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ONION MARKET DYNAMICS: INTEGRATION AND PRICE TRANSMISSION ACROSS KEY INDIAN MARKETS.

S Harshitha Nayak[1], Shivendra Kumar Srivastava[2]

1: *Ph.D. Research Scholar, ICAR- Indian Agricultural Research Institute, New Delhi*
2: *Senior Scientist, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.*

Corresponding author email: harshithanayak009@gmail.com

Abstract

Analysis of agricultural commodity price and market arrivals over time is important to know the fluctuations. It helps to formulate appropriate ways and means for reducing price fluctuations. Hence, trend, seasonal indices and variability in arrivals and prices of onion were studied in selected markets viz., Bengaluru, Mumbai, Ahmedabad and Pune. The secondary monthly data pertaining to arrivals and prices of onion in the above mentioned four markets was collected from agmarknet website for the period of 15 years i.e., from 2009 to 2023. The co- integration between markets was analyzed using Johansen's co-integration test and the pairwise causality between markets was analyzed using Granger causality test. The trend analysis shows the positive trend in both arrivals and prices in all the four markets. Variability of prices was found pretty higher than that of market arrival. The result also revealed that all of the price series were non stationary at level and stationary at first difference. Presence of co-integration among the sample markets and price transmission from one market to another market excluding one or two markets was established.

JEL Codes: M310 Marketing
F100 Trade: General
F190 Trade: Other

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ABSTRACT

Analysis of agricultural commodity price and market arrivals over time is important to know the fluctuations. It helps to formulate appropriate ways and means for reducing price fluctuations. Hence, trend, seasonal indices and variability in arrivals and prices of onion were studied in selected markets *viz*., Bengaluru, Mumbai, Ahmedabad and Pune. The secondary monthly data pertaining to arrivals and prices of onion in the above mentioned four markets was collected from agmarknet website for the period of 15 years i.e., from 2009 to 2023. The co- integration between markets was analyzed using Johansen's co-integration test and the pairwise causality between markets was analyzed using Granger causality test. The trend analysis shows the positive trend in both arrivals and prices in all the four markets. Variability of prices was found pretty higher than that of market arrival. The result also revealed that all of the price series were non stationary at level and stationary at first difference. Presence of co-integration among the sample markets and price transmission from one market to another market excluding one or two markets was established.

Key Words: Trend, Seasonal Indices, Variability, Johnsen's co-integration test, Granger causality test.

I INTRODUCTION

India's agriculture sector, employing nearly half of the nation's workforce and constituting a substantial 18 percent of the GDP, has witnessed commendable growth in production value over the years. However, despite these achievements, the economic conditions of farmers continue to face persistent challenges. This predicament is primarily attributed to the inadequacies within the agricultural marketing system, which play a vital role in determining the prosperity of those involved in the sector.

In 2022-23, India's total horticulture area was 28.12 million hectares, with a total production of 351.92 million tonnes (Anonymous, 2023). The central focus of this study is on the dynamics of the onion market, recognizing the critical role that effective agricultural marketing plays in stimulating production, reducing costs, and maintaining price stability. The significance of onions in the Indian context cannot be overstated; they are a fundamental ingredient in everyday cooking and a crucial component of the country's horticulture landscape. The demand for vegetables, including staples like potatoes, carrots, and onions, is consistently high, underscoring their importance in our daily diet.

In the larger context of "Transformation Towards Sustainable Agri-Food Systems," this study assumes a significant role. It aims to address the existing deficiencies within the agricultural marketing system, aligning its objectives with the broader goal of fostering sustainability and equity in the agricultural landscape. The focus on onion market dynamics serves as a microcosm, representing the larger challenges and opportunities within the agricultural sector.

Analyzing the integration and price transmission across key Indian onion markets becomes crucial in this pursuit (Ghafoor *et al.*, 2009). Market integration is not merely a matter of economic significance but holds broader implications for transparency, stability, and fairness within the agri-food system. The study seeks to unravel the spatial linkages among the country's main onion markets, recognizing that their interconnectedness provides essential market signals. The regional disparities in market integration, influenced by varying infrastructural and institutional frameworks, become focal points for investigation.

By setting forth these objectives, the study aspires to contribute valuable insights that can enhance the efficiency and resilience of the agri-food system. It endeavors to go beyond the specific challenges of the onion market, addressing the overarching themes of sustainability and equity that are paramount for the transformation of India's agricultural landscape. In doing so, the study strives to be a catalyst for positive change, paving the way for a more sustainable, transparent, and equitable agri-food system that benefits all stakeholders involved, from producers to consumers.

Objectives

1. To analyze the trend, seasonality and variability in arrivals and prices of onion in major markets.
2. To examine the extent of integration of major onion markets and price transmission among them.

II METHODOLOGY

2.1 Selection of markets

The major onion producing Indian states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Rajasthan, Andhra Pradesh, Haryana, West Bengal, Uttar Pradesh (Monthly Report Onion, GOI, 2023). Out of these states, based on highest market arrivals of onion, three states i.e., Karnataka, Maharashtra and Gujarat were selected for present study. From these states, major markets for onion were selected on the basis of highest market arrivals were Bengaluru (Karnataka), Mumbai (Maharashtra), Pune (Maharashtra) and Ahmedabad (Gujarat) for present study.

2.2 Nature and Sources of the Data

The research was based on secondary data and attempted on a macro theoretical account. Time series data on price and arrival from January 2009 to December 2023 were collected primarily from www.agmarkenet.nic.in, National Horticultural Board, State Department of Agriculture and secondary reports of various published journals, papers, studies and surveys as required to meet the research's objectives.

2.3 Analytical Tools and Techniques Employed

Objective 1 – To analyse the trend, seasonality and variability in arrivals and prices of onion in major markets

A. Linear trend

For computing linear trend, price and market arrival of the major markets of onion from the period January 2009 to December 2023 were put to trend analysis. The linear trends of market arrivals and prices of the onion was observed through the linear trend equations in the form of linear regression (Saha, 2020) as under:

$$Y = a + bt$$

Where,

Y = Market arrival/ Price of the crops

a = Intercept coefficient

b = Regression coefficient

t = time variable

B. Seasonality indices of Arrivals and Prices

To measure the seasonal variation in monthly arrivals and prices of time series data seasonal index are used which was calculated by method of simple averages.

Simple Averages method of Seasonal Index

The method of simple averages of seasonal index involves the following steps:

- Arrange the data by years and months
- Compute the monthly averages for i^{th} month for all the years. (i^{th} month, i = 1, 2……12 represents Jan, Feb, …. Dec respectively)
- Compute the average of monthly averages
- Seasonal indices are for different months are obtained by expressing monthly averages as percentage of $\bar{X}$
- Thus, seasonal index for i^{th} month = ($\frac{\bar{x}_i}{\bar{x}}$× 100); i = 1, 2, 3…12

C. Variability Index

Variability can be calculated from the simple coefficient of variation also, but it often overestimates the level of instability in time series data due to the presence of long-term trend, so, Cuddy-Della-Valle index was constructed to correct the flaws present in coefficient of variation. Cuddy Della Valle Index was used to estimate variability in price and arrival of onion (Saha, 2020). The variability coefficient has been computed using the following formula:

$$\mathbf{I= CV^*\sqrt{1 - AdR^2}}$$

Where,

I =Instability index (in percent)
CV =Coefficient of variation (in percent)
$\mathbf{R^2}$ =Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom

Objective 2 - To examine the extent of integration of major onion markets and price transmission among them

Market integration occurs when the prices of a product in various geographically isolated markets move together over a long period of time. When the price of a commodity changes, and the price of goods of the same quality in other markets changes in the same direction, the markets are said to be integrated. The following steps are involved in market co-integration analysis.

A. Augmented Dickey-Fuller Test (ADF Test)

The co-integration test is used to see whether two markets are co-integrated or not. However, before conducting the co-integration test, the data must be checked to see whether it is stationary or nor, because lack of stationarity renders the relationship both spurious and meaningless. This test determines whether or not the time series is stationary. If the data is not stationary, no integration test can be performed. When price series stationarity is established at the same level of differences, the price relationship is assumed to be good. The Augmented Dickey Fuller (ADF) test was used to assess price stationarity in this analysis (Dickey and Fuller, 1981). The test's null hypothesis is that the price series has a unit root. The presence of a unit root in data indicates that it is non-stationary. As a consequence, the existence of unit root at the data level allows the data to be converted into first differences, where the unit root test is repeated and the stationarity is tested before continuing with the analysis.

The model is:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \epsilon_t$$

Where,

Y_t = Price of sample vegetable in a given market at time t

Δ**Y_t** $= Y_t - Y_{t-1}$

ε = Pure white noise error term

m = Optimal lag value which is selected on the basis of Schwartz Information Criterion (SIC) and Akaike Information Criterion (AIC)

ADF test

Null Hypothesis H0: $\delta = 0$

Alternate Hypothesis H1: $\delta < 0$

Accepting the null hypothesis to test for a unit root in the price series means that the time series is non stationary. The time series is stationary if the null hypothesis is rejected and the alternative hypothesis is accepted.

B. Johansen Co-integration Test

Co-integration test by non-stationary sequence explains the degree of divergence from the long run equilibrium relationship. The co-integration of markets was checked using Johansen maximum-likelihood methods after verifying stationarity in the whole price series at the same order of differences. The Johansen co- integration test was used to analyze the long-term price relationship between the markets (Johansen and Juselius 1990).

When two variables have a long-term, stable equilibrium relationship, they are said to be integrated. In this case, the Johansen co-integration test would be used:

$$\Delta Y_t = \sum \prod_i \Delta Y_{t-i} + \prod Y_{t-k} + \epsilon_t$$

Where,

Y_t = vector of price time series

ΔY_t = first order difference and matrix,

Π = $\alpha\beta'$ is n*n order with rank 'r' ($0 \leq r \leq n$), the no. of independent co-integration relations.

α is the speed of adjustment to the disequilibrium

β is the long-term coefficients.

The model was estimated by regressing ΔY_t matrix against the lagged differences ('k' lags) of ΔY_t to determine the number of co-integration vectors, the rank of $\Pi = \alpha\beta'$ has to be found.

The co-integration test implies that when the number of co-integrating vectors is increased it will give rise to increasing strength and stability of price linkage.

C. Granger Causality Test

To show the causal relationship between the price sequences, the Granger causality test is used (Granger, C.W. 1969). The Granger causality test oriented within a vector auto regressive (VAR) model can be used to determine the existence and causality orientation of long-run market price relationships. For the Granger causality test, an autoregressive distributed lag (ADL) model was defined as follows:

$$X_0 = \sum_{i=1}^{n} \alpha i\, Y0 - i + \sum_{j=1}^{n} Q\, j\, X0 - j + \mu\mathbf{10}$$

$$Y_0 = \sum_{i=1}^{n} \boldsymbol{\lambda} i\, Y0 - i + \sum_{j=1}^{n} \boldsymbol{\delta}\, j\, X0 - j + \mu 2\mathbf{0}$$

Where,

$\mu 10$ & $\mu 20$ are error term

t = time period

$X0$ and $Y0$ are the price series of two different markets.

To test the pattern of causality between two markets, F test was used.
The null hypothesis H_0: The lagged X_0 does not granger cause Y_0
The Alternative hypothesis H_1: The lagged X_0 granger cause Y_0

When determining the significance of the results, the F statistic must be used in combination with the p value. Specific p values are tested whether the p value is smaller than the alpha level to assess which of the individual variables is statistically significant.

III REULTS AND DISCUSSION

Objective 1: To analyze the trend, seasonality and variability in arrivals and prices of onion in major markets

Vegetables have more variable output due to their seasonal and perishable nature, which causes dramatic swings in market arrivals. Onion was chosen from among all the vegetables produced in India because of its relevance in Indian homes and its part in overall vegetable production.

A. Trend in market arrivals and prices

The trend component was calculated to determine the overall movement of onion arrivals and prices in the major markets. Many functional forms were explored to evaluate the trends but the linear form was chosen since it best represented the data.

i. Linear trend in arrivals of onion in sample markets

The linear trend was used to calculate the long-run movement of market arrivals of onion in the selected markets during the study period, and the results are shown in Table 3.1. The coefficient of arrivals of onion in all the selected markets was found to be positive, which indicates that the arrivals of onion in all the selected markets was increasing over the years in the study period. In the long-run per annum increase in the arrival of onion was found to be highest in Bengaluru markets which was 30140 quintals followed by Mumbai (21901 quintals), Ahmedabad (7896.2) and lowest per annum increase was observed in Pune market (1845.4 quintals). These results are in accordance with Saha (2020).

Further, it was found that in Bengaluru, Mumbai, Ahmedabad and Pune market 52.05, 44.50, 63.06 and 29.65 per cent change in arrivals respectively was governed by the independent variable time as indicated by the R^2 values 0.5205, 0.4450, 0.6306 and 0.2965. It indicated that the change in the linear trend over the years was more captured by the trend equation of Ahmedabad market and least was in case of Pune market.

Table 3.1 Linear trend in arrivals of Onion in sample markets

Markets	Coefficient	Intercept	R^2	Trend equation
Bengaluru	30140	242055	0.5205	y = 30140x + 242055
Mumbai	21901	163608	0.4450	y = 21901x + 163608
Ahmedabad	7896.2	39906	0.6306	y = 7896.2x + 39906
Pune	1845.4	12019	0.2965	y = 1845.4x + 12019

ii. Linear trend in prices of Onion in sample markets

The linear trend for onion price in selected market is presented in the Table 3.2. There was an increase in trend in prices of onion in all the selected markets, the increasing trend in prices varied from one market to another market. Among all the markets the per annum increase in price was more in Mumbai market (Rs.99.61/q), followed by Ahmedabad (Rs.91.34/q), Bengaluru (Rs.80.12/q) and least in case of Pune market (Rs.77.06).

Further, it was found that in Bengaluru, Mumbai, Ahmedabad and Pune market 43.14, 46.79, 47.71 and 33.41 per cent change in prices respectively was governed by the independent variable time as indicated by the R^2 values 0.4314, 0.4679, 0.4771 and 0.3341 respectively. These results are in accordance with Saha (2020).

Table 3.2 Linear trend in prices of Onion in sample markets

Markets	Coefficient	Intercept	R^2	Trend equation
Bengaluru	80.12	710.50	0.4314	y = 80.12x + 710.50
Mumbai	99.61	582.51	0.4679	y = 99.61x + 582.51
Ahmedabad	91.34	433.74	0.4771	y = 91.34x + 433.74
Pune	77.06	739.18	0.3341	y = 77.06x + 739.18

B. Seasonal Indices of market arrivals and prices

Seasonal variations are patterns that reoccur over known, defined periods of time within the data set. These changes might be regular or semi-regular and they occur every year and have ayear-to-year origin. Almost every aspect of agricultural output is affected by seasonality to some degree. Organizations must be able to recognize and measure seasonal fluctuations in their markets in order to prepare for a more profitable price. The arrivals of market have a significant influence on price formation. Prices often rise during lean seasons and fall during peak periods, when the majority of farmers, particularly small and marginal farmers and tenant cultivators with limited negotiating power and poor retention power, sell their produce. They can't keep the extra stock for very long period of time after harvesting. This impact is generally explained by an inverse relationship between market arrival and price. For evaluating changes in arrivals and pricing, monthly indices were calculated on time series data for years from January 2009 - December 2023.With the aid of ratio to simple average approach, the seasonality in arrivals and prices of onion have been worked out and described hereafter market wise.

i. Seasonal indices of market arrivals of Onion in sample markets

Seasonal indices of market arrivals of onion in Bengaluru, Mumbai, Ahmedabad and Pune markets are given in Table 3.3. The seasonal indices revealed the existence of seasonal variations in the arrival of onion in all the selected markets. The seasonal indices in Bengaluru market were highest in the month of October with an index 203.33, which is the prime harvesting time of kharif onion in Karnataka followed by November (162.72) and September (127.67), lowest in the month of February with an index of 67.88. In Mumbai market the indices were highest in the month of December with an index of 137.71 followed by February (127.87). In Ahmedabad markets the arrivals are not fluctuating as compared to other markets, the indices show the highest arrival in the month of April (111) which is the peak harvesting period of Rabi onion in North India. In Pune market the arrival is maximum in the month of March with indices 127.66, followed by February (126.24) and December (121.08). Among all the markets the highest and the lowest arrivals are seen the Bengaluru market in the month of October with an index 203.33 and in the month of February with an index 67.88 respectively. These results are in accordance with Saha (2020).

Table 3.3 Seasonal indices of market arrivals of Onion in sample markets

Months	Bengaluru	Mumbai	Ahmedabad	Pune
January	82.69	107.60	100.58	108.17
February	67.88	127.87	103.81	126.24
March	74.99	103.95	106.90	127.66
April	74.71	87.52	111.00	95.83
May	71.63	100.99	105.02	81.32
June	77.76	99.63	99.71	89.10
July	70.66	113.98	100.17	90.68
August	78.05	82.16	92.41	82.86

September	127.67	73.53	102.07	99.64
October	203.33	84.22	102.02	96.72
November	162.72	80.85	86.73	80.70
December	107.91	137.71	89.60	121.08

ii. Seasonal indices of prices of Onion in sample markets

Seasonal indices of prices of onion in Bengaluru, Mumbai, Ahmedabad and Pune markets are given in Table 3.4. The seasonal indices in the Bengaluru market were highest in the month of November with the indices of 159.17 followed by December (152.28) and October (130.90) and lowest was in the month of April (55.50). In Mumbai market seasonal indices were highest in the month of November with the indices of 159.19 followed by December (147.52) and October (146.57) and lowest was in the month of April (55.89). In Ahmedabad market seasonal indices were highest in the month of November with the indices of 149.92 followed by October (143.15) and December (141) and lowest was in the month of May (51.09). In Pune market seasonal indices were highest in the month of December with the indices of 163.85 followed by November (163.01) and October (133.31) and lowest was in the month of April (51.05). Overall, the seasonal indices for prices were highest in the months from July to January and lowest in the months from February to July. These results are in accordance with (Saha 2020).

Table 3.4 Seasonal indices of prices of onion in sample markets

Months	Bengaluru	Mumbai	Ahmedabad	Pune
January	113.36	103.01	110.26	110.51
February	81.47	75.68	82.10	70.31
March	62.45	59.80	67.15	54.52
April	55.50	55.89	56.08	51.05
May	58.61	58.28	51.09	61.01
June	76.88	72.92	65.44	71.12
July	88.50	81.55	83.38	83.36
August	107.74	111.78	117.13	117.23
September	113.14	127.80	133.79	123.72
October	130.90	146.57	143.15	133.31
November	159.17	159.19	149.42	160.01
December	152.28	147.52	141.00	163.85

C. Variability of market arrivals and prices in major markets

The Cuddy Della Valle (C-D-V) index was used to assess data instability or variability. The index was used to calculate the instability of both market arrival and price of onion in the selected markets. The result of analysis of variability in market arrival and prices over the time period from January 2009 to December 2023 are presented in the Table 3.5. The variability in prices was more profound as compared to arrivals. The variability of arrivals was more in the Pune market with the index 79.18percent, while Ahmedabad market showed the lowest value with index of 35.03. Variability in prices were quite high in all the four market however, Pune market showed the highest variability with an index of 75.55percent. These results are in accordance and similar with Saha (2020).

Table 3.5 Variability of market arrivals and prices of onion in sample markets

C-D-V Index (percent)		
Markets	**Market arrival**	**Prices**
Bengaluru	59.98	69.09
Mumbai	75.30	74.44
Ahmedabad	35.03	73.40
Pune	79.18	75.55

Objective 2 To examine the extent of integration of major onion markets and price transmission among them

When the prices of the same product in different markets in different places follow a common trend over time, this is known as market integration. Prices also change in proportion to one another and where this relationship is very clear among different markets, the markets are said to be integrated. It is critical to co-integrate price series in order to create a long-run equilibrium relationship between markets. The degree of integration was determined by analyzing prices in spatially isolated markets. The integration of markets has been studied using econometric methods such as the Johansen Co-integration Test and the Granger Causality Test.

Before beginning either of the above-mentioned statistical tests, we have to make sure that the time series are stationary, because it can cause erroneous effects, and testing the stationarity of price series can help to prevent this. Further to establish the long-run equilibrium relation among the price series, it was necessary to co-integrate them. Co-integration among the variables in turn requires checking the order of integration among the variables and variables cannot be integrated in the presence of unit root, the same can be examined through conducting a stationarity test. Once it was confirmed that all of the price series were stationary at same order of differences, the co- integration of markets were tested by Johansen maximum-likelihood techniques. The Johansen and Juselius (1990) co-integration test for the long run relationship among the price series were employed. The Granger causality test is conducted to test the existence and direction of long-run causal price relationship between the markets.

- **Augmented Dickey Fuller test (ADF):** The Augmented Dickey Fuller test was used to determine if onion price series are stationary at their current levels or at their differences. The null hypothesis in the test at level was that the price sequence has a unit root. The fact that there is a unit root indicates that the data is non-stationary.
- **Johansen Co-integration Test**: This measure was used to determine whether or not the markets are integrated. The price series must be non-stationary at first order and stationary at first difference to perform this test. This test was used to determine the relationship between the markets after the data series was shown to be stationary at first difference.
- **Granger causality test:** After determining the market integration, the Granger causality test was used to determine the direction of price transmission.

i. Results of Augmented Dickey-Fuller test (ADF) for selected onion markets

Typically, the Johansen co-integration test required that the time series to be integrated at order one, with the order of integration determined using the standard Augmented Dickey-Fuller (ADF) unit root tests. The ADF test compares the null hypothesis of a unit root in the time series to the alternative hypothesis of no unit root. Based on the critical value and corresponding probability value, the null hypothesis of both tests was accepted or rejected. The series was said tobe non-stationary if the test statistics are smaller in absolute terms than the critical values and the corresponding probability value was greater than 5 percent or 1 percent level of significance.

Table 3.6 and Table 3.7 show the results of the ADF test on onion prices in four major markets at the level and at the first difference, respectively. The price series in all four markets (Bengaluru, Mumbai, Ahmedabad, and Pune) accepted the null hypotheses of having unit root at their levels at a 1percent significance level and rejected at the first difference, indicating that the underlying series are nonstationary at levels and stationery at first difference. These results are in accordance and similar with (Sendhil *et.al.*, 2014).

Table 3.6 Results of Augmented Dickey-Fuller test (ADF) for selected onion markets at levels

Markets	t-statistic	Probability	Remark
Ahmedabad	-0.31	0.5741	Non-stationary
Bengaluru	-0.37	0.5439	Non-stationary
Mumbai	-0.28	0.5801	Non-stationary
Pune	-1.13	0.2347	Non-stationary

Table 3.7 Results of Augmented Dickey-Fuller test (ADF) for selected onion markets at first difference

Markets	t-statistic	Probability	Remark
Ahmedabad	-5.85	0.0000	Stationary
Bengaluru	-8.59	0.0000	Stationary
Mumbai	-5.87	0.0000	Stationary
Pune	-7.94	0.0000	Stationary

Graphical presentation of the level series and first differenced series of all the four markets i.e., Bangalore, Mumbai Ahmedabad and Pune are presented in the figures 3.1 to 3.8.

Time plot of level series of the markets showed that during some period there was an increasing trend of price and at other times it is decreasing. It indicates non-stationarity of the data series because it specifies fluctuating values of mean and variance. But the time plot of difference series shows that though there are fluctuations in the data but more or less they fluctuate around a fixed value, i.e., it indicates constant mean and variance which in turn means that the data series was stationary.

ii. Johansen co-integration test

The integration among selected onion markets were analyzed through applying the Johansen co-integration procedure to the time series monthly price data for years from 2009 to 2023. The results of Johansen co-integration test for the onion markets have been presented in the table 3.8 and 3.9. Two types of tables have been presented, one shows the co-integration relationship based on trace statistic, and another one is showing the relationship based on the maximum eigenvalue statistic. Unrestricted co-integration rank tests (Trace and Maximum Eigenvalue) indicated the presence of at least 3 co-integrating equations at 5 percent level of significance, thus revealing that onion markets were having long run equilibrium relationship. These results are in accordance and similar with Ahmed and Singla (2017).

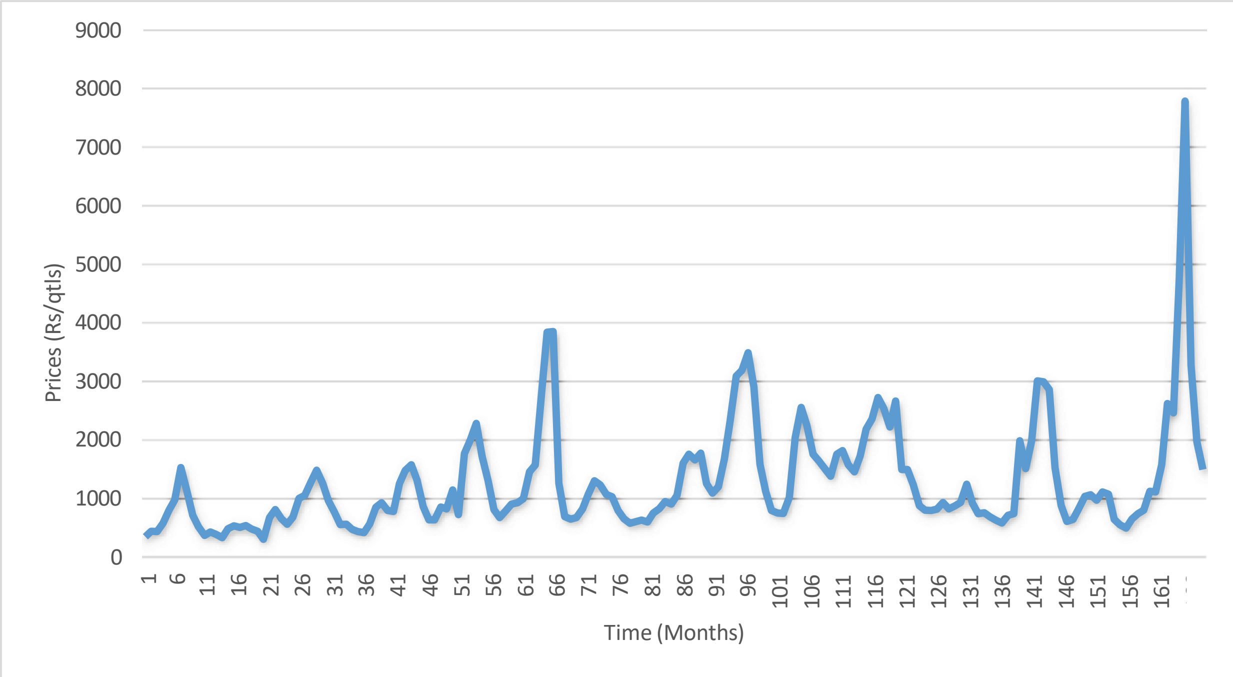

Fig 3.1 Time plot of level series of prices of Onion in Bengaluru market

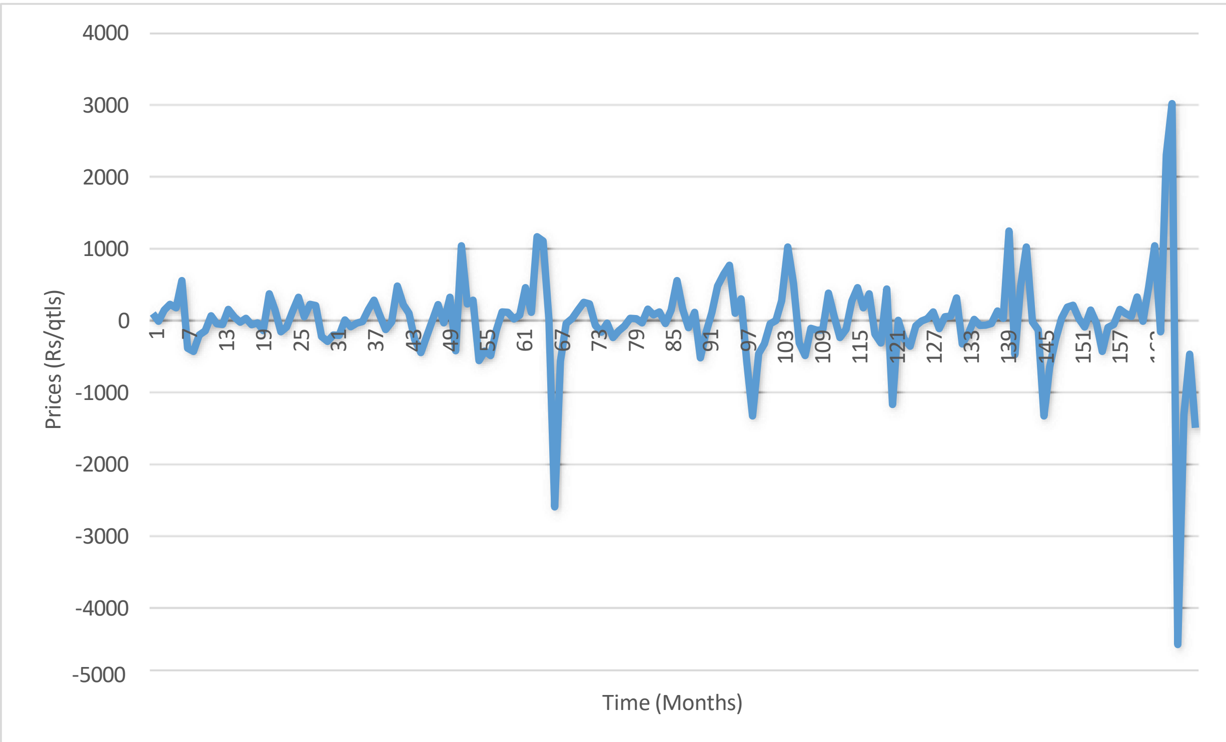

Fig 3.2 Time plot of differenced series of prices of Onion in Bengaluru market

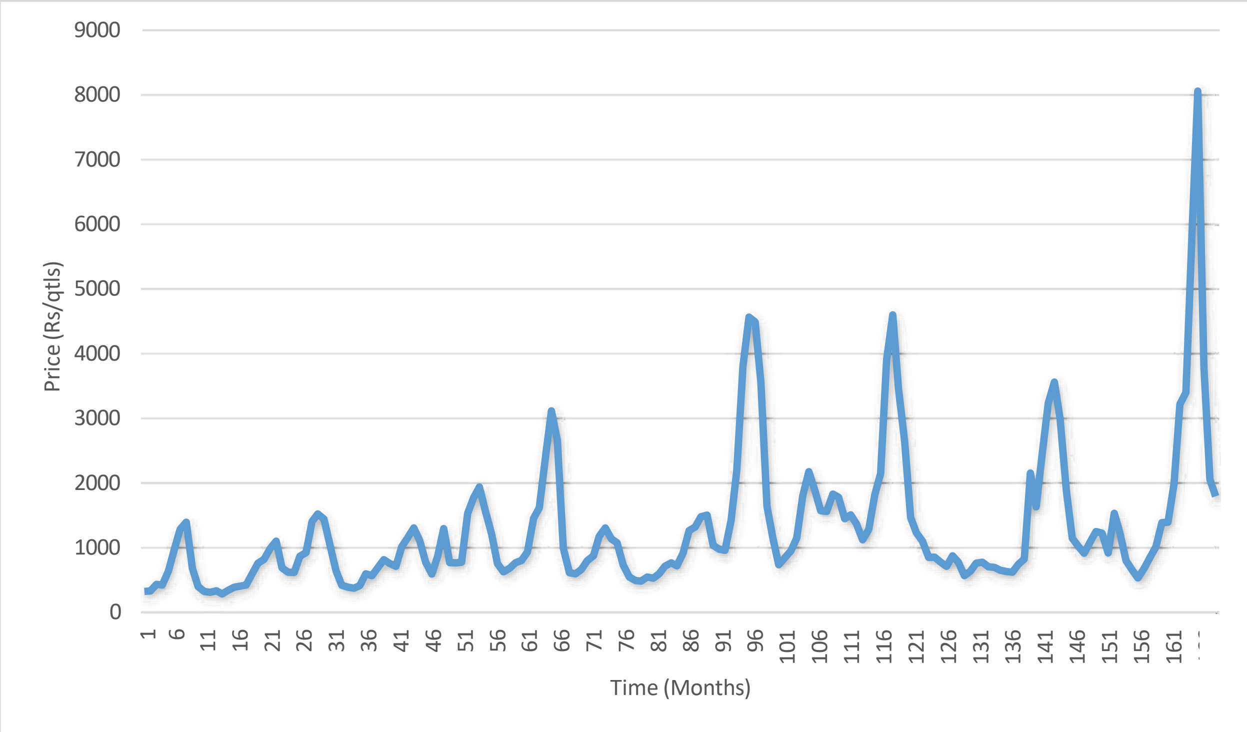

Fig 3.3 Time plot of level series of prices of Onion in Mumbai market

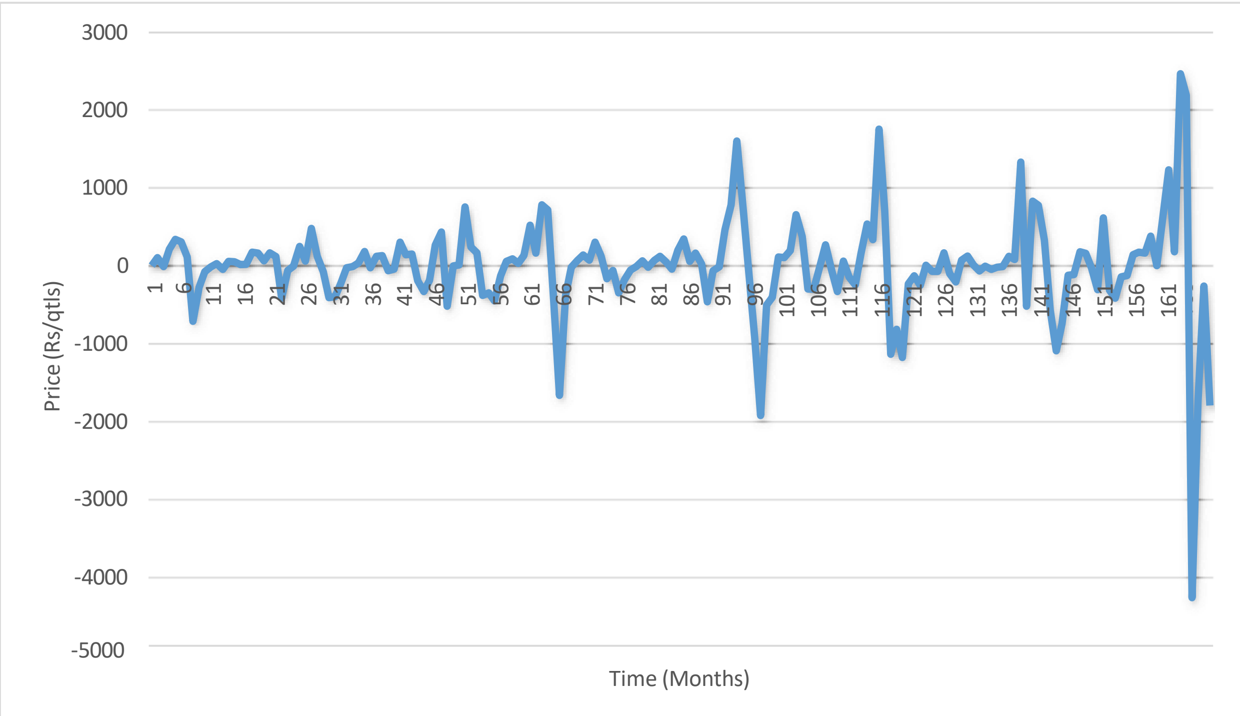

Fig 3.4 Time plot of differenced series of prices of Onion in Mumbai market

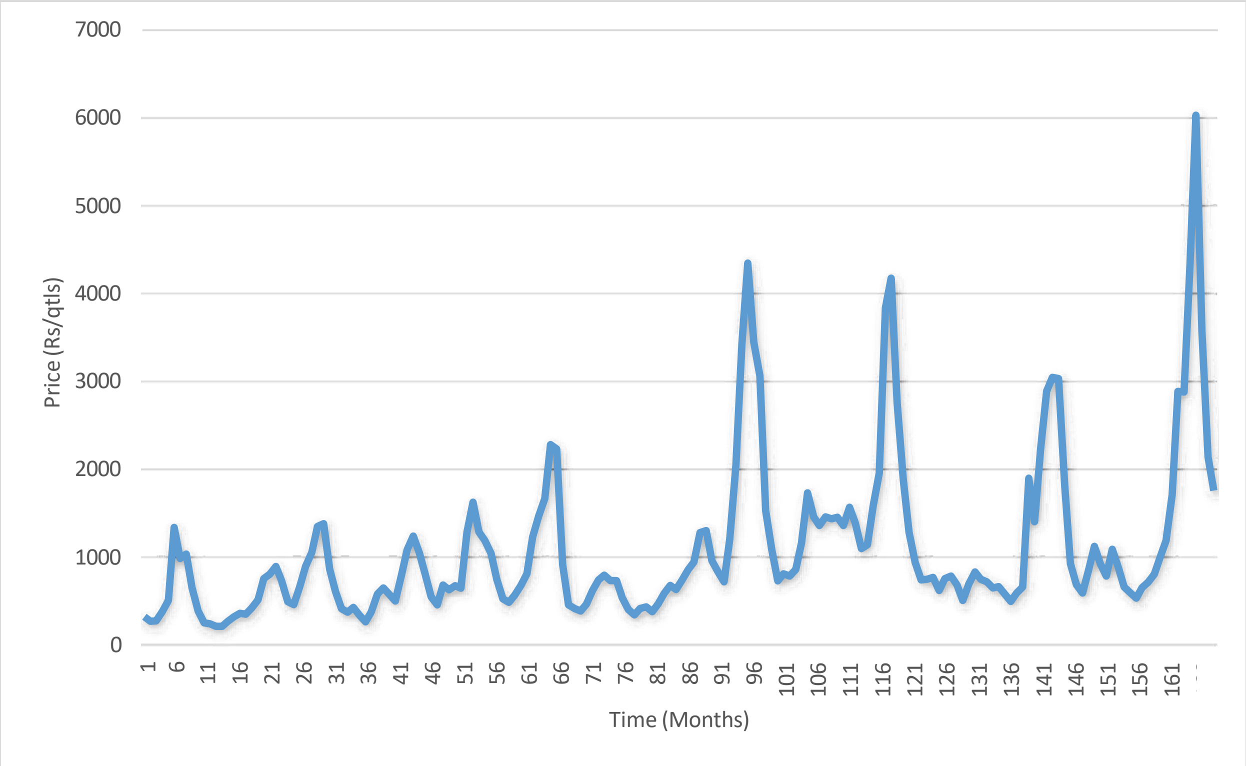

Fig 3.5 Time plot of level series of prices of Onion in Ahmedabad market

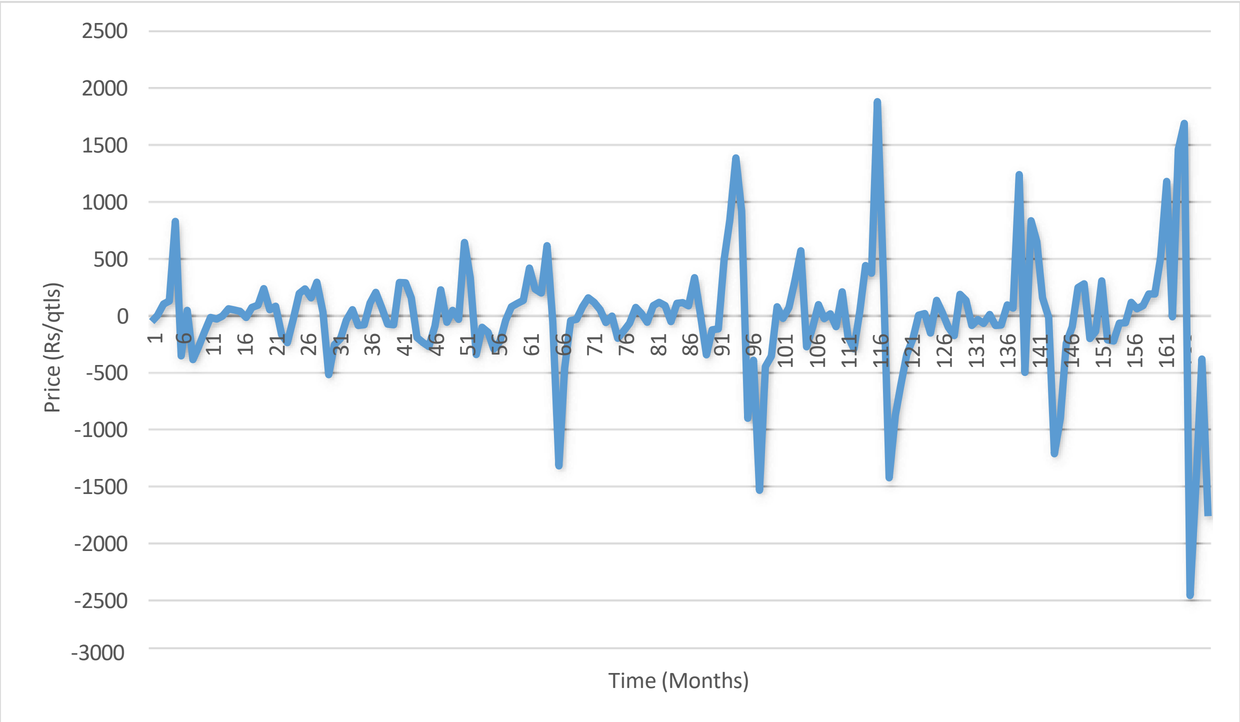

Fig 3.6 Time plot of differenced series of prices of Onion in Ahmedabad market

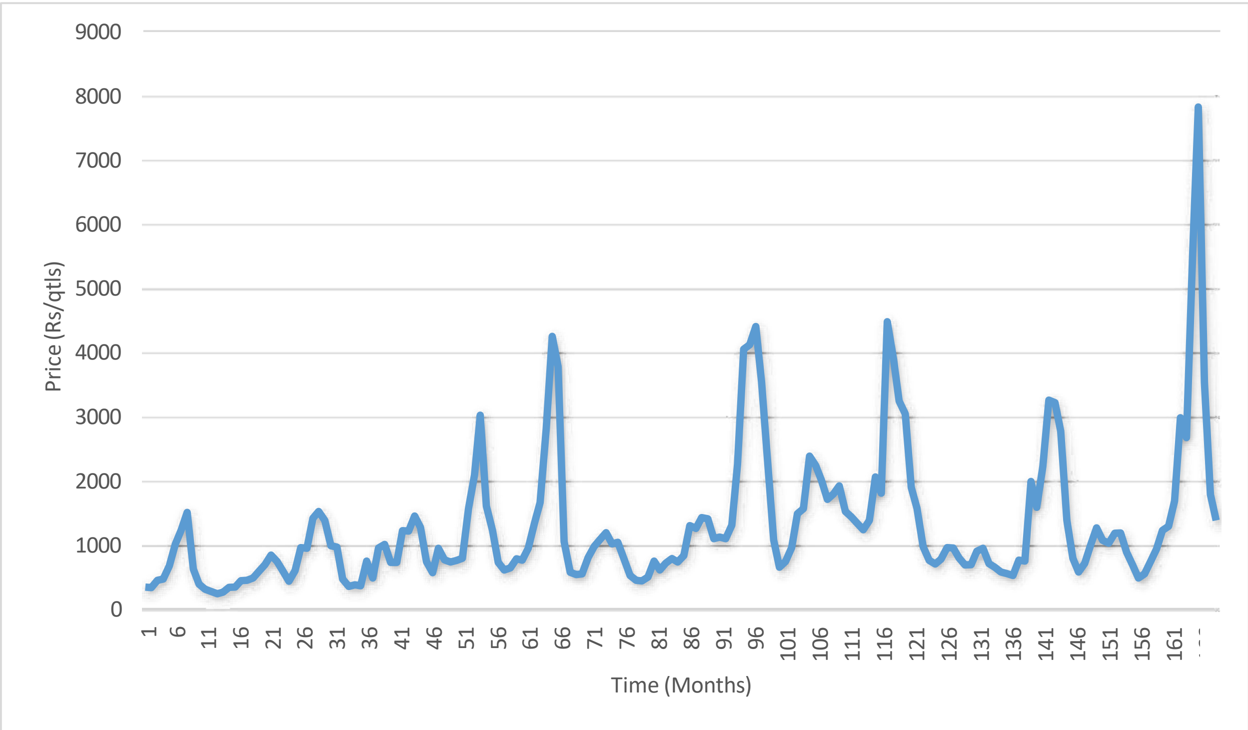

Fig 3.7 Time plot of level series of prices of Onion in Pune market

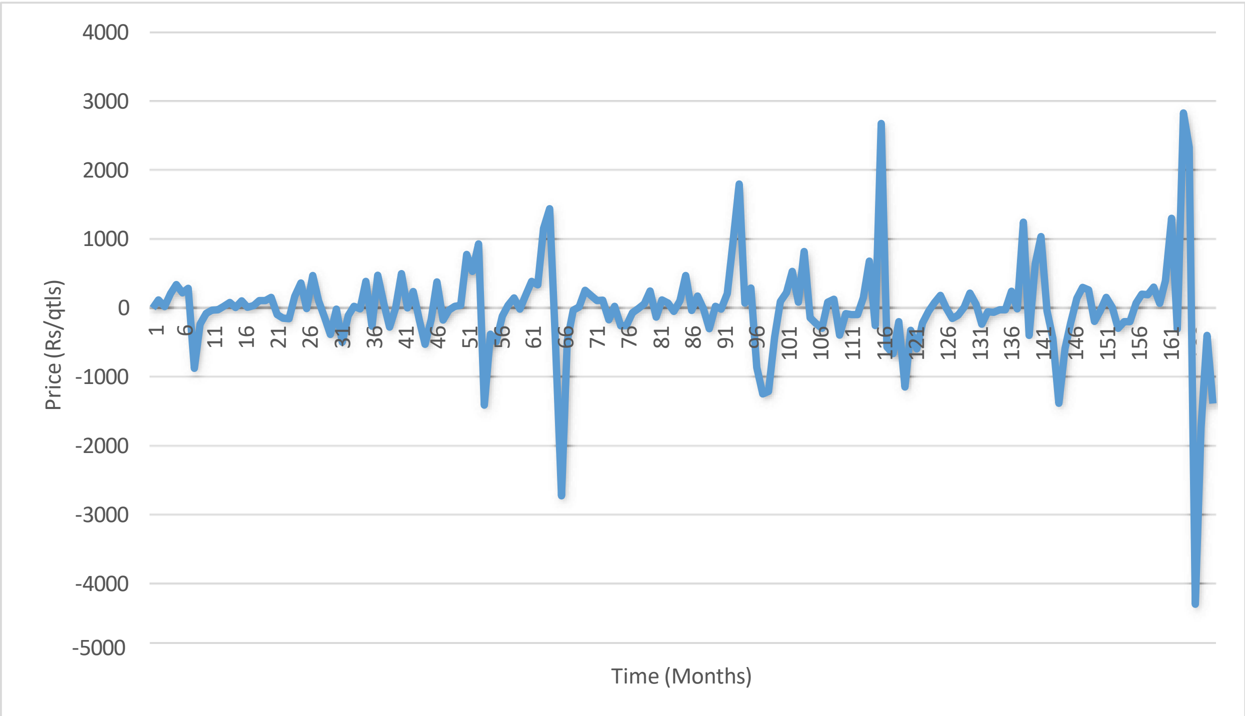

Fig 3.8 Time plot of differenced series of prices of Onion in Pune market

Table 3.8 Results of Unrestricted Co-integration Rank Test (Trace) for selected onion markets

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.1684	82.93	47.85	0.0000
At most 1*	0.1410	50.64	29.79	0.0001
At most 2*	0.1148	24.04	15.49	0.0020
At most 3	0.0152	2.69	3.84	0.1010

Trace test indicates 3 co-integrating markets (s) at the 0.05 level
*Denotes rejection of the hypothesis at the 0.05 level
**Mackinnon-Haug-Michelis (1999) p-values

Table 3.9 Results of Unrestricted Co-integration Rank Test (Maximum Eigenvalue) for selected onion markets

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.1684	32.29	27.58	0.0115
At most 1*	0.1410	26.60	21.13	0.0077
At most 2*	0.1148	21.35	14.26	0.0032
At most 3	0.0152	2.68	3.84	0.1010

Trace test indicates 3 co-integrating markets (s) at the 0.05 level
*Denotes rejection of the hypothesis at the 0.05 level
**Mackinnon-Haug-Michelis (1999) p-values

iii. Granger Causality Test

After confirming the integration of prices series, in the next step, was to perform pair-wise Granger causality test for four onion markets to comprehend causal relation between them. Granger causality test, tests the null hypothesis of no causality between the selected pairs of onion markets. The results presented in Table 3.10 explains that the Ahmedabad market has bidirectional causality in price transmission with the prices of Mumbai and Pune market and unidirectional causality in price transmission with the prices of Bengaluru market. Bengaluru market shows bidirectional causality with the Mumbai market and no causality with the Pune and Ahmedabad market. Mumbai shows bidirectional causality with the Ahmedabad and Bengaluru market and unidirectional causality with the Pune market. Pune market shows bidirectional causality with the Ahmedabad market and no causality with the Mumbai and Bengaluru market. These results are in accordance and similar with Ahmed and Singla (2017).

Table 3.10 Results of Granger Causality test for selected Onion markets

Market-Pairs	No. of Obs.	F-Statistic	P-Value	Decision of null hypothesis	Remarks
Bengaluru-Ahmedabad	178	1.49	0.2277	Do not reject	No causality
Ahmedabad-Bengaluru	178	10.25	6.E-05	Reject	Unidirectional
Mumbai-Ahmedabad	178	6.16	0.0026	Reject	Bidirectional
Ahmedabad-Mumbai	178	10.60	5.E-05	Reject	Bidirectional
Pune-Ahmedabad	178	4.02	0.0195	Reject	Bidirectional
Ahmedabad-Pune	178	9.14	0.0002	Reject	Bidirectional
Mumbai-Bengaluru	178	13.40	4.E-06	Reject	Bidirectional
Bengaluru-Mumbai	178	7.21	0.0010	Reject	Bidirectional
Pune-Bengaluru	178	4.39	0.0137	Reject	Unidirectional
Bengaluru-Pune	178	0.005	0.9950	Do not reject	No causality
Pune-Mumbai	178	0.533	0.5335	Do not reject	No causality
Mumbai-Pune	178	8.586	0.0003	Reject	Unidirectional

IV SUMMARY AND CONCLUSION

The global cultivation of onions spans 1.79 million hectares, producing approximately 31.01 million metric tonnes in the 2022-23 period (FAOSTAT, 2023). India, as the second-largest onion producer worldwide, contributes significantly to this global output, generating export opportunities for farmers, with major destinations including Bangladesh, Malaysia, UAE, Sri Lanka, and Nepal (APEDA, 2023). The primary onion-producing countries globally encompass China, India, Egypt, the USA, Iran, and Turkey, with China leading in production.

In the Indian context, onions are a crucial foreign exchange earner and a staple in virtually every household. Recognizing the challenges posed by fluctuating onion prices and the demand-supply gap, the Indian government initiated "Operation Greens," a scheme mirroring the successful "Operation Flood," aimed at stabilizing tomato, onion, and potato prices. With a budget of Rs. 500 crores, this program strives to control prices, supply, and demand, providing support to both farmers and consumers.

However, the onion market faces inherent challenges due to seasonal production, leading to significant fluctuations in market arrivals and prices. This volatility not only affects farmers' income but also poses obstacles to overall agricultural development. High price fluctuations contribute to uncertainty for producers and consumers alike, rendering agricultural investments insecure. The need for efficient market functioning becomes evident, emphasizing the importance of market integration. Examining selected onion markets, positive trends were observed in both market arrivals and prices over time. Notably, the Bengaluru market exhibited the highest annual increase in onion arrivals, while Mumbai experienced the highest annual increase in prices. The seasonal impact on prices was evident, with higher arrival indices coinciding with peak harvesting seasons in most markets. Interestingly, a negative relationship between arrivals and prices was identified, indicating price declines during periods of heavy arrivals.

The analysis delved into market integration using the Johansen Co-integration test, revealing that all onion markets were well integrated. Focusing on infrastructure development, particularly road networks and communication facilities, could further enhance market integration. The Granger Causality test elucidated bidirectional price transmission relationships among most market combinations, emphasizing the role of quick absorption of price signals, good communication facilities, and transportation services in ensuring effective price transmission.

In conclusion, the research underscores the global significance of onion production, with India playing a pivotal role. To address market challenges and support both farmers and consumers, initiatives like "Operation Greens" are crucial. The study advocates for enhancing market integration through infrastructure development, thereby promoting stability in onion prices and fostering agricultural development.

To improve the situation, present study suggests the following policy implications.

1. **Seasonality in Onion Prices:** Aligning with sustainable agri-food systems, the emphasis is on reducing dependency on seasonal fluctuations. Developing early or late-maturing onion varieties, along with strengthening cold storage infrastructure, promotes year-round production and contributes to the resilience and sustainability of the agri-food system.
2. **Market Spatial Integration and Bidirectional Transmission:** The spatial integration of markets is essential for sustainable agri-food systems. The lack of bidirectional price transmission highlights inefficiencies. Policy interventions, such as the computerization of market intelligence and the establishment of an online marketing system, align with the transformation goal by enhancing market efficiency, transparency, and connectivity.
3. **Widely Accessible Market Price Information:** Transparency is a cornerstone of sustainable agri-food systems. Making market price information widely accessible through electronic and print media promotes transparency, empowers stakeholders with timely information, and contributes to the overall sustainability of the food supply chain.

4. **Reducing Vulnerability of Onion Growers:** Sustainable agri-food systems prioritize the well-being of all stakeholders. Policies aimed at enhancing market functioning and addressing the negative impacts of extreme volatility contribute to the resilience of onion growers. This aligns with the broader transformation goal of creating a more stable and equitable agri-food system.

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