International Journal of Statistics and Applied Mathematics 2023; SP-8(4): 160-164

International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(4): 160-164

https://www.mathsjournal.com
Received: 04-04-2023
Accepted: 07-05-2023

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Co-integration of groundnut markets in Gujarat with special reference to the Saurashtra region

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DOI: https://doi.org/10.22271/maths.2023.v8.i4Sc.1061

Abstract
Oilseeds play an important role in Indian agriculture as the second major crop (next to cereals). Groundnut (*Arachis Hypogaea* L.) is one of the important oilseed crops among major oilseed crops in India and Gujarat. Gujarat ranks first in the area and production of groundnut among all the states of the country accounting for 34 and 43 percent respectively. The study utilized monthly time series data on arrival and prices of groundnut for 20 years (April-1998 to March-2018). The market co-integration was calculated by us Engle-Granger Co-integration test. The results of the Granger Causality test concluded that Select groundnut markets in the Saurashtra region have considerable integration. According to the findings of the overall co-integration test, Saurashtra's various wholesale groundnut markets are well-integrated and have a long-term pricing relationship.

Keywords: Augmented Dickey-Fuller, pricing relationship, Saurashtra region

Introduction
Oilseeds play an important role in Indian agriculture as the second major crop (next to cereals) occupying 11 percent of the total cropped area and 9 percent of the total agricultural production. India emerged in the late 1990s as one of the world's largest importers of edible oils and is a major producer and consumer of oilseeds and their products and now goes down to 4th position (Anon., 2017) [1]. Groundnut (*Arachis Hypogaea* L.) is one of the important oilseed crops among the major oilseed crops. India has the largest area under groundnut in the world. Groundnut plays a major role in bridging the vegetable oil deficit in the country. Groundnut accounts for 45 percent of the area and 55 percent of the production of total oilseeds in India. It occupies an area of 7.5 million ha in the country with an output of 6.21 million tonnes and an average productivity of 1341 kg/ha during 2017- 2018, and the bulk of the crop is grown during the *kharif* season as a rainfed crop. Gujarat ranks first in the area and production of groundnut among all the states of the country accounting for 34 and 43 percent respectively. It is annually grown in an area of about 16.5 lakh ha producing 30.5 lakh tonnes with average productivity of 1879 kg/ha in 2017-18 (Anon., 2018) [2]. Saurashtra region consisting of groundnut growing districts is leading in the Gujarat state.
Market integration and price volatility study in the markets gives a scope to the policymakers and farmers regarding policy-making and investment activity. Market integration is concerned with spatial and temporal integration. Spatial and temporal integration is the key to studying the performance of markets. Engle and Granger test and multivariate Johansen likelihood method are applied to the price series of spatially separated markets to test whether the markets are integrated. Even if the markets are integrated, price fluctuation in these markets determines the income stabilization of the farmers. Fluctuations in commodity prices have always been a major concern of the producers as well as the consumers as they affect their decision and planning process (Sundaramoorthy *et al.*, 2014) [3].

Data and methodology
To analyze market integration, the markets, Rajkot, Junagadh, Amreli, and Gondal were selected based on the maximum arrival of groundnut.

The monthly time series data on arrivals and prices of groundnut for 20 years (April-1998 to March-2018) were collected from the registers maintained in the respective Agricultural Produce Market Committees (APMCs) and analyzed using EViews7 software. Since the data are of the time-series variety, stationarity must be established before including them in the model. Since co-integration between market pairings requires that both markets be in the same order, stationarity in the data series would disclose the order of differences.

Unit root test

The presence of non-stationarity in the present series of data is tested by performing Augmented Dickey-Fuller (ADF) test using the following regression equation:

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

Where ε_t is a pure white noise error term, $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, α is the drift parameter and p is several lag lengths which is determined using Partial Autocorrelation Function (PACF) of the series.

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) [3]. 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.

$$P_{1t} = \alpha + \sum_{i=1}^{m} \beta_i P_{it-1} + \sum_{j=1}^{m} y_j P_{2t-j} + u_{1t}$$

$$P_{2t} = \alpha' + \sum_{i=1}^{m} \theta_i P_{1t-i} + \sum_{j=1}^{m} \Phi_j P_{2t-j} + u_{2t}$$

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, 2003) [7].

Engle-granger Co-integration test

Bi-variate co-integration analysis between market pairs was carried out using Engle and Granger formulation test using the following regression:

$$P_{1t} = \alpha + \beta P_{2t} + \varepsilon_t$$

Where P_1 and P_2 are two price series from different regions. The residuals from the equation 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 the ADF test cannot be used for determining their significance but the ADF unit root test can be conducted on the residuals ε_t obtained from the equation using the following linear equation.

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

Where δ and α are the estimated parameters and it 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) [5], the residuals obtained from the co-integration equation will be stationary and the price series P_1 and P_2 are said to be integrated in the long run and vice-versa.

Results and Discussion

In time series analysis, stationary data are significant one because the estimation procedures are available only for that data. The analysis of non-stationary time series data leads to spurious results. The Augmented Dickey-Fuller (ADF) based unit root test procedure is used to check whether the price series of the groundnut market are stationary or not. The results of the ADF unit root test for prices of groundnut are presented in Table 1. Results of the ADF test showed that the original series was non-stationary for all districts based on the probability value and the null hypothesis was accepted which indicates the presence of a unit root problem. After the first order differencing series became stationary.

Table 1: Unit root test for prices of Groundnut

Groundnut Markets	Unit root test	
	Level	First difference
Rajkot	-3.04	-12.32**
Junagadh	-2.83	-14.65**
Amreli	-3.12	-15.35**
Gondal	-2.87	-11.83**

Granger causality testa

The Granger causality test was applied to find out the dominating market for price formulation as well as the direction of information flow. The results of the Granger Causality test are presented in Table 2. The results revealed that there is the existence of unidirectional causality from the Junagadh market to the Rajkot market. The wholesale prices in the Rajkot market do not influence the wholesale prices in the Junagadh market. The wholesale prices in the Rajkot market had a bidirectional price transmission with the Amreli market and the Gondal market. The price of groundnut in the Gondal market has bidirectional causality with all selected markets. Amreli market exhibited bidirectional price transmission with Gondal, Junagadh, and Rajkot markets. This result implies that there is strong integration existed between selected groundnut markets of the Saurashtra region.

Figure 1 represents the causal relationship among selected groundnut markets under study. There is a strong relationship between Granger causality and co-integration.

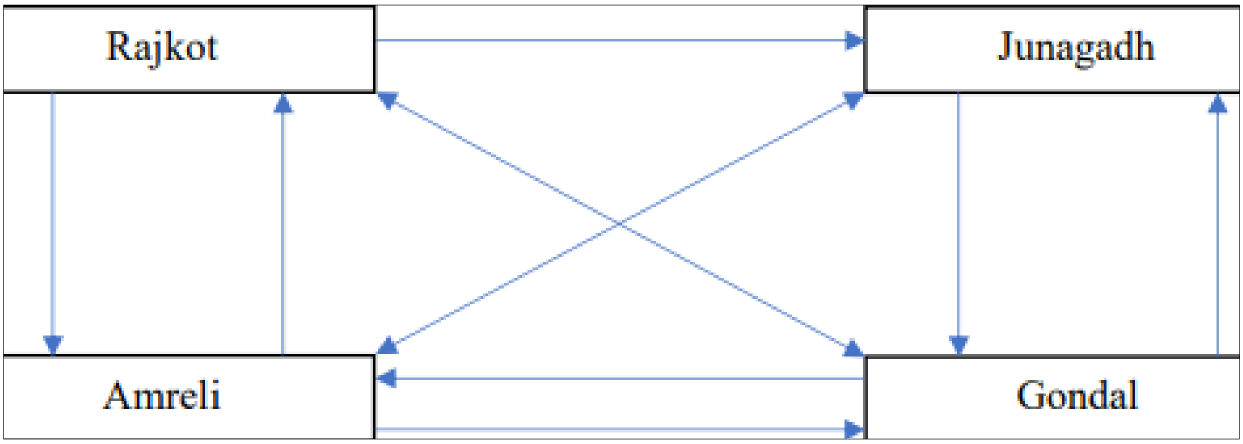

Fig 1: The causal relationship among selected groundnut markets

Table 2: Pair-wise Granger causality test of groundnut price for selected groundnut markets

Null Hypothesis	F-Statistics	Direction
Junagadh does not Granger Cause Rajkot	17.00**	Unidirectional
Rajkot does not Granger Cause Junagadh	0.11	
Amreli does not Granger Cause Rajkot	3.10**	Bidirectional
Rajkot does not Granger Cause Amreli	15.16**	
Gondal does not Granger Cause Rajkot	4.63**	Bidirectional
Rajkot does not Granger Cause Gondal	14.58**	
Amreli does not Granger Cause Junagadh	0.67*	Bidirectional
Junagadh does not Granger Cause Amreli	48.70**	
Gondal does not Granger Cause Junagadh	0.89*	Bidirectional
Junagadh does not Granger Cause Gondal	25.06**	
Gondal does not Granger Cause Amreli	7.84**	Bidirectional
Amreli does not Granger Cause Gondal	13.23**	

Engle-Granger Co-integration test

Engle-Granger co-integration test is a bivariate test and is performed based on the causal relationship between the market pairs as presented in Figure 1. In co-integration regression, the market which influences another market is kept as an exogenous variable, and estimation is done by using OLS (Ordinary Least Square) method. The residual obtained from the co-integration regression is subjected to an ADF test to test whether the two series are integrated or not.

Rajkot = 41.97** + 1.03** Junagadh (22.28) (0.01) (1.0)

$\Delta\varepsilon\_t$ = -8.27** $\varepsilon\_(t-1)$ = -0.44** (0.05) (1.1)

Where, $\varepsilon\hat{}\_t$ = Rajkot – 41.97** - 1.03** Junagadh

Amreli = 149.48** + 0.96** Rajkot (29.30) (0.01) (2.0)

$\Delta\varepsilon\_t$ = -8.21** $\varepsilon\_(t-1)$ = -0.44** (0.05) (2.1)

Where, $\varepsilon\hat{}\_t$ = Amreli – 149.48** - 0.96** Rajkot

Rajkot = -82.31** + 1.01** Amreli (31.19) (0.01) (3.0)

$\Delta\varepsilon\_t$ = -8.11** $\varepsilon\_(t-1)$ = -0.43** (0.05) (3.1)

Where, $\varepsilon\hat{}\_t$ = Rajkot + 82.31** - 1.01** Amreli

Gondal = 28.17** + 1.00** Rajkot (20.23) (0.01) (4.0)

$\Delta\varepsilon\_t$ = -9.30** $\varepsilon\_(t-1)$ = -0.54** (0.06) (4.1)

Where, $\varepsilon\hat{}\_t$ = Gondal – 28.17** - 1.00** Rajkot

Rajkot = 2.92 + 0.98** Gondal (20.11) (0.01) (5.0)

$\Delta\varepsilon\_t$ = -9.44** $\varepsilon\_(t-1)$ = -0.55** (0.06) (5.1)

Where, $\varepsilon\hat{}\_t$ = Rajkot – 2.92 – 0.98** Gondal

Amreli = 172.03** + 0.99** Junagadh

(29.33) (0.01) (6.0)

$\Delta\varepsilon\_t$ = -8.85** $\varepsilon\_(t-1)$ = -0.50** (0.06) (6.1)

Where, $\varepsilon\hat{}\_t$ = Amreli - 172.03** - 0.99** Junagadh

Junagadh = -101.16** + 0.98** Amreli (30.45) (0.01) (7.0)

$\Delta\varepsilon\_t$ = -8.88** $\varepsilon\_(t-1)$ = -0.50** (0.06) (7.1)

Where, $\varepsilon\hat{}\_t$ = Junagadh + 101.16** - 0.98** Amreli

Gondal = 63.75** + 1.03** Junagadh (27.08) (0.01) (8.0)

$\Delta\varepsilon\_t$ = -8.74** $\varepsilon\_(t-1)$ = -0.49** (0.06) (8.1)

Where, $\varepsilon\hat{}\_t$ = Gondal – 63.75** - 1.03** Junagadh

Junagadh = -6.97 + 0.95** Gondal (26.26) (0.01) (9.0)

$\Delta\varepsilon\_t$ = -8.99** $\varepsilon\_(t-1)$ = -0.51** (0.06) (9.1)

Where, $\varepsilon\hat{}\_t$ = Junagadh + 6.97 - 0.95** Gondal

Gondal = -72.80** + 1.02** Amreli (30.47) (0.01) (10.0)

$\Delta\varepsilon\_t$ = -8.85** $\varepsilon\_(t-1)$ = -0.50** (0.06) (10.1)

Where, $\varepsilon\hat{}\_t$ = Gondal + 72.80** - 1.02** Amreli

Amreli = 135.24** + 0.95** Gondal (28.46) (0.01) (11.0)

$\Delta\varepsilon\_t$ = -9.05** $\varepsilon\_(t-1)$ = -0.52** (0.06) (11.1)

Where, $\varepsilon\hat{}\_t$ = Amreli – 135.24** - 0.95** Gondal

Note: Engle and Yoo (1987) [5] critical values are 3.43 and 4.00 for 5 and 1 percent, respectively

*, ** indicates significant at 5% and 1% levels, respectively

Values in parenthesis are corresponding standard errors

The Rajkot and Junagadh markets were non-stationary in levels. In other words, we can say they were integrated into order one *i.e.* I (1). So, estimating co-integration regression between these markets was meaningful. The causality between these two markets was unidirectional, here the Rajkot market did not Granger cause the Junagadh market. So, the Junagadh market was kept as a regress or (independent variable) and the Rajkot market as regressed (dependent variable), and co-integration regression was estimated as given in equation (1.0). The parameters of co-integration were found to be highly significant. Unit root test was performed on the residuals obtained from the co-integration regression to confirm the existence of co-integration between the markets. The ADF test statistics is 8.27 which was higher than the critical values given by Engle and Yoo (1987) [5]. This indicates stationarity of the residual series *i.e.*; the two markets are integrated in the long run.

The causality between Rajkot and Amreli markets was bidirectional. To estimate co-integration regression, the Rajkot market was first kept as an independent variable and the Amreli market was assumed to be influenced by the former market. The estimated co-integration regression is given in equation (2.0), indicating the high significance of the co-integration parameters. The integration of two markets was confirmed by the ADF test on residuals as given in equation (2.1) which indicates the presence of long-run price movements between the two markets was established. As there was the existence of bidirectional causality between the markets, it was necessary to estimate the second co-integration regression by keeping the Amreli market as an independent variable. The estimated parameters and residual ADF statistics are presented in equations (3.0) and (3.1). The co-integration parameter and ADF statistic were found highly significant. Thus, the Rajkot and Amreli markets were integrated in the long run.

There was bidirectional causality existing between the Rajkot and Gondal market. So first, the Rajkot market was kept as an exogenous variable, and co-integration regression estimated is presented in equation (4.0), and estimates of ADF statistic is presented in equation (4.1). The co-integration parameter and ADF statistics were highly significant which conclude that Rajkot and Gondal markets were co-integrated. Now Gondal markets were kept as independent variables and co-integration regression was estimated which is presented in equation (5.0). The co-integration parameter was found to be non-significant and the results presented in equation (5.1) confirmed that there was a long-run equilibrium between those two markets.

Junagadh and Amreli markets were found stationary at order one *i.e.* I (1). So, estimating co-integration regression was meaningful. Since there exists bidirectional causality between Junagadh and Amreli markets, co-integration regression was estimated twice. For the first time, the Junagadh market was kept as an independent variable, and for the second time, the Amreli market was kept as the independent variable. The estimated parameters of each co-integration were presented in equations (6.0) and (7.0). The residuals were obtained from the fitted co-integration regression and the unit root test was performed on the residuals. The ADF test results are presented in equations (6.1) and (7.1) revealing that the residual series was stationary. Thus, Junagadh and Amreli markets were co-integrated.

Junagadh and Gondal markets were stationary at order one *i.e.* I (1), estimating co-integration regression was meaningful. Since there was bidirectional causality existing between the Junagadh and Gondal markets, the Junagadh market was kept as an independent variable and the co-integration regression estimated is presented in equation (8.0). Here the co-integration parameter was highly significant but to confirm the existence of co-integration between these markets. Residuals were obtained from the fitted co-integration regression and the unit root test was performed on the residuals. The results of the ADF test presented in equation (8.1) revealed that the ADF test statistic was higher than the critical values given by Engle and Yoo (1987) [5] which indicated that the residuals series was stationary. Thus, the Junagadh and Gondal markets were co-integrated. Now Gondal market was kept as an independent variable and the co-integration regression estimated is presented in equation (9.0). The co-integration parameter was highly significant and the result presented in equation (9.1) confirmed the stationarity of the residuals. Since the Engle-Granger test confirmed the integration of Junagadh and Gondal markets *i.e.*, there was a long-run price equilibrium between these two markets.

Unlike the above two markets, the causality between the Amreli and Gondal markets was found to be bidirectional. So first, the Amreli market was kept as an independent variable as it causes the Gondal market. The estimated co-integration regression is presented in equation (10.0). It revealed that the co-integration parameter (β) was highly significant and a 1 percent price rise in the Amreli market will lead to a 1.02 percent price rise in the Gondal market if the two markets were integrated. The integration of two markets was confirmed by the ADF test on residuals given in equation (10.1). Now Gondal market was kept as an independent variable and the co-integration regression estimated is presented in equation (11.0). The co-integration parameter was highly significant and the results presented in equation (11.1) confirmed that the residuals obtained from that co-integration regression were stationary. Since the Engle-Granger test confirmed the integration of Amreli and Gondal markets *i.e.*, there was a long-run price equilibrium between these two markets.

Conclusion

The study has examined co-integration and causality in major groundnut markets of the Saurashtra region. ADF test showed that the original series was nonstationary indicating the presence of a unit root problem. After the first order differencing series became stationary. The results of the overall co-integration test have indicated that different wholesale groundnut markets in Saurashtra are well-integrated and have long-run price associations across them.

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