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# Co-integration analysis of pomegranate in selected markets of Maharashtra

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**Abstract**
Market integration shows the degree to which prices in different markets are in motion together. The high degree of market integration indicates the competitiveness of the markets. Market integration also plays a very important role in determining pattern and pace of diversification towards the high value crops. The present research has been undertaken to study the relationship between arrivals and prices of pomegranate, to evaluate the price volatility and co-integration of pomegranate in the selected markets of Maharashtra.

The co-integration of prices of pomegranate was observed for the selected market. It indicated that selected markets are competitive to each other. The pair wise granger causality test of pomegranate price results indicated that the market pairs *viz;* Mumbai-Nashik, Pune-Mumbai, Nashik-Nagpur, Nagpur-Pune and Nashik-Pune have unidirectional causality. It revealed that a price change in the first market in each pair granger cause the price formation in the second market, whereas the price change in the second market is not feed backed by the price change in the first market. It is concluded that very high price volatility present in selected markets of pomegranate. It should be minimized and needs to protect price security for farming community.

**Keywords:** Pomegranate, market, volatility arrivals, prices

## Introduction

Maharashtra is now regarded as a horticultural state in India and the fruit crops *viz.* mango, grape, banana, pomegranate and oranges are largely grown. Among these fruits pomegranate is produced in certain packets and the prices in some markets are dependent on the prices in other markets and also an arrivals in particular market. In some markets, only demand determines the prices of fruits. Such type of information is needed by the pomegranate growers in order to take decision for selection of markets for selling their produce at better prices with price stability. In this context, present investigation was carried out in major wholesale markets of Maharashtra. Bhagat *et al*. (2023) [4] studied the instability in banana export from India and it is suggested that there is a need to give more attention towards export of banana. ARIMA (3, 1, 6) and Brown's exponential smoothing model was found best fit for banana export and its total value respectively. Madhusudan Ghosh (2000) [6] studied spatial integration of rice markets in India and found that intra-state and inter-state regional rice markets are integrated and linked together into a single financial market. Mohan *et al* (2013) [7] analyzed the behavior of onion prices in Kurnool market and forecasted the prices for the future.

Pomegranate is a main fruit crop of arid and semiarid regions of world. In India, area under pomegranate has in excess of doubled in a short span of less than two decades. Pratibha *et al*, (2014) [10] stated that the pomegranate was cultivated in 107 thousand hectare area during 2010-11 which has now improved to 246 thousand hectares in 2018-19. The total production of pomegranate fruit was 7.43 lakh tones during the year 2010-11 and which have increased to four times 28.65 lakh tones in the year 2018-19. Maharashtra is the foremost producer of pomegranate followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. The pomegranate is commercially cultivated in Solapur, Sangli, Nasik, Ahmednagar, Pune, Dhule, Aurangabad, Satara, Osmanabad and Latur districts of Maharashtra state; Bijapur, Belgaum and Bagalkot districts of Karnataka and to a smaller coverage in Gujarat, Andhra Pradesh and Tamil Nadu. Bhagat *et al*. (2022) [3] studied markov chain analysis on the export prospectus of banana in India and concluded that UAE and Maldives were found most stable markets among for Indian banana. However, the countries like Nepal, Oman and other countries were moderately stable.

Market integration shows the degree to which prices in different markets move together, efficiently functioning and competitive with each other. The present research has been undertaken to study the relationship between arrivals and prices of pomegranate, to evaluate the price volatility and co-integration of pomegranate among the selected markets of Maharashtra.

## Materials and Methods

### Source of data

The data on arrivals and prices of pomegranate were collected for four major markets of Maharashtra *viz;* Mumbai, Nagpur, Nashik and Pune for the period of last nine (2012 to 2020) years were obtained from NHB database.

The analysis was carried out by using the following statistical techniques.

$$Arithmetic\ mean\ (\bar{x}) = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Where, n is total number of obs., xi is the month wise arrivals and prices of pomegranate in a particular market.

$$\text{Standard Deviation } (\sigma) = \frac{1}{n-1}\sum_{i}(x_i - \bar{x})^2$$

$$\text{Coefficient of Variation } (\%) = \frac{\sigma}{\bar{X}} X100$$

### Augmented Dickey Fuller Test (ADF test)

$$\Delta \ln P_t = \alpha_0 + \delta_1 t + \gamma lnP_{t-1} + \sum_{j=i}^{q} \vartheta_j \Delta lnP_{t-j} + \varepsilon_t$$

Where,

P is indicates the price in each market, $\alpha_0$ is a constant, t is a time or trend variable q indicate the number of lag length and $\varepsilon_t$ is the error term.

### Autoregressive Conditionally Heteroscedastic (ARCH) model

An ARCH(m) method is one for which the variance at time t is conditional on observations at the previous *m* times, and the relationship is

$$Var(y_t|y_{t-1},\ldots,y_{t-m}) = \sigma_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2 + \cdots + \alpha_m y_{t-m}^2$$

### Generalized Autoregressive Conditionally Heteroscedastic (GARCH) model

It uses values of the past squared observations and past variances to model the variance at time t GARCH (1, 1) is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

### Johansen Co integration

To verify long run prices relation between chosen markets.

$$P_t = \sum_{i=1}^{k} A_i P_{t-1} + \mu + \beta_t + \varepsilon_t ; (t = 1,2,3 \ldots T)$$

The method for estimating the co-integration vectors is based on error correction model (ECM) given by

$$\Delta P_t = \mu + \pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \beta \mu_t + \varepsilon_t$$

Where,

$\Gamma_i$ = - (I-$\Pi_i$ - ……, T); i= 1,2 ….K-1; $\Pi$ = -(I- $\Pi_i$ - ……, $\Pi_k$)

$\mu$ is a constant, t is a time or trend variable, $\varepsilon_t$ is the error term

### Likelihood ratio test statistics (Trace and Max Eigen test Statistics)

$$J_{trace} = -T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_1)$$

$$\lambda_{max} = -T \ln(1 - \hat{\lambda}_{r+1})$$

Where, r is no. of co integrated vector, $\hat{\lambda}_1$ eigen value and $\hat{\lambda}_{r+1}$ is the largest squared eigen value

### Granger causality test

The estimation of the simple form of vector autoregressive model (VAR) is as below:

$$lnP_t^A = \sum_{i=1}^{n} \delta_i lnP_{t-1}^B + \sum_{j=i}^{n} \vartheta_j lnP_{t-j}^A + \mu_{At}$$

$$lnP_t^B = \sum_{i=1}^{n} \emptyset_i lnP_{t-i}^B + \sum_{j=i}^{n} \partial_j lnP_{t-j}^A + \mu_{Bt}$$

Where,

Pt is the price and super subscript A and B indicates the two markets.

t is a time trend.

$\mu_A$, $\mu_B$ are the error terms of both the model.

## Results and Discussion

The results of mean and coefficient of variation (C.V.) of arrivals and prices of pomegranate in selected markets of Maharashtra from the period of 2012 to 2020 are presented in Table 1 and 2.

The overall mean arrivals of pomegranate in Mumbai, Nagpur, Nashik and Pune market were 2320, 2741, 4058 and 1808 metric tones and magnitude of coefficient of variation in arrivals were 54.34, 107.50, 197.45 and 81.16 percent, respectively. The maximum variability in arrivals was noticed in Nashik market among the months as compared to Mumbai, Nagpur and Pune. The maximum variability in Nashik and Nagpur markets was recorded in September and August months respectively. While in case of Mumbai and Pune market maximum variability was recorded in September and July months, respectively. The lowest variability in arrivals of selected markets was observed during the months of January, October, March and August respectively. Bhagat *et al*. (2020) [1] stated that the coefficient of variation for minimum temperature (5.1%) was found higher than the maximum temperature (2.5%) during the season of green gram. The wind velocity in Jalgaon district was 7.7 kmph with coefficient of variation of 58.4 percent and bright sunshine hours were 6.6 with a variability of 43.9 percent.

**Table 1:** Variability in arrivals of pomegranate in major markets of Maharashtra (MT) (2012-2020)

| Months | Mumbai | | Nagpur | | Nashik | | Pune | |
|---|---|---|---|---|---|---|---|---|
| | Mean | CV(%) | Mean | CV(%) | Mean | CV(%) | Mean | CV(%) |
| January | 2554 | 31.66 | 1906 | 82.39 | 1459 | 76.09 | 2394 | 59.31 |
| February | 1892 | 36.65 | 1637 | 51.06 | 1454 | 70.85 | 1866 | 64.45 |
| March | 1750 | 38.40 | 1361 | 73.22 | 1452 | 67.94 | 1461 | 67.55 |
| April | 1828 | 33.73 | 1647 | 80.93 | 1851 | 126.94 | 1002 | 61.53 |
| May | 1477 | 63.64 | 1811 | 87.26 | 1909 | 90.07 | 984 | 72.98 |
| June | 1607 | 54.08 | 2275 | 110.10 | 4268 | 140.71 | 851 | 59.60 |
| July | 3077 | 33.90 | 3405 | 115.05 | 9367 | 159.16 | 1794 | 95.49 |
| August | 3356 | 38.09 | 4834 | 123.48 | 11137 | 153.01 | 1771 | 43.21 |
| September | 3308 | 80.96 | 3891 | 102.50 | 6444 | 170.91 | 2395 | 56.46 |
| October | 2163 | 34.16 | 3361 | 42.01 | 4111 | 140.18 | 2948 | 95.20 |
| November | 2311 | 45.03 | 3704 | 96.78 | 2559 | 99.85 | 1973 | 69.50 |
| December | 2521 | 36.23 | 3066 | 69.69 | 2686 | 78.69 | 2262 | 76.00 |
| Mean | 2320 | 54.34 | 2741 | 107.50 | 4058 | 197.45 | 1808 | 81.16 |

**Table 2:** Variability in prices of pomegranate in major markets of Maharashtra (Rs./q) (2012-2020)

| Months | Mumbai | | Nagpur | | Nashik | | Pune | |
|---|---|---|---|---|---|---|---|---|
| | Mean | CV (%) | Mean | CV (%) | Mean | CV (%) | Mean | CV (%) |
| January | 6023 | 17.24 | 5168 | 11.00 | 7461 | 21.26 | 4272 | 13.42 |
| February | 6575 | 25.58 | 5677 | 16.59 | 8241 | 26.03 | 4576 | 9.53 |
| March | 6360 | 18.50 | 5773 | 17.33 | 8402 | 23.92 | 5063 | 10.31 |
| April | 6117 | 19.96 | 5480 | 19.01 | 8041 | 13.05 | 5306 | 11.55 |
| May | 6056 | 32.63 | 5202 | 17.53 | 7428 | 24.14 | 5468 | 11.73 |
| June | 5999 | 24.57 | 4675 | 26.33 | 7385 | 19.44 | 5144 | 10.47 |
| July | 5522 | 17.73 | 4864 | 16.74 | 6799 | 22.70 | 4710 | 11.08 |
| August | 5477 | 30.05 | 4867 | 21.78 | 6115 | 21.77 | 4536 | 18.04 |
| September | 5537 | 22.17 | 4944 | 19.89 | 6695 | 21.75 | 4446 | 13.50 |
| October | 6775 | 12.84 | 5480 | 18.70 | 7415 | 18.00 | 4759 | 10.76 |
| November | 7018 | 10.59 | 5549 | 21.30 | 7503 | 16.90 | 4975 | 13.21 |
| December | 6901 | 28.71 | 5065 | 18.95 | 6369 | 20.08 | 4597 | 16.17 |
| Mean | 6197 | 22.86 | 5229 | 19.11 | 7321 | 22.15 | 4821 | 14.00 |

The overall mean prices of pomegranate in Mumbai, Nagpur, Nashik and Pune market were Rs.6197, Rs.5229, Rs.7321 and Rs. 4821 per quintals and magnitude of coefficient of variation in prices were 22.86, 19.11, 22.15 and 14.00 percent, respectively during the study period. The maximum variability in prices was noticed in Mumbai market among the months as compared to Nashik, Nagpur and Pune. The maximum variability in Mumbai market was recorded in May month followed by August and December. While in case of Nagpur, Nashik and Pune market maximum variability was recorded in June, February and August months, respectively. The similar results was reported by Bhagat *et al*. (2021) [2] and Tamilselvi *et al*. (2020) [14]. The minimum variability in prices of selected markets was observed during the months of November, January, April and February respectively in selected markets during the study period.

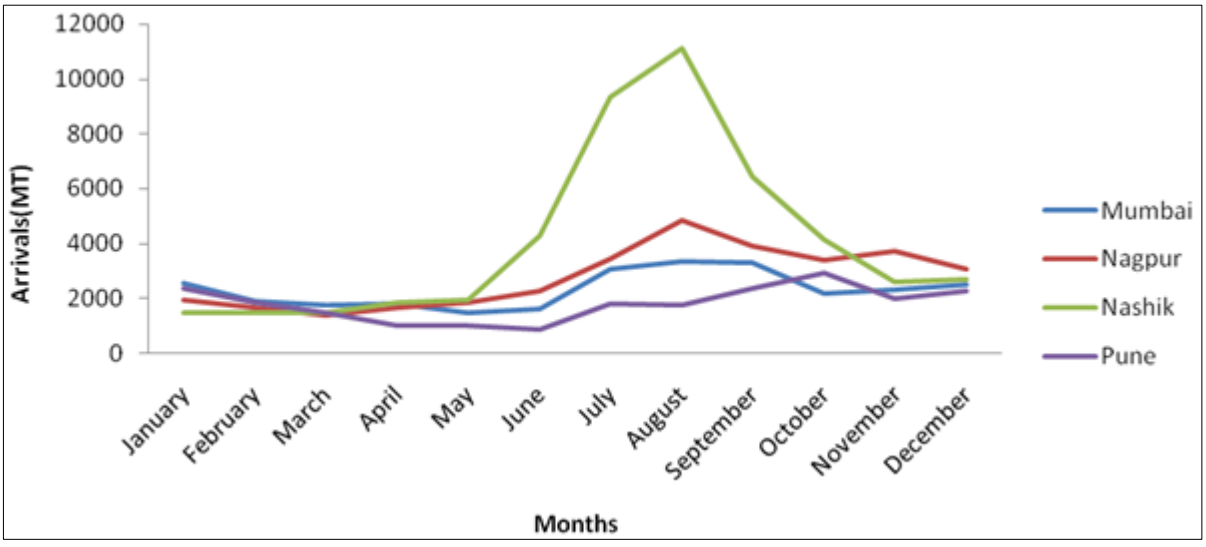


**Fig 1:** Month wise mean arrivals (MT) of pomegranate in selected markets of Maharashtra

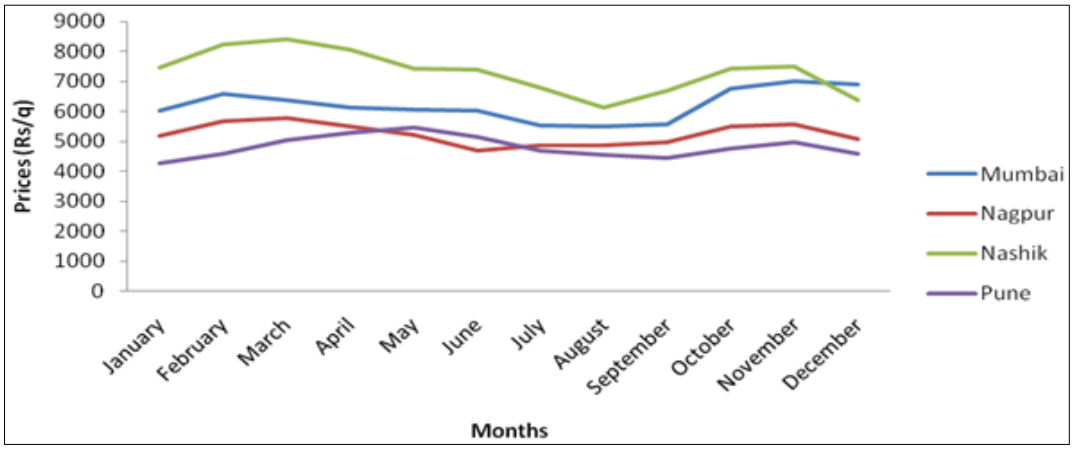


**Fig 2:** Month wise mean prices (Rs. /q) of pomegranate in selected markets of Maharashtra

The results of correlation between the arrivals and prices of markets of pomegranate are depicted in Table 3. The negative significant correlation was noticed in Nashik market in May (-0.74), June (-0.67) and July (-0.69) months respectively. It indicated that increase in arrival of pomegranate in market leading to decline in pomegranate price in Nashik market during these months. The non-significant positive correlation was observed in July, August, September and October months in Mumbai market. However, in Nagpur market there was non-significant positive correlation observed during most of the months except January and October months. The overall non-significant positive correlation between arrivals and prices was noticed in Mumbai and Nagpur market while overall negative non-significant correlation between arrival and prices of pomegranate was observed in Nashik market and Pune market during the study the period.

**Table 3:** Results of correlation between arrivals and prices of pomegranate in markets (2012 to 2020).

| Months | Mumbai | Nagpur | Nashik | Pune |
|---|---|---|---|---|
| January | -0.24 | -0.36 | -0.31 | -0.21 |
| February | -0.44 | 0.31 | -0.65 | 0.13 |
| March | -0.58 | 0.30 | -0.41 | -0.19 |
| April | -0.52 | 0.21 | -0.05 | 0.29 |
| May | -0.33 | 0.31 | -0.74* | 0.04 |
| June | -0.27 | 0.24 | -0.67* | -0.59 |
| July | 0.44 | 0.08 | -0.69* | -0.34 |
| August | 0.66 | 0.13 | -0.60 | -0.47 |
| September | 0.40 | 0.06 | -0.29 | -0.41 |
| October | 0.36 | -0.11 | -0.42 | -0.21 |
| November | -0.10 | 0.29 | 0.08 | -0.52 |
| December | -0.57 | 0.03 | -0.58 | -0.41 |
| Overall | 0.35 | 0.35 | -0.63 | -0.24 |

The results of normality and stationarity in selected markets of pomegranate are presented in Table 4 and Table 5. It indicated that the prices of pomegranate in selected markets are not normal and also the prices of pomegranate in selected markets are non-stationary at level and it becomes stationary after first difference.

**Table 4:** Results of Shapiro-Wilk Normality test for the prices of pomegranate in selected market

| Market | W | p-value |
|---|---|---|
| Mumbai | 0.97 | 0.00 |
| Nagpur | 0.98 | 0.00 |
| Nashik | 0.96 | 0.00 |
| Pune | 0.99 | 0.00 |

**Table 5:** Results of Unit Root test in the prices of Pomegranate

| ADF test at level | | | | PP test at level | | |
|---|---|---|---|---|---|---|
| **Market** | **t-statistic** | **Prob.** | **Remarks** | **Adj. t -statistic** | **Prob.** | **Remarks** |
| Log Mumbai | -0.05 | 0.66 | Non -stationary | 0.26 | 0.76 | Non -stationary |
| Log Nagpur | -0.38 | 0.54 | Non -stationary | -0.71 | 0.41 | Non -stationary |
| Log Nashik | -0.85 | 0.35 | Non -stationary | -0.25 | 0.59 | Non -stationary |
| Log Pune | -1.22 | 0.20 | Non -stationary | -0.23 | 0.60 | Non -stationary |
| **ADF test after 1st diff.** | | | | **PP test after 1st diff.** | | |
| D(Log Mumbai) | -10.71 | 0.00 | stationary | -32.23 | 0.00 | stationary |
| D(Log Nagpur) | -13.55 | 0.00 | stationary | -19.79 | 0.00 | stationary |
| D(Log Nashik) | -5.65 | 0.00 | stationary | -16.48 | 0.00 | stationary |
| D(Log Pune) | -7.85 | 0.00 | stationary | -40.46 | 0.00 | stationary |

The results of price volatility are depicted in Table 6. It was observed that the sum of Alpha and Beta is nearer to 1 that is 1.05, 0.93, 1.05 and 1.14 for Mumbai, Nagpur, Nashik and Pune markets, respectively, revealed that the volatility shocks

in the prices of pomegranate are quite persistence for long time in these markets. Sadiq *et al*. (2018) [12] studied the causes of price volatility and the process of price discovery of okra in India.

**Table 6:** Results of ARCH-GARCH analysis of prices of pomegranate

| Parameter | Mumbai | Nagpur | Nashik | Pune |
|---|---|---|---|---|
| (α) | -0.06 | 0.41 | 0.31 | 0.86 |
| (β) | 1.11 | 0.52 | 0.74 | 0.28 |
| **(α + β)** | 1.05 | 0.93 | 1.05 | 1.14 |

The results of Johansen multiple co-integration trace tests is depicted in Table 7. It indicated that the four co-integration equations were significant at 5 percent level of significance which implied that there existed co-integration among the markets.

The results of pair wise Johansen co-integration test are depicted in Table 8. The results clearly indicated that there exists co-integration between all the pairs of markets. The prices of pomegranate in these pair of markets move together and efficiently functioning. It revealed that the prices are competitive and closely associated with each other. The similar results were also reported by Reddy *et al* (2012) [11]; Mumtaz *et al*. (2017) [8].

**Table 7:** Results of multiple co-integration analysis of logged pomegranate prices

| Hypothesis for no. of Cointegrated equation | Trace Statistics | | | Max-Eigen statistics | | | No. of Co-integrating equation CE(s) |
|---|---|---|---|---|---|---|---|
| | Trace statistics | critical value @ 5% | p-value | Max-eigen Statistic | critical value @ 5% | p-value | |
| None * | 110.78** | 55.25 | 0.00 | 58.20** | 30.82 | 0.00 | 04 |
| At most 1 * | 52.58** | 35.01 | 0.00 | 25.76* | 24.25 | 0.03 | |
| At most 2* | 26.82** | 18.40 | 0.00 | 15.82 | 17.15 | 0.08 | |
| At most 3* | 11.00** | 3.84 | 0.00 | 11.00** | 3.84 | 0.00 | |

**Table 8:** Results of pair wise Johansen co-integration test

| Markets pair | Hypothesis for no. of Cointegrated equation | Trace Statistics | | | Max-Eigen statistics | | |
|---|---|---|---|---|---|---|---|
| | | Trace statistics | critical value @ 5% | p-value | Max-eigen Statistic | critical value @5% | P value |
| Mumbai-Nagpur | None * | 32.21** | 15.49 | 0.00 | 20.38** | 14.26 | 0.00 |
| | At most 1 * | 11.83** | 3.84 | 0.00 | 11.83** | 3.84 | 0.00 |
| Mumbai - Nashik | None | 31.02** | 18.40 | 0.00 | 16.87 | 17.15 | 0.05 |
| | At most 1 * | 14.15** | 3.84 | 0.00 | 14.15** | 3.84 | 0.00 |
| Mumbai - Pune | None * | 62.47** | 18.40 | 0.00 | 41.74** | 17.15 | 0.00 |
| | At most 1 * | 20.73** | 3.84 | 0.00 | 20.73** | 3.84 | 0.00 |
| Nagpur - Nashik | None | 23.88* | 18.40 | 0.01 | 14.04 | 17.15 | 0.13 |
| | At most 1 * | 9.84** | 3.84 | 0.00 | 9.84** | 3.84 | 0.00 |
| Nagpur - Pune | None * | 66.98** | 18.40 | 0.00 | 54.51** | 17.15 | 0.00 |
| | At most 1 * | 12.47** | 3.84 | 0.00 | 12.47** | 3.84 | 0.00 |
| Nashik- Pune | None * | 83.11** | 18.40 | 0.00 | 73.04** | 17.15 | 0.00 |
| | At most 1 * | 10.07** | 3.84 | 0.00 | 10.07** | 3.84 | 0.00 |
| Pune - Mumbai | None * | 62.47** | 18.40 | 0.00 | 41.74** | 17.15 | 0.00 |
| | At most 1 * | 20.73** | 3.84 | 0.00 | 20.73** | 3.84 | 0.00 |

*, ** denote significance at 5 and 1 percent level

The results of pair wise granger causality test of pomegranate price are depicted in Table 9 and it explicates that the market pairs *viz.* Mumbai-Nashik, Pune-Mumbai, Nashik-Nagpur, Nagpur-Pune and Nashik-Pune have unidirectional causality. It means that a price change in the first market in each pair granger cause the price formation in the second market, whereas the price change in the second market is not feed backed by the price change in the first market. Sanjib and Joice (2012) [13] studied the relationship between savings and investment in three diverse economies *viz.* US, UK and China and compared it with India and revealed existence of a cointegrated relationship between savings and investment in these countries.

**Table 9:** Results of Granger Casualty test of pomegranate prices in selected markets

| Market Pairs | No. of obs. | F-Statistic | P-value | Remarks |
|---|---|---|---|---|
| Mumbai-Nagpur | 106 | 2.83 | 0.06 | No causality |
| Nagpur- Mumbai | 106 | 0.37 | 0.69 | No causality |
| Mumbai - Nashik | 106 | 23.69** | 0.00 | Unidirectional |
| Nashik- Mumbai | 106 | 1.84 | 0.16 | No causality |
| Mumbai - Pune | 106 | 0.03 | 0.97 | No causality |
| Pune - Mumbai | 106 | 19.78** | 0.00 | Unidirectional |
| Nashik- Nagpur | 106 | 4.53* | 0.01 | Unidirectional |
| Nagpur -Nashik | 106 | 2.83 | 0.06 | No causality |
| Pune-Nagpur | 107 | 2.08 | 0.15 | No causality |
| Nagpur -Pune | 107 | 4.42* | 0.04 | Unidirectional |
| Pune- Nashik | 106 | 0.68 | 0.51 | No causality |
| Nashik-Pune | 106 | 8.94** | 0.00 | Unidirectional |

## Conclusions

The maximum variability in arrivals of pomegranate was noticed in Nashik market among the months as compared to Mumbai, Nagpur and Pune. The maximum variability pomegranate in Nashik and Nagpur markets was recorded in September and August months. The maximum variability in prices was noticed in Mumbai market among the months as compared to Nashik, Nagpur and Pune. The maximum variability in Mumbai market was recorded in May month followed by August and December. The overall non-significant correlation between arrivals and prices of pomegranate were noticed. The significant negative correlation between arrivals and prices of pomegranate was observed in the months of May, June and July in Nashik market. The volatility shocks in the prices of pomegranate are quite persistence for long period of time. The co-integration of prices of pomegranate was observed for the selected market. It indicated that selected markets are competitive to each other. The pair wise granger causality test of pomegranate price results indicated that the market pairs *viz;* Mumbai-Nashik, Pune-Mumbai, Nashik-Nagpur, Nagpur-Pune and Nashik-Pune have unidirectional causality. It indicated that a price change in the first market in each pair granger cause the price formation in the second market, whereas the price change in the second market is not feed backed by the price change in the first market. It is concluded that very high price volatility present in selected markets of pomegranate. It should be minimized and needs to protect price security for farming community.

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