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Market integration and price volatility of green gram in Maharashtra

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Abstract
Green gram is one of the important pulse crops in India. It has been reported that Green gram has been cultivated in India since ancient times. The present study aimed to know Market integration of Green gram *i.e.* seasonal variation, price volatility and co-integration among the major Green gram markets in Maharashtra. For study purpose the data related to monthly average prices of Green gram were collected from major markets of Maharashtra state *viz.* Buldana, Akola, Amravati and Latur markets for the period 2005 to 2016. Moving average method was used to study seasonal variations. The econometric tools like ADF test, Johansen's multiple co-integration tests, Granger causality test and ARCH-GARCH model were used to study price volatility and co-integration among different markets. The results of study showed that the prices of Green gram were higher in the months from December to June in all the selected markets. The cyclical variation observed in the prices of Green gram in the selected markets. For all selected markets, the price series showed the consequences of unit root and were stationary at first difference. The selected markets showed long run equilibrium relationship and co-integration between them. Most of the markets showed bidirectional influence on Green gram prices of each other. Buldana, Akola, Amravati and Latur market, recorded price volatility in Green gram prices.

Keywords: green gram, market integration, price volatility, seasonal variation, ADF test, arch-garch, co-integration, granger causality test

Introduction

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry is one of the largest contributions to the Gross Domestic Product (GDP). Being a key sector, occupying almost 17.2 per cent share of India's Gross Domestic Product (GDP) during 2017-18, the growth of agriculture and allied sector has a significant role in the overall growth of Indian economy. The planned increase in agricultural output must be coordinated with changes in the demand and supply for agricultural commodities and marketing. This can be fruitful only when the producer's share in consumer's rupee increase considerably irrespective of the volume of the marketable surplus produced with the farmers. The farmers sell their produce in the regulated markets, in accordance with the Agricultural Produce Market Act of 1939 (APMC Act, 1939) [1].

Green gram (*Vigna radiata*), or mung beans, is known in India as moong and is native to north-eastern India and Myanmar. Green gram is one of the important pulse crops in India. It has been reported that Green gram has been cultivated in India since ancient times. In India, Green gram is one of the most widely cultivated pulse crops after gram and tur. India is the world's largest producer as well as consumer of a Green gram. It produces about 20. 70 lakh tonnes of Green gram annually from about 43.05 lakh hectares of area with average productivity of 481 kg per hectare in the year 2016-17. (DES, 2016-17). The area under Green gram cultivation in Maharashtra is 4.44 lakh hectares, Production 2.60 lakh Tonnes and Productivity 585 kg per hectare in the year 2016-17. (State APY, 2016-17). Therefore, the present study was undertaken with the following specific objectives:

- To study the seasonal and cyclical variations in prices of Green gram.
- To assess the stationarity and volatility in prices of Green gram.
- To assess the co-integration and causality of price signals among selected Green gram markets in Maharashtra.

Methodology

For study purpose the major Green gram markets from the Maharashtra State were selected *viz.*, Buldana, Akola, Amravati and Latur. As per the records available the time series data on monthly average prices of Green gram for the period from 2005 to 2016 was collected from agmarknet website.

Estimation of seasonal indices of monthly data

The method of simple moving average most widely used method of measuring seasonal fluctuations and the seasonal indices were used to calculate seasonal indices.

Estimation of cyclical indices

The most commonly used method for estimating cyclical movement of time series is the residual method by eliminating the seasonal variation and trend is used to work out cyclical indices.

Testing of stationarity in price series

Before analysing any time series data testing for stationarity is per-requisite. The stationarity of time series data on chickpea prices was tested by applying the Augmented Dickey-Fuller test (ADF). The (ADF) test is the test for the unit root in a time series sample. A stationary series is one whose parameters are independent of time, exhibiting constant mean and variance and having autocorrelations that are invariant through time. If the series is found to be non-stationary, the first order differences of the series are tested for stationarity. The number of times (d) a series is differenced to make it stationary is referred to as the order of integration, I(d).

ADF unit root test are based on the following three regression forms:

Without constant and trend $\Delta Y_t = \delta Y_{t-1} + u_t$

With constant $\Delta Y_t = \alpha + \beta T + \Delta Y_{t-1} + u_t$

With constant and trend

The hypothesis is: H0: $\delta = 0$ (Unit root)

H_1: $\delta \neq 0$

If t*>ADF critical value then accept the null hypothesis, i.e. unit root exists and

If t*< ADF critical value then reject the null hypothesis, i.e. unit root does not exists.

Presence of price volatility

To access the presence of price volatility the ARCH-GARCH analysis was carried out. Auto Regressive Conditional Heteroscedasticity (ARCH) models are specifically designed to forecast conditional variances. ARCH model introduced by Engel (1982) and generalized as GARCH by Bollersllev (1986). These models are widely used in various branches of econometrics, especially in financial time series analysis. The ARCH model has two distinct specifications one for the conditional variance and the standard GARCH (1, 1) specification is presented below:

$$Yt = \gamma_0 + \gamma_1 X_{1t} + \ldots\ldots. + \gamma_k X_{kt} + e \qquad \ldots\ldots\ldots 1$$

$$\sigma^2_t = \omega + \alpha e^2_{t-1} + \beta \sigma^2_{t-1} \qquad \ldots\ldots\ldots 2$$

Equation (1) is the mean equation and equation (2) is the conditional variance equation. The ARCH component (α) indicate the lag of the squared residual from the mean equation and the GARCH term (β) the last period's forecast variance and the resultant sum of these co-efficient (α + β) are presented. The sum of co-efficient very close to 1 would indicate that the volatility shocks are quite persistent in the series.

Johansen's multiple co-integration test

Johansen's multiple Co-integration test is employed to determine the long rum relationship between the price series. The test shows whether the selected Green gram markets are integrated or not. Johansen (1988) [4] has developed a multivariate system of equations approach, which allows for simultaneous adjustment of both or even more than two variables. The multivariate system of equations approach is more efficient than single equation approach *i.e.* it allows to estimate 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 erogeneity of either of the variables.

Causality or co-movement of price signals between selected markets

The Granger causality test was applied to study the price interaction and to know the direction of causation between the selected Green gram markets. It is named after the first causality tests performed by Clive Granger (1969) [3]. It analyses the extent to which the past variations of one variable explain (or precede) subsequent variations of the other. When a co-integration relationship is present for two variables, a Granger Causality Test can be used to analyze the direction of this co-movement relationship. Granger causality tests come in pairs, testing weather variable x_t Granger-causes variable y_t and vice versa. All permutations are possible:

Univariate Granger causality from x_t to y_t or from y_t to x_t,

Bivariate causality or absence of causality.

Formally, the Granger causality test analyses weather the unrestricted equation:

$$y_t = \alpha_0 + \sum T_i = 1\ \alpha_1 i\ y_{t-i} + \sum T_j = 1\ \alpha_2 i\ x_{t-j} + \varepsilon_t \text{ with } 0 \leq i, j \leq T$$

Yield better results than the restricted equation:

$$y_t = \beta_0 + \sum T_{i=}1\ \beta_1 i\ y_{t-i} + \varepsilon_t \text{ with } \sum T_j = 1\ \alpha_2 j\ x_{t-j} = 0$$ (The null hypothesis)

i.e. if H_0, in which $\alpha_{21=}\ \alpha_{22=} \ldots\ldots = \alpha_2 T = 0$, is rejected then one can state "variable x_t Granger causes variable y_t"

Results and Discussion

Seasonal indices for green gram prices

The seasonal indices of monthly average prices of Green gram in Buldana, Akola, Amravati and Latur markets were worked out, which are presented in table 1. From table 1 it was noticed that in selected markets the prices of Green gram were higher during the month of December to June. All the markets recorded lower prices during the month from July to November. During these months the arrivals starts which lowered down the prices. Similar results were obtained by Benke *et al.* (2016) [1] the highest prices of Green gram was observed during March to June.

Table 1: Seasonal indices of green gram prices for selected markets

Month	Buldana	Akola	Amravati	Latur
Jan	106.16	98.73	105.86	98.04
Feb	104.24	97.74	107.99	93.76
Mar	78.12	100.11	104.38	97.64
Apr	107.68	96.43	100.75	102.71
May	110.60	104.06	93.52	107.16
Jun	112.40	108.04	100.97	110.24
Jul	101.22	94.88	97.67	93.55
Aug	96.78	94.06	98.72	95.77
Sep	82.94	102.12	105.06	98.50
Oct	95.82	99.59	88.37	99.85
Nov	95.15	99.60	86.76	97.26
Dec	108.88	104.64	109.96	105.53

Cyclical indices for green gram prices

From table 2 it was observed that the cyclical variations were observed in the prices of Green gram in selected markets. Higher prices were observed in the year 2006, 2009, 2010, 2014 and 2015 for all the markets. The rise in prices might be attributed to less production due to bad weather condition. Lower prices were observed in the year 2005, 2007, 2008, 2011, 2012 and 2016. Benke *et al.* (2016) [1] revealed that the higher prices in Green gram were observed in the year 1997, 1998, 1999, 2000 and 2001 and lower prices were noticed in the year 2001 to 2005 for the selected markets.

Table 2: Cyclical indices of green gram prices for selected markets

Year	Buldana	Akola	Amravati	Latur
2005	90.56	102.14	108.10	104.99
2006	109.67	117.75	126.37	120.51
2007	91.43	84.54	91.49	89.73
2008	84.11	76.57	58.06	78.45
2009	107.39	114.59	122.99	114.14
2010	121.66	121.54	126.31	109.64
2011	90.90	90.23	85.54	85.52
2012	93.74	88.74	83.32	87.82
2013	104.76	92.54	73.15	94.05
2014	118.22	104.87	103.44	109.07
2015	106.89	115.77	126.22	116.20
2016	80.67	90.72	95.00	89.88

Testing of stationarity in green gram price series

The Augmented Dick-Fuller (ADF) test is applied for the selected markets of study and the results are presented in table 3.

From Table 3 it was revealed that at level with lag 1, the ADF values were higher than the critical value at 1 per cent level of significance indicating the existence of unit root, indicated that the prices series in all markets were non-stationary. The table further showed that in 1st order difference with lag 1, the ADF values were lower than the critical value at 1 per cent level of significance indicated that the price series were free from the consequences of unit root. This implied that the prices series were stationary at 1st order difference level. Similar results were reported by Patil and Tingre (2015) [6], that the price series showed the consequences of unit root and were stationary at first order difference.

Table 3: ADF test results of green gram prices for selected markets

Market	Level (ADF)	First difference (ADF)	Critical value (1%)
Buldana	-3.385	-19.907	-3.476
Akola	-2.004	-12.003	
Amravati	-3.244	-9.463	
Latur	-1.388	-9.304	

Presence of green gram price volatility

To confirm the presence of price variability in the prices of Green gram in Buldana, Akola, Amravati and Latur markets, ARCH-GARCH analysis was carried out and the results are presented in Table 4.

The sum of Alpha and Beta (α+β), indicated ARCH and GARCH effect for the given market. It was observed that among the selected markets, the sum of Alpha and Beta is nearer to 1 i.e. 0.995, 1.006, 0.971 and 1.015 for Buldana, Akola, Amravati and Latur markets respectively, indicated that the volatility shocks in the prices of Green gram are quite persistent for a long time in these markets. Sharab *et al.* (2018) [7] reported that the sum of Alpha and Beta is nearer to 1 for selected markets of Garlic and indicated that the volatility shocks in the prices of Garlic are quite persistent for a long time in selected markets of study.

Table 4: Results of ARCH-GARCH analysis for green gram prices of selected markets

Parameter	Buldana	Akola	Amravati	Latur
Alpha (α)	0.320	0.924	0.428	0.924
Beta (β)	0.676	0.082	0.543	0.091
Sum of α & β	0.995	1.006	0.971	1.015

Market co-integration test for green gram prices

From table 5 it was seen that the presence of three co-integration equations significant at 5 per cent level of significance confirms that there exists long run equilibrium relationship between the markets in terms of Green gram prices. The results of Co-integration test showed three co-integration equations were significant at 5% level of significance which confirmed that there existed co-integration among the markets.

Table 5: Results of multiple co-integration analysis of green gram prices for the selected markets

Hypothesized no. of CE(s)	Eigen value	Trace statistic	Critical value 5%	Prob.**	Number of co-integrating equation CE(s)
None *	0.264	100.518	47.856	0	Three
At most 1 *	0.229	57.242	29.797	0	
At most 2 *	0.116	20.527	15.495	0.008	
At most 3	0.022	3.171	3.841	0.075	

Note: Trace test indicates 3 co-integrating equations significant at the 0.05 percent level of significance

Causality of price signals between selected green gram markets

The results of the Granger Causality test showing the relationship of prices between selected Green gram markets were presented in table 6. It was seen from table 6 that there is bidirectional causality in Green gram prices between Latur and Akola, Buldana and Amravati markets respectively. The prices of Akola market exhibited unidirectional causality and affects the prices of Amravati and Buldana market. The prices of latur market exhibited unidirectional causality and affects prices of Amravati and Buldana. So the influence of Akola and Latur market prices played a significant role over the other selected markets. From the, above discussion it can be concluded that Akola and Latur market can be considered as a lead market of Green gram and influencing the prices of the remaining markets. Thus a strong market integration of the four markets Akola, Buldana, Latur and Amravati are established through the results of the analysis.

Table 6: Results of pair wise granger causality test for green gram prices

Null hypothesis	Obs.	F-statistic	Prob.
Amravati does not Granger Cause Akola	142	2.151	0.1202
Akola does not Granger Cause Amravati		24.132*	1.00E-09
Buldana does not Granger Cause Akola	142	0.777	0.462
Akola does not Granger Cause Buldana		12.358*	1.00E-05
Latur does not Granger Cause Akola	142	8.398*	0.0004
Akola does not Granger Cause Latur		4.236*	0.0164
Buldana does not Granger Cause Amravati	142	6.218*	0.0026
Amravati does not Granger Cause Buldana		3.309*	0.0395
Latur does not Granger Cause Amravati	142	16.500*	4.00E-07
Amravati does not Granger Cause Latur		0.817	0.4441
Latur does not Granger Cause Buldana	142	12.012*	2.00E-05
Buldana does not Granger Cause Latur		1.315	0.2718

Note: *denotes significant at 1% level of significance

Conclusion

The results of analysis showed that volatility shocks in the prices of Green gram were persistent in the selected markets of Green gram in Maharashtra. The selected markets having long-run equilibrium relationship for the prices and there exists co-integration among them.

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