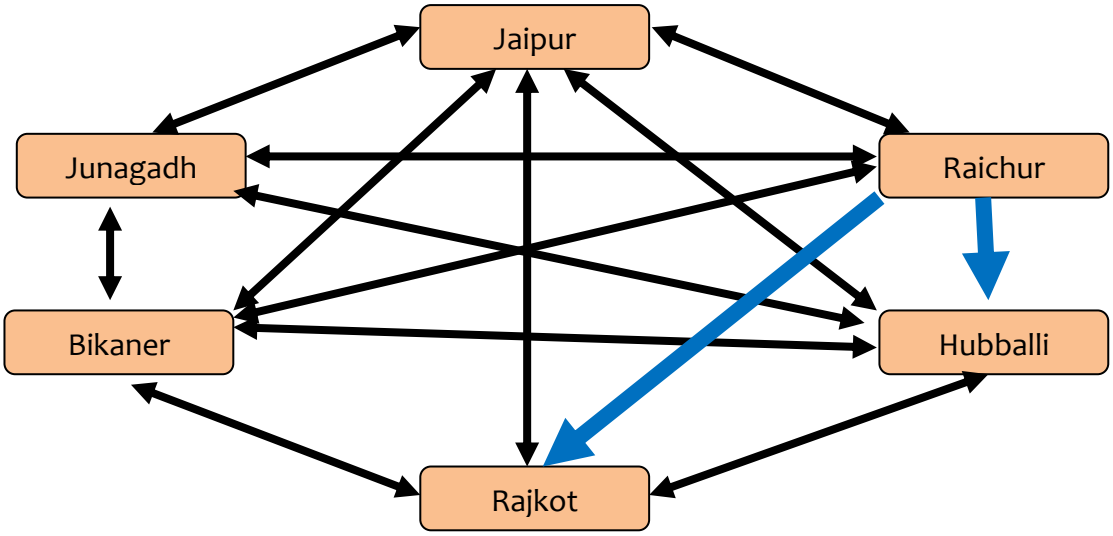

Fig 1 Pairwise granger causality of groundnut markets

Table 3 Johansen's multiple co-integration analysis for groundnut in selected markets unrestricted co integration rank test (Trace)

Trace statistics of Series Hubballi, Jaipur, Junagadh, Raichur, Rajkot, and Bikaner				
No. of CE(s)	Eigen value	Statistic	Critical value	Probability
None	0.3115	182.72**	95.75	0.0000
At most 1	0.2294	117.39**	69.81	0.0000
At most 2	0.1590	71.783**	47.85	0.0001
At most 3	0.1292	41.47**	29.79	0.0015
At most 4	0.0791	17.26*	15.49	0.0268
At most 5	0.0160	2.83	3.84	0.0925

Critical values based on MacKinnon (1999); LR test indicated 5 co-integrating equation
**Significant at 1 per cent level; *Significant at 5 per cent level

Table 4 Reduced form vector error correction estimates for groundnut markets

Error correction	D (Hubballi)	D (Jaipur)	D (Junagadh)	D (Raichur)	D (Rajkot)	D (Bikaner)
ECM	-0.5805	-0.0963	0.1009	0.1655	0.0403	0.0033
	[-6.6037]	[-.5934]	[1.8710]	[1.5917	[0.8385]	[0.0564]
D (Hubballi -1)	-0.0014	0.0721	-0.0364	-0.1589	-0.0297	0.0730
	[-0.0175]	[1.2657]	[-0.7165]	[-1.6203]	[-0.6550]	[1.2865]
D (Hubballi -2)	0.0744	0.0712	*-0.1112*	-0.1646	-0.0755	0.0307
	[0.9490]	[1.3215]	[-2.3113]	[-1.7745]	[-1.7617]	[0.5723]
D (Jaipur -1)	0.1146	*-0.3084*	*0.1934*	-0.1199	0.0265	*0.1650*
	[1.0287]	[-4.0239]	[2.8287]	[-0.9098]	[0.4351]	[2.1638]
D (Jaipur -2)	0.0294	*-0.1835*	*0.1698*	0.0020	0.0773	-0.0111
	[0.2639]	[-2.3961]	[2.4854]	[0.0157]	[1.2704]	[-0.1457]
D (Junagadh -1)	0.1639	-0.0228	*-0.2726*	-0.0440	*0.3252*	*0.2414*
	[0.9987]	[-0.2020]	[-2.7067]	[-0.2269]	[3.6243]	[2.1490]
D (Junagadh -2)	0.0609	*-0.2959*	*-0.2402*	-0.0745	*0.1863*	0.0607
	[0.3658]	[-2.5857]	[-2.3516]	[-0.3786]	[2.0483]	[0.5331]
D (Raichur -1)	-0.0957	-0.0484	-0.0152	-0.0378	0.0343	0.0283
	[-1.2754]	[-0.9377]	[-0.3311]	[-0.4263]	[0.8361]	[0.5512]
D (Raichur -2)	-0.1110	-0.0513	0.0467	-0.0161	-0.0198	0.0605
	[-1.4796]	[-0.9948]	[1.0144]	[-0.1817]	[-0.4848]	[1.1799]
D (Rajkot -1)	*-0.4912*	-0.0354	0.1631	0.2291	*-0.3587*	-0.1297
	[-2.3746]	[-0.2488]	[1.2855]	[0.9366]	[-3.1725]	[-0.9165]
D (Rajkot -2)	-0.0576	*0.3298*	0.0990	0.2183	-0.1530	0.0523
	[-0.3088]	[2.5694]	[0.8644]	[0.9886]	[-1.4991]	[0.4096]
D (Bikaner -1)	*0.4490*	*0.4176*	0.1207	-0.0017	0.1029	*-0.3567*
	[2.7907]	[3.7743]	[1.2234]	[-0.0090]	[1.1700]	[-3.2395]
D (Bikaner -2)	-0.1657	0.1832	0.0370	-0.1560	0.0803	-0.2087
	[-1.0701]	[1.7204]	[0.3900]	[-0.8515]	[0.9483]	[-1.9688]
C	15.26	13.48	10.86	20.53	12.46	15.53
R-squared	0.33	0.21	0.17	0.05	0.20	0.13
AIC	14.927	14.1781	13.9504	15.2627	13.7193	14.1685

Bold and italics are the significant variable and t-statistics in []

Vector error correction model

Vector Error Correction test from the (Table 4), revealed that a change of one rupee in Hubballi market in present month would decrease groundnut prices in succeeding month of Junagadh market by 11 paisa. Similarly, if one month lagged groundnut prices in Jaipur market would decrease by 33 paisa in next month at Jaipur market and would increase in next month prices of Junagadh by 19 paisa and Bikaner by 16 paisa. If other than this, any change occurs in the prices of groundnut in Jaipur it would be due to other factors. Two months lagged prices of vector error correction test revealed that a change in price by one rupee in Jaipur market in present month would be responsible for decrease in price by 18 paisa in succeeding month. Similarly, it would result in increase in prices at Junagadh market by 16 paisa [8-10].

With respect to Junagadh market, if one month lagged prices are taken it would result in decrease of price by 27 paisa in Junagadh market during next month, while price would increase in next month groundnut prices in Rajkot (32 paisa) and Bikaner (24 paisa). While two month lagged groundnut prices of Junagadh market lead to decrease in next month groundnut prices in Jaipur (29 paisa), Junagadh (24 paisa) but would result in increase in Rajkot groundnut prices by 18 paisa.

The analysis of vector error correction model revealed that for one month lagged prices of Rajkot market, change in price by one rupee in Rajkot market in the present month would be responsible for decrease in next month groundnut prices of Hubballi by 49 paisa and Rajkot itself by 35 paisa. Similarly, two month lagged price in Rajkot market leads increase in next month groundnut prices in Jaipur to an extent of 32 paisa [11].

The analysis using one month lagged prices of Bikaner market revealed that change of one rupee in Bikaner market price in the present month would be responsible for decrease in next month groundnut prices of Bikaner by 35 paisa and increase of 44 paisa in groundnut prices of Hubballi, 41 paisa in Jaipur market, if there exists any change other than this in the prices of groundnut in Jaipur, it would be attributable to some other factors [12].

CONCLUSION

The domestic groundnut markets are highly integrated. Price transmission among domestic groundnut markets is proved since it had long run association with the domestic markets. Results of the time series econometric analyses confirmed that domestic groundnut markets were integrated with international market prices and the world prices are transmitted to the domestic markets. Results of Johansen‟s multiple co- integration tests revealed that the domestic groundnut markets of Junagadh, Rajkot, Jaipur, Bikaner, Hubballi and Raichur, are integrated with at least two co-integration vectors.

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