

## PRICE BEHAVIOUR AND CO-INTEGRATION OF GREEN GRAM IN GUJARAT

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**Abstract:** The secondary and time series data on monthly wholesale prices and arrivals of green gram were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016). The results evident that the inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of green gram in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets. By using Augmented Dickey Fuller Test, Johansen test and causality test was examined. The results of the study indicated that therefore ADF test at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I). The price series of all markets were stationary at their levels themselves. Trace statistic and maximum Eigen value test revealed that Gujarat Green Gram markets were found to be integrated with 3 co-integrating equations. All the market pairs exhibited bi-directional causality and prices were transmitted vice versa i.e., mutual influence was exerted by the market on each other.

**Keywords:** Green gram, Price behaviour, Wholesale prices, Causality test

## INTRODUCTION

Pulses are an important source of protein in our daily diet and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security. The United Nations, declared 2016 as “International Year of Pulses” (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. Pulses are main source of high quality protein, essential amino acids, fibers, minerals, vitamins and fatty acids for the poor as well as for the vegetarians which constitute major population of the country. The major pulses grown in India are chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea and they are important for sustainable environment and agriculture (Asthana and Chaturvedi, 1999).

India is the largest producer with around 25 per cent of global production as well as consumer about 27 per cent of world consumption and is the largest importer with 14 per cent in the world (Mohanty and Satyasai, 2015). This is because the demand for pulses far outweighs their domestic production. Even a liberal import of pulses has not been able to supplement the widening gap between their demand and supply. The skyrocketing prices of pulses since 2008 can be attributed to almost stagnated production leading to a decline in per capita availability. The yields of pulses are often subjected to moderate to severe losses due to recurrent drought situation under rainfed due to low or erratic rainfall. Presently about 24 to 25 million hectares of land is under pulses producing about 19 million tons annually. Even though about 2-3 million tons need to be imported

every year to meet the demand. The yield (around 780 kg a hectare) of pulses is less than the global average and the per capita availability ([www.iipr.res.in](http://www.iipr.res.in)). Therefore, due to the backdrop of wide mismatch between demand and supply it is necessary to look at the price movement of pulses.

## MATERIALS AND METHODS

To achieve the stipulated objective of the study the secondary and time series data for last thirty years (1986-87 to 2015-16) on area, production and productivity of Green gram was collected from various issues of Directorate of Agriculture, Agriculture & Cooperation Department, Government of Gujarat. The data pertaining to area, production and yield for the year 2013-14 and 2014-15 was used provisional or estimated data. The secondary data on monthly wholesale prices and arrivals were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016). The CGR and Instability Index were calculated by using the following methods.

The CGR was calculated by fitting the exponential function given below:

$$Y = a b^t \quad (1)$$

Where, Y = area/production/yield/annual index number of wholesale prices

a = constant

b = regression co-efficient

t = time variable

Thus, natural log on both the sides of eq (1) was taken to convert it in to linear form.

$$\log Y = \log a + t \log b \quad (2)$$

CGR (%) was work out using following formula:

$$\text{CGR} (\%) = (\text{antilog of } b - 1) \times 100$$

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The simple co-efficient of variation (CV) often contains the trend component and thus over estimates the level of instability in time series data characterized by long-term trends. To overcome this problem, the Cuddy Della Valle Index was used to correct the CV.

$$\text{Instability Index (II)} = \text{CV} \times \sqrt{(1-R^2)}$$

Where, CV = co-efficient of variation and  $R^2$  = co-efficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The significant CGRs were classified in two groups *i.e.* negative and positive CGR.

#### Inter-year Price Behaviour

To examine the general behavior of wholesale prices the year to year price behavior was ascertained by examining the prices of the crop over the period. The general price behavior of wholesale prices was studied through their price indices.

Annual price index was calculated by the following formula:

$$I_t = P_t/P_0 \times 100$$

Where,

$I_t$  = price index for year t,

$P_t$  = price in period t,

$P_0$  = price in the base year (triennium ending 2007-2009)

To know the trend and rate of increase or decrease in annual wholesale prices the Compound Growth Rate (CGR) was calculated by using the exponential model as given in equation (1) and (2).

#### Intra-year Price Behaviour

The intra-year price behavior was studied by calculating the seasonal price indices of monthly wholesale prices of green gram in selected markets.

#### Seasonal Price Indices

The multiplicative model of time series analysis was used to know the seasonal pattern of wholesale prices of green gram.

$$O = T \times C \times S \times I$$

where,

O = Monthly wholesale prices,

T = Trend value,

S = Seasonal variations, and

I = Irregular variations.

The seasonal index numbers were constructed by using the twelve months moving average method. To remove the effects of trend (T) and cyclical variations (C), twelve months moving average were calculated and centered. Further, ratios of original price indices to centered moving average were calculated to obtain the combine effect of S x I. In order to eliminate the effect of irregular component (I), these ratios were averaged and finally adjusted seasonal indices (S) were obtained.

#### Market Integration

Augmented Dickey- fuller test involve testing for stationary of the variables. The Augmented Dickey- fuller (ADF) test considers the null hypothesis that

given series has a unit- root, *i.e.* it is non- stationary. The autoregressive formulation of the ADF test with a drift term is given by equation (1).

$$\Delta p_{it} = a_0 + \gamma P_{it-1} + \sum_{i=2}^n \beta_i \Delta p_{it-1} + \epsilon_t \quad (1)$$

Where  $P_{it}$  is the price in market i at the time t,  $\Delta P_{it} = (P_{it} - P_{it-1})$  and is the intercept or drift term. The joint hypothesis to check the presence of unit root is  $H_0: Y = a_0 = 0$  using  $\phi_1$  statistics. Failure of the rejection of null hypothesis means that the series non- stationary.

#### Johansen's Multiple Co-integration Analysis

For co-integration analysis, the Johansen (1988) maximum likelihood estimator was chosen over the Engle and Granger (1987) two steps procedure. The Johansen procedure is a multivariate generalization of the Dickey Fuller test and formulation is as follows:

$$p_{it} = A_1 p_{it-1} + \epsilon_t \quad (2)$$

So that,

$$\Delta P_{it} = A_1 p_{it-1} - p_{it-1} + \epsilon_t \quad (3)$$

$$\Delta p_{it} = (A_1 - I) P_{it-1} + \epsilon_t \quad (4)$$

$$\Delta p_{it} = \lambda P_{it-1} + \epsilon_t \quad (5)$$

Where, and are  $(n \times 1)$  vectors;  $\lambda$  is an  $(n \times n)$  matrix of parameters; I is an  $(n \times n)$  identity matrix and n is the matrix.

Trace test was used to determine the presence of co-integration relationship between the prices –series, using the estimates of the characteristics roots, the test for the number of characteristic roots that are insignificantly different from unity was conducted using the following statistics:

$$\lambda_{\text{trace}}(r) = -T \sum_{j=r+1}^n h(1 + \lambda_j^{\wedge}) \quad (6)$$

Where,  $\lambda$  denotes the estimated values of the characteristics roots (eigen value) obtained from the estimated matrix ; and T is the number of usable observations. The Eigen values representing the strength of the correlation between the first difference and error – correction.

#### Granger Causality Test

When a co-integration relationship is present for variables, Granger Causality test (Granger, 1969) can be used to analyze the direction of this co- movement relationship. Whether market  $p_1$ Granger causes market  $p_2$  or vice versa was checked using equation (7).

$$p_{it} = c + \sum_j^n \phi P_{it-j} + S_j p_{2t-j} + \epsilon_t \quad (7)$$

A simple test of the joint significance was used to check the Granger causality, *i.e.*

$$H_0: S_1 = S_2 = S_n = 0$$

## RESULTS AND DISCUSSION

Table 1 represents the results of Compound Growth Rate (CGRs) and Instability Index (II) of area, production and yield of green gram in Gujarat. It is revealed from the table that the growth rate of area was found positive but statistically non-significant, whereas the CGR of production (3.22 per cent) and productivity (3.01 per cent) was found positive and statistically significant. This clearly indicates that the

production and productivity of green gram in Gujarat was increased significantly in last thirty years. Further, the result shows that the instability index of production was found high (41.47) as compare to

area (25.43) and yield (29.68). This showed that the variability in production was found more as compared to area and yield. This may be due to the fluctuations in market prices in last years.

**Table 1.** Compound Growth Rate (CGR) and Instability Index (II) of Area, Production and Yield of Green Gram in Gujarat

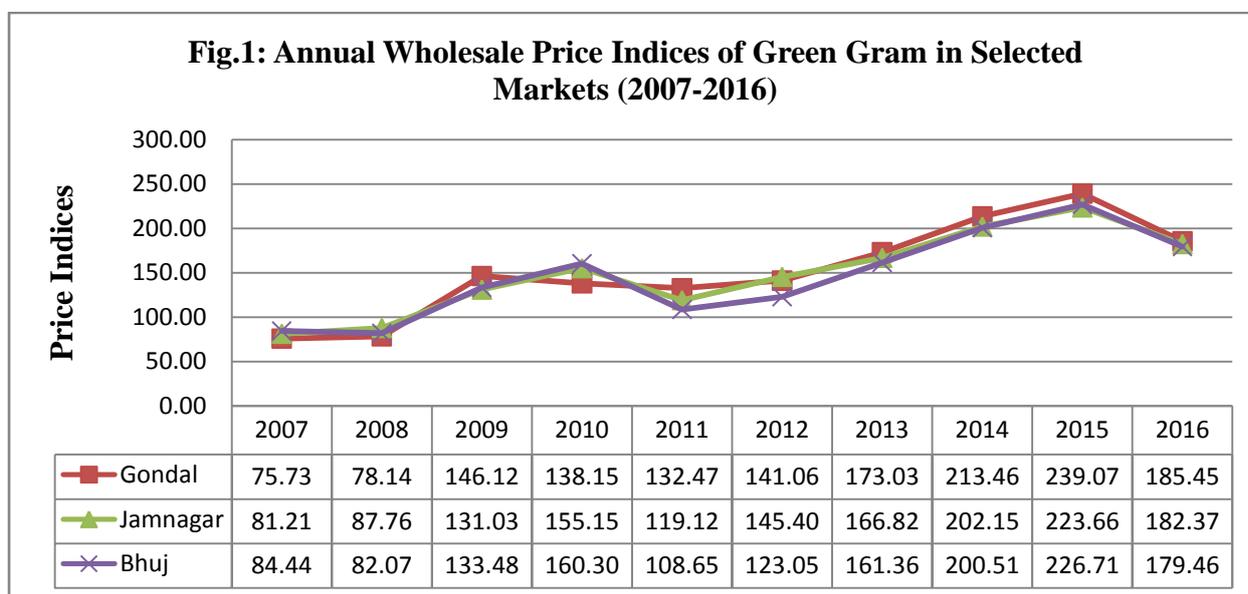
Particulars	Compound Growth Rate (CGR) in Percentage	Instability Index
Area	0.19	25.43
Production	3.22*	41.47
Yield	3.01**	29.68

\*\* Significant at 1% level, \* Significant at 5% level

**Inter-Year Price Behaviour**

The annual wholesale price indices of green gram during the period 2007-2016 (with base year triennium end 2007-09 =100) were presented in Fig. 1. It can be seen from the figure that the upward trend of annual prices with few exceptions was found in all the selected markets with similar pattern. The

annual price indices was continuously increased from the year 2011 to 2015 and slightly decreased in the year 2016, that means the prices of green gram was decreased in the year 2016 as compared to past two years. This may be due to the significantly increased in production and yield of green gram over the years.



The estimates of compound annual growth rate of wholesale price of green gram were presented in Table 2. The results revealed that the compound rate of increase in prices of green gram in all the selected markets were statistically significant at one per cent level of probability during study period. The prices

of green gram in Gondal, Jamnagar and Bhuj markets increased at the rate of 11.87, 10.46 and 10.23 per cent per annum, respectively. This clearly indicates that the price of green gram was significantly increased in last one decade in all the selected markets.

**Table 2.** Estimates of Compound Growth Rate of Wholesale Price Indices of Gram in Selected Markets (2007-2016).

Markets	Intercept (a)	Estimates of Coefficient (b)	Compound Growth Rate (CGR) in %	R <sup>2</sup>	Adjusted R <sup>2</sup>
Gondal	1.89	0.05	11.87**	0.80	0.77
Jamnagar	1.92	0.04	10.46**	0.81	0.78
Bhuj	1.91	0.04	10.23**	0.72	0.68

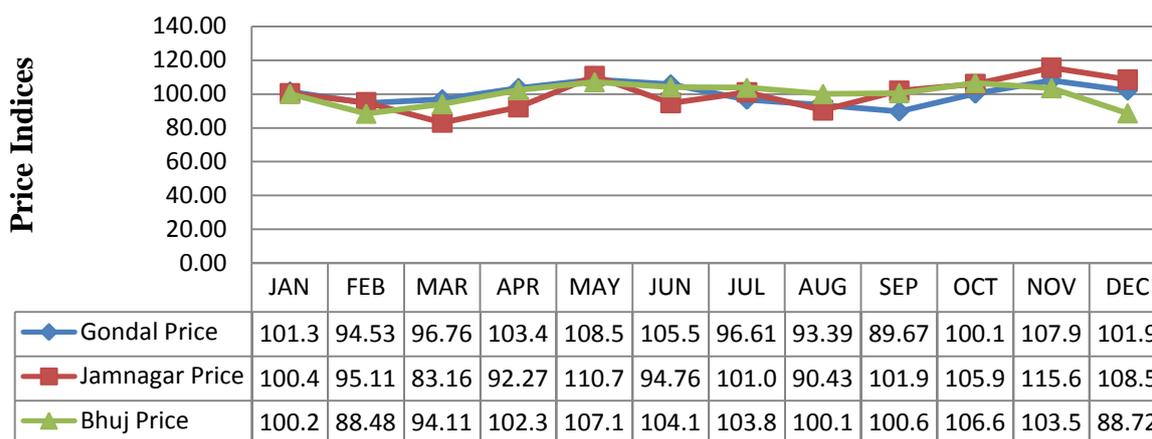
\*\* Significant at 1 per cent probability level

### Intra-Year Price Behaviour

The monthly seasonal price indices of green gram in the selected markets (Gondal, Jamnagar and Bhuj) are presented in Fig. 2. The results put forth that the intra-year seasonal price indices of green gram was all most stable and showing the similar trend in all the selected markets and it varies from 86.67

(September) to 108.50 (May) in Gondal, 83.16 (March) to 115.60 (November) in Jamnagar and 88.48 (February) to 107.13 (May) in Bhuj market. It can be concluded that the price of green gram was slightly decreased in peak season and increased in off season.

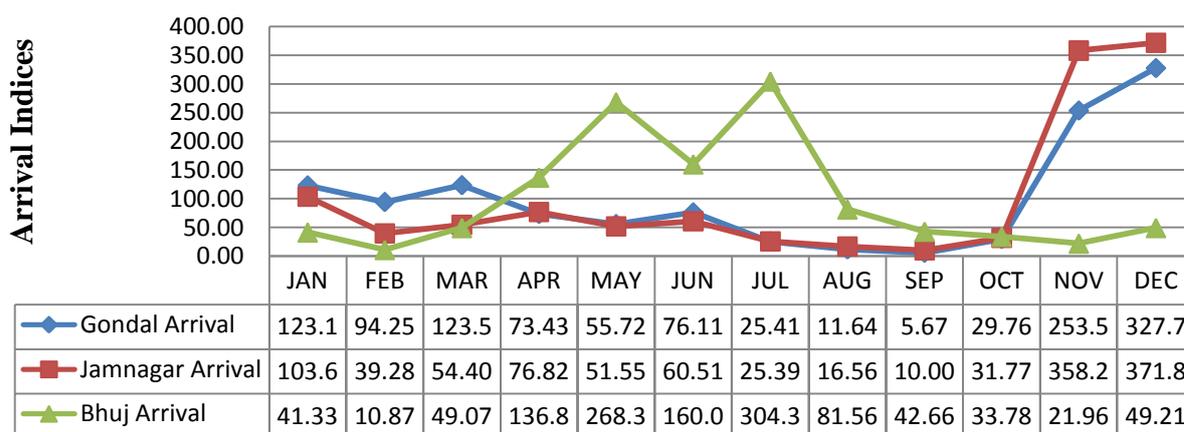
**Fig. 2: Seasonal Indices of Wholesale Prices of Green Gram in Selected Markets (2007-2016)**



The Monthly pattern of arrivals of green gram in Gondal and Jamnagar market was showing the similar pattern with highest arrival in the month of December (327.70, 371.80) and lowest in the month of September (5.67, 10.00), respectively. Whereas, in Bhuj market the arrival pattern was slightly different from these two markets with highest arrival in the

month of July (304.30) and lowest in the month of February (10.87) (Fig. 3). This may be due to the summer arrival in the Bhuj market, this clearly indicated that the arrivals of green gram were highest in peak season in all the selected markets because the farmers immediately sale the crop after harvesting period.

**Fig. 3: Monthly Pattern of Arrivals of Green Gram in Selected Markets (2007-2016)**



### Market Integration

#### Augmented Dickey Fuller Test

The Dickey- Fuller test for stationarity of price series for green gram in selected markets of Gujarat is presented in Table 1. The t statistic value for the

ADF test at the level price for the Gondal, Jamnagar and Bhuj markets were found to be -2.011, -1.95 and -1.76 respectively which were less than the critical value hence it was insignificant and so the null hypothesis about the presence of unit root could not

be rejected. The t statistic value for the ADF test at the first difference were found to be -5.19, -3.09 and -13.53 respectively for Gondal, Jamnagar and Bhuj, since the absolute values of t statistic were more than the critical value i.e.  $5.19 > 3.85$ ,  $3.09 > 3.85$  and

$13.53 > 3.85$ , therefore the results of ADF at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I).

**Table 3.** Augmented Dickey Fuller test for stationarity of the price series

Markets	At Level	Stationary	At First difference	Stationary	Critical values (at 1% level)
Gondal	-2.011664	Non- stationary	-5.193857	stationary	-3.85
Jamnagar	-1.953845	-do-	-3.099397	-do-	
Bhuj	-1.764947	-do-	-13.53137	-do-	

**Johansen’s Co-integration Test**

After having confirmed that the price series are in fact, first difference stationarity, the next step is to examine the number of co-integration vectors. Since there were two price series (n) therefore maximum number of co-integrating vectors (n-1) was one.

The trace test rejected the null hypothesis of zero co-integrating vectors since the p value is 0 per cent which is less than 5 per cent and also the value of corresponding trace statistic is  $67.28 > 29.79$ ,  $18.99 > 15.49$  and  $3.88 > 3.84$ , it means trace statistics is higher than the corresponding critical value at 5% significance level. The null Hypothesis of three co-integrating vector was accepted because the corresponding trace statistic is higher than the corresponding critical value (Table 4).

Eigen value Test also gave the similar result. Since the probability is 0 per cent and the Maximum Eigen

Value (48.2871), (15.1186) and (3.87798) is more than the corresponding critical value (21.1316), (14.2646) and (3.84146) at 5% significance level, therefore the null hypothesis of zero co-integrating equation was rejected. Here also same result came up; the null hypothesis of three co-integrating vector was accepted because the corresponding Maximum Eigen statistic is higher than the corresponding critical value. Therefore there is three error terms in long run (Table 5).

Having confirmed that trace test procedure indicated that green gram markets were integrated with three co-integrating equations. At the same time, co-integration between the markets was confirmed with Maximum Eigen value test also 3 co-integrating equations. The existence of co-integration between markets confirmed that there was a long – run relationship among markets.

**Table 4.** Results of Unrestricted Co- integration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None*	67.28376	29.79707	0.0000
At most 1 *	18.99667	15.49471	0.0142
At most 2 *	3.877985	3.841466	0.0489

**Table 5.** Results of Unrestricted Co- integration Rank Test (Maximum- Eigen value)

Hypothesized No. of CE(s)	Maximum-Eigen Statistic	0.05 Critical Value	Prob.**
None*	48.2871	21.1316	0.0000
At most 1 *	15.1186	14.2646	0.0366
At most 2 *	3.87798	3.84146	0.0489

**Causality in Different Markets**

The causal relationship between the price series in Green Gram markets was approached through Granger Causality technique. The causal relationship between the price series in Green Gram markets was approached through Granger Causality technique. The findings revealed that no co-integration was existing within three pair of market (Gondal- Jamnagar, Jamnagar- Bhuj, Bhuj- Gondal). In order to know the direction of causation between selected green gram markets, Granger causality test was employed. When a co-integration relationship is present for two

variables, the Granger causality test can be used to analyze the influence of price of each market on all other markets.

Gondal market prices influence the prices at Jamnagar market and not vice-versa. Bhuj market prices influence the prices at Jamnagar market and not vice-versa. Gondal market prices influence the prices at Bhuj market and not vice-versa.

From Table 4, it could be inferred that all the market pairs exhibited bi-directional causality and prices were transmitted vice versa i.e., mutual influence was exerted by the market on each other.

**Table 6.** Results of Pair – Wise Granger Causality Test

Null Hypothesis	Obs	F- Statistics	Prob
GONDAL does not Granger Cause JAMNAGAR JAMNAGAR does not Granger Cause GONDAL	119	31.6447 1.06844	<b>1.E-07</b> 0.3034
JAMNAGAR does not Granger Cause BHUJ BHUJ does not Granger Cause JAMNAGAR	119	3.01445 58.1321	0.0852 <b>7.E-12</b>
BHUJ does not Granger Cause GONDAL GONDAL does not Granger Cause BHUJ	119	0.19971 11.5899	0.6558 <b>0.0009</b>

## CONCLUSION

The results observed that the production and yield of green gram was increased significantly in last thirty years. This shows that the production and yield of green gram was increased significantly over the years in Gujarat. The inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of green gram was found in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets. Among the three selected markets only two markets were co integrated at 5 % level of significance. The study indicated that therefore the results of ADF test at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I). The price series of all markets were stationary at their levels themselves. Trace statistic and maximum Eigen value test revealed that Gujarat Green Gram markets were found to be integrated with 3 co- integrating equations. All the market pairs exhibited bi-directional causality and prices were transmitted vice versa *i.e.*, mutual influence was exerted by the market on each other.

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