MARKET INTEGRATION AND PRICE VOLATILTY OF ONION IN MAJOR MARKETS OF INDIA

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THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

Master of Science (Agriculture)

in

Agricultural Economics

Supervisor
Dr. O.P. Singh

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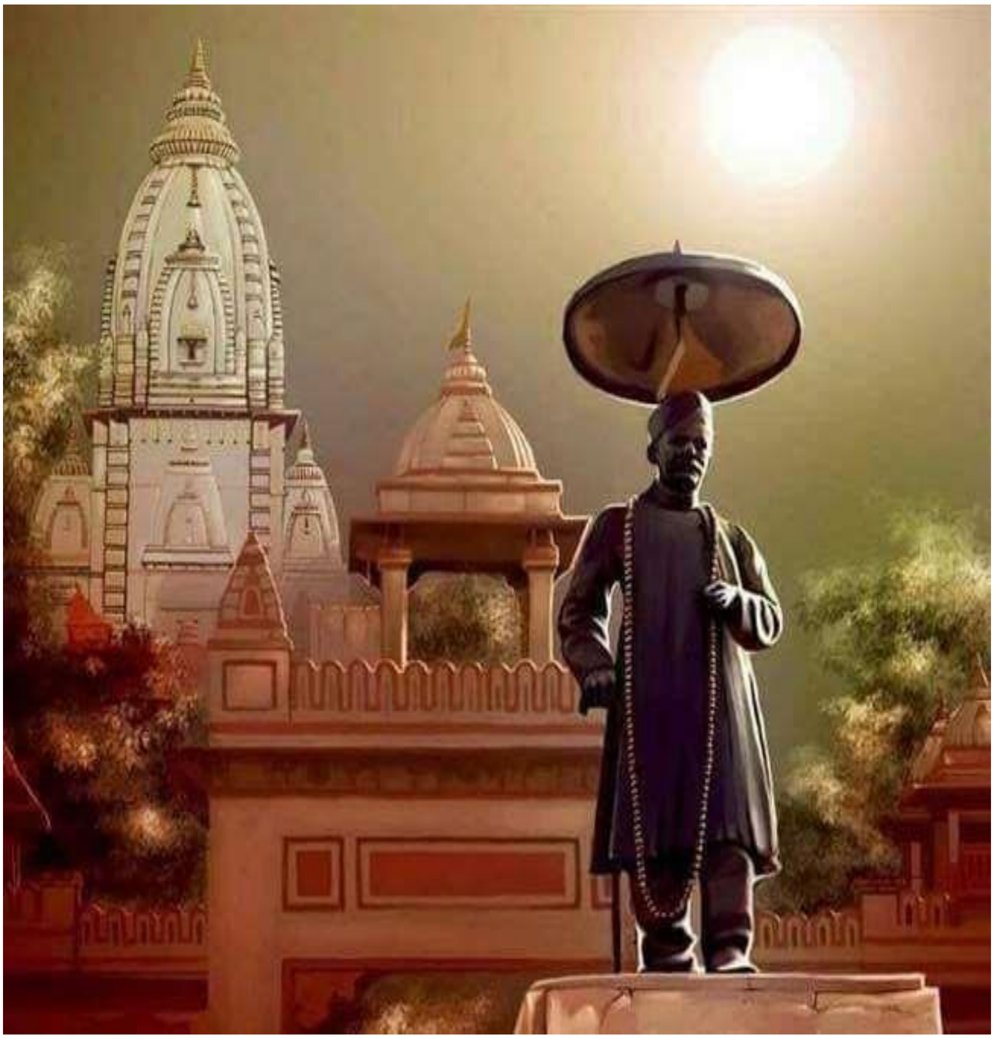

Dedicated to

My

Parents

Mr. AJJANNA B S

Ms. CHAITRA

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

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CERTIFICATE

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Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Market Integration and Price Volatility of Onion in Major Markets of India"** submitted by **Mr. Pavana B A, I.D. No. 19412AGE021**, in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture) in Agricultural Economics**, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that he has completed the requisite residential requirements as contained in the statute of the University.

I certify that the entire scheme of investigation presented herein was planned and carried out solely by the candidate under my guidance and supervision. The data presented in the thesis, to the best of my knowledge and belief, are genuine and original.

Thanking you,

Forwarded by yours faithfully

(Head of department) ***(Dr. O.P. Singh)***
Supervisor

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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 2006 to 2020. 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. To study the volatility Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was used. 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. The results of GARCH model confirms persistence of volatility in all the four markets.

Key Words: Johnsen's co-integration test, Granger causality test, Generalized Autoregressive Conditional Heteroscedasticity

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Date:

Place: Varanasi ***(Pavana B A)***

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Percentage
/	:	Per
ADF	:	Augmented Dickey Fuller
AIC	:	Akaike Information Criterion
AM	:	Arithmetic Mean
ANOVA	:	Analysis of Variance
APMCs	:	Agricultural Produce Marketing Committees
AR	:	Auto Regressive
ARCH	:	Autoregressive Conditional Heteroskedasticity
ARMA	:	Auto Regressive Moving Average
ARIMA	:	Auto Regressive Integrated Moving Average
BC	:	Before Christ
BHU	:	Banaras Hindu University
C-D-V Index	:	Cuddy Della Valle Index
CV	:	Coefficient of Variation
EGARC	:	Exponential Generalized Autoregressive Conditional Heteroskedasticity
e.g.	:	For example
et al.	:	And others
etc.	:	And so on

FAO	: Food and Agriculture Organization
Fig	: Figure
GARCH	: Generalized Autoregressive Conditional Heteroskedasticity
GDP	: Gross Domestic Product
i.e.	: That is
Max	: Maximum
Min	: Minimum
No.	: Number
qtls	: Quintals
R^2	: Coefficients of Multiple Determination
SD	: Standard Deviation
SIC	: Schwarz Information Criterion
viz	: Namely

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Introduction

Chapter I

INTRODUCTION

India's agriculture industry employs about 48 percent of the workforce and generates 19.9 percent of GDP. It provides raw materials to a diverse range of industries. The agriculture sector has seen considerable growth in terms of production value over the years. Despite this impressive success, the nation has not been able to change the economic condition of farmers. This is largely attributed to shortcomings in the agricultural marketing system, such as a lack of market facilities, logistics, scientific storage, competitive market conditions, grading and so on. As a result, the producers are unable to achieve fair price in the market.

Marketing is essential for economic growth and development because it stimulates production, reduces production costs, and prevents excessive fluctuations in output and prices. However, in order to achieve these advantages, the marketing system and infrastructure must keep up with production technology and the country's socioeconomic development.

Agricultural marketing is important for moving commodities from the producers to the consumers and for keeping prices stable. The expected growth in agricultural production must be synchronized with changes in agricultural commodities' demand and supply, as well as marketing. This would only be fruitful if the producer's share of the consumer's rupee increases substantially, regardless of the amount of marketable surplus generated by the farmers. As a result, marketing is considered as an important input in modern agriculture, alongside better seed and fertilizer.

In 2020-21, India's total horticulture area was 27.17 million hectares, with a total production of 326.58 million tonnes (Anonymous, 2021). Vegetables are vital part of our everyday diet and the demand is brimming with them. Vegetables are inherently have anti-cancer, anti-diabetic and anti-heart disease elements. Almost all of the vegetables are low in fat and calories, have no cholesterol, and are rich in nutrients. Vegetables contain a high volume of fibre, which helps to maintain the digestive tract balanced and reduce constipation. Vegetables contain a variety of vitamins and other nutrients that the body needs. Vegetables also contain essential amino acids, which are required by the body for survival. Potato, carrot, onion, brinjal, cabbage, cauliflower, peas and okra are the main vegetable crops grown in India, which account for 11.2 percent of global vegetable production (FAOSTAT, 2020)

About Onion

The onion (Alleum cepa L.) is a member of the Amaryllidaceae family. When grown for bulb production, it behaves as an annual, but when grown for seed production, it behaves as a biennial. It has bisexual flowers that are heavily pollinated. Shallow adventitious fibrous roots, a bulb and tabular leaves characterize this plant. In the second year of the plant's development, the stem grows to a height of 100-200 cm. The umbel-like inflorescence grows from a ring-like apical meristem.

Onion is India's third most popular vegetable crop, after potato and tomato, and it is widely consumed throughout the year by all households. It is available throughout the year in India and can be grown in a wide range of agro-climatic conditions. The green leaves, as well as the immature and mature bulbs are eaten raw or used in vegetable preparation. Onions are used in soups, sauces, and other foods to add flavour. Onion bulbs are high in phosphorus, calcium, and carbohydrates. A volatile oil called allyl-propyl disulphide gives onions their pungent flavour. Onions' red colour comes from anthocyanin, while their yellow colour comes from quercetin. Raw onions are very low in calories, containing just 40 calories per 100 gram. They comprise 89 percent water, 9 percent carbohydrate and 1.7 percent fibre by fresh weight, with trace amounts of protein and fat. Onions are rich in vitamin C, folate (B9), vitamin B6, and potassium, all of which have health benefits. In Indian cooking, onions are one of the most important and widely used ingredients. As a result, price increase have a major effect on food security, farmer health and consumer welfare. The customer is affected by a rise in food consumption expenditure, while the producer is affected by a fall in onion prices below the cost of cultivation. There is sufficient evidence to suggest that agricultural commodity prices are more unpredictable than non-farm commodity prices. Onion is grown in India during two season’s i.e Kharif and Rabi. In India, both red and white onion varieties are cultivated.

According to the *Charaka Samhita*, a common early medical treatise, onions have been grown in India since ancient times (6 B.C.) onions were also used by Greeks and Romans (Mehta, 2017). After the Romans brought the onion to Europe, it quickly became a common crop. The onion has slowly reclaimed credibility over the years, amid long-standing social and religious taboos. Today, onions play an important role in our diet. The onion is a well-known horticultural crop that is cultivated for its culinary and medicinal properties all over the world.

The onion is one of the oldest crops used in medicine and has a wide variety of medicinal properties. Snake and scorpion wounds are treated with onion extracts. The onion has diuretic, anti-inflammatory, expectorant, anti-asthmatic and tonic properties. It is well known for its ability to reduce blood sugar and fat levels. The packaging industry uses dehydration in the form of onion flakes and powder, which are in high demand on the global market, to a lesser extent. Onions are thought to decrease blood pressure and improve blood supply owing to the pressure of a lower amount of allicin.

Global scenario

Onion is cultivated all over the world. In 2019, onions were grown on 5.19 million hectares of global crop land, yielding 99.96 metric tonnes of onion with an average productivity of 19.25 quintals per hectare. India's vast production base creates immense export opportunities. Bangladesh, Malaysia, UAE, Sri Lanka and Nepal are the major importing countries of Onion from India. China, India, Egypt, the United States of America, Iran, and Turkey are the world's major onion producers. China is the world's top onion producer. India is the world's second-largest onion producer (FAOSTAT, 2020).

Indian scenario

India is the world's second-largest onion grower and consumer with 26.2 percent of overall acreage and 22.8 percent of global production in 2020 (FAOSTAT, 2020). Onion production in India was 26.29 million tonnes, covering 15.95 lakh hectares (Anonymous, 2021). Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, and Gujarat are the major onion-growing states in India (Monthly Report Onion, GOI, 2020).

Table 1.1 State-wise Onion production in India

STATE/UTs	Five year Average (2014-15 to 2018-19)		2018-19		2019-20	
	Production	Percent Share	Production	Percent Share	Production	Percent Share
Maharashtra	7105.23	32.78	8047.00	35.26	11363.00	43.31
Madhya Pradesh	3356.93	15.49	3672.00	16.09	4082.90	15.20
Karnataka	2903.42	13.40	2558.00	11.21	2275.00	8.47
Rajasthan	1107.84	5.11	997.26	4.37	1557.00	5.80
Gujarat	1085.96	5.01	1111.09	4.87	1243.00	4.63
Bihar	1259.13	5.81	1311.45	5.75	1313.16	4.89
Andhra Pradesh	854.76	3.94	980.66	4.30	980.61	3.65
Haryana	702.12	3.24	780.15	3.43	609.65	2.27
Uttar Pradesh	428.67	1.98	440.38	1.93	454.03	1.69
Tamil Nadu	398.68	1.84	301.00	1.32	434.58	1.62
Telangana	376.95	1.74	309.29	1.36	163.34	0.61
total of above states	19579.69	90.34	20508.29	89.87	24476.27	91.14
other states	2093.91	9.66	2311.14	10.13	2379.66	8.86
ALL INDIA	**21673.60**	**100.00**	**22819.43**	**100.00**	**26855.93**	**100.00**

Source: State directorate of horticulture, 2020

Market integration can be calculated in terms of the intensity and speed at which prices are transmitted between markets in different parts of the world (Ghafoor *et al*., 2009). Consumers and suppliers can prosper to varying degrees depending on how domestic markets are combined with global markets and how different regional markets are integrated with one another. Despite the geographical dispersion of regional economies, prices across various trading centres inside and across states have demonstrated long-run spatial linkages, meaning that all trade locations are interconnected and that prices provide important market signals. However, there are regional differences in the degree of market integration, which may be attributed to regional differences in infrastructure and institutional structure of agricultural markets. Examining the spatial integration of the country's main onion markets is crucial, as the findings would have direct consequences for agricultural price policy. As a result, the following basic objectives were set for the current study to analyse the behaviour of onion prices and arrivals, the co-integration of national and regional onion markets and the price volatility of onion markets.

Justification of study

The onion is one of India's most widely used vegetables, and it is a staple item consumed in virtually every home almost every day in a variety of culinary preparations as well as raw. Though vegetable demand is generally elastic in nature, onion demand in India is extremely inelastic due to consumption patterns. They are cultivated seasonally, but they are in great demand all year, resulting in price volatility. Despite their high production costs, their prices are constantly fluctuating in a vicious cycle

Hence, the current research aims to evaluate the seasonality, trend and variability of market arrival and price of onion in major markets, as well as the amount of co-integration and price transmission among themselves. The research also looks at the price volatility of onion markets.

Objectives

The specific objectives of the present study were:

1. To analyse 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; and
3. To analyse the price volatility of onion markets.

Hypotheses

1. In the study region, there is a growing trend in the arrival and prices of onion.
2. Onion markets are better integrated.
3. There is a persistent volatility in the prices of onion.

Presentation of study

The entire research study is presented in five chapters. Chapter first devoted for the introduction in which area and production of onion in India and world was discussed. The importance of onion consumption, specific objectives of the study and hypothesis are discussed. The reviews of relevant research studies related to the objectives are covered and it was presented in second chapter i.e. review of literature. The third chapter covers the research methodology in which the key characteristics of the research field and the study description are discussed. The essence and origins of relevant data, as well as the statistical tools and techniques used in the analysis to evaluate the objectives have been discussed. Chapter four devoted to the findings of the data analysis through a variety of tables in which pertinent information have been compressed and summarized under relevant headings and described in the tables. The discussion on results are also presented in this chapter. The summary of the study's key findings as well as the policy consequences that arose from the study's findings are presented in the fifth chapter.

Limitations of the study

The current investigation has been limited to the collection of sample size and variables due to a lack of time and other resources. As a result, the findings have to be interpreted in the sense of the study area's circumstances and cannot be extended to a broader geographical area. However, in order to conduct the analysis as objectively as possible systematic protocols were used.

Review of literature

Chapter II

REVIEW OF LITERATURE

A variety of studies have been performed in the past on this subject, which include current information, substantive observations and theoretical and methodological contributions to a specific topic. The scope and evidence for further claims and research modification are provided by a literature review, which aids in a clearer understanding of the research issues. It helps to generate the most accurate result by providing a reliable method of integrating the results. The current chapter addresses previous research, including their context, methodological approach and analytical methods, as well as the results they obtained, which assist in framing the current study. This chapter consist of reviews of literature in following headings.

1. Studies on trend, seasonality and variability in arrivals and prices.
2. Studies on market integration and price transmission among them.
3. Studies on price volatility.

2.1 Studies on trend, seasonality and variability in arrivals and prices

Agarwal and Dhaka (1998) investigated the relationship between spices arrivals and prices In Rajasthan. The study found that when the first lots of new chillies arrived in the market, arrivals of chillies were higher in February and prices of dry chillies were also higher in February. Prices peaked in September, when arrivals were at an all-time low. Seasonality was also revealed by the trend of cumin and coriander seed deliveries on the market. The correlation coefficient analysis revealed a negative and important association between arrivals and prices in subsequent months, implying that price influenced arrivals more in subsequent months than corresponding month.

Mitrannavar and Gummagolmath (1998) looked at the seasonal indices of potato arrivals and prices in north Karnataka's regulated markets. The three-year moving average approach was used to investigate long-term patterns in potato arrivals and prices in the Belgaum and Hubli markets. In both markets, arrivals were highest in November, suggesting a surplus during harvesting season, according to the study. However, prices did not fall during the glut season because the majority of traders in the Belgaum market bought potatoes at that time, while there was a negative relationship between arrivals and prices in the Hubli market.

Mundinamani *et al.* (1999) looked at trends and seasonality in groundnut market arrivals and prices in three Karnataka districts from 1965 to 1991. The trends as well as seasonal movements of arrivals and prices were investigated using orthogonal regression analysis and seasonal indices in this research. The trend and monthly seasonal indices for arrivals in all of the markets studied suggested a persistent upward shift and higher monthly seasonal indices immediately after harvest. It was determined that the crop was primarily grown under rain-fed conditions in the hinterlands of some markets, resulting in large variations in arrivals and prices.

Mehta and Shrivastava (2000) looked at the seasonality of groundnut and maize prices from 1984 to 1999. The price of maize had a linear trend, according to the findings. The price oscillatory movements were normal in terms of time and amplitude. There was a 12-month seasonality of crop production. The seasonality index ranged from 5.0 to 5.9, indicating that supply and demand were almost evenly distributed during the year. The sharp price drop after September corresponded to the crop reaching maturity three months after sowing. In the case of groundnut, the results revealed a moderately growing pattern, with non-uniform cycle and amplitude periodic variations.

Singh *et al.* (2000) used a linear equation and a moving average to look at the pattern as well as seasonal variations in rape seed and mustard arrivals and prices in Haryana. The results showed that from 1985-86 to 1995-96, there was a general trend of increasing prices, although the arrival indicated greater fluctuations from year to year in all markets. At peak season, more than half of all arrivals arrived in the market.

Nadaf (2002) investigated the behaviour of maize prices and arrivals in the Belgaum district in general and in Gokak (1985-2001), Ramdurga (1987-2001), and Soundatti markets (1986-2001) in particular. The results showed that arrivals in Gokak were higher from December to March, and in Ramdurga and Soundatti markets from November to February. Gokak market had the lowest arrivals from August to November, while Ramdurga and Soudatti markets had the lowest arrivals in April and June. The highest prices were seen in the months of May to September, while the remaining months saw a modest price in the Gokak market. In Ramdurga market, increased price was seen during April to September while prices in the Soundatti market peaked during June to October.

Wadhwani and Bhogal (2003) studied the cauliflower and cabbage prices in western Uttar Pradesh from 1988 to 1997. According to the results the price of the two vegetables peaked in September and then began to decline from October onwards. From the month of May onwards, the price has been rising. In the month of March, the price was the lowest. The two vegetables had a negative relationship in terms of price and arrivals.

Kumar *et al.* (2005) investigated the variability pattern of market arrivals and prices of selected vegetable crops in four metropolitan markets (Delhi, Mumbai, Bangalore and Kolkata) for the period from 1990 to 2001. The findings revealed that the degree of variation in cabbage arrivals was lower in Bangalore and higher in Mumbai. In Mumbai, prices were relatively stable, but in Bangalore, they were more volatile. The variability in market arrivals in the case of cauliflower was more pronounced in Kolkata than in the other markets. In all four markets, the degree of variability in tomato market arrivals across months was extremely high. While the prices of peas varied the most in the Delhi market, they varied significantly less in the Bangalore market.

Godara and Bhonde (2006) looked at the arrivals and prices of a variety of major fruits at the Agriculture Produce Market Committee in Azadpur for three years, from 2003-04 to 2005-06. The seasonal index was used to calculate the movement of arrivals and price. According to the results, the prices of all fruits rose as the number of new arrivals in the market decreased. Arrivals of most fruits were higher in the peak season of crop and lower in the lean season.

Khunt *et al.* (2006) looked at potato seasonal indices in Ahmadabad from 1981 to 2000. According to the results, the month of March has the highest index of market arrivals. The potato price index was lowest in March, when the subsequent arrivals were highest. From January to May, the price index was below average (100), and from June to December, it was above average.

Asmatoddin *et al.* (2009) investigated arrivals and price behaviour in the APMC market Parbhani district over a nine-year period, gathering monthly data from 1996-97 to 2004-05 in order to assess price index variations for essential oilseed crops. More than 90percent of the cumulative arrivals in the soybean crop at the Parbhani market occurred in October and December, according to the findings. July was the month with the highest price index (115.46 percent). The arrival index for sunflowers was highest in May and June, and the price index for May and June was higher than the other months.

Meena *et al*. (2011) studied the price behaviour and market integration of rapeseed mustard In Rajasthan. Market arrivals and price details for rapeseed mustard were collected for the years 1991-92 to 2007-08. The trend in arrivals and price for rapeseed mustard in the selected markets were studied using linear trend analysis, which showed an identical pattern. The price correlation coefficients between selected markets were found to be between 0.946 and 0.997, showing that the markets are highly integrated.

Pandian *et al*. (2011) examined the trend, seasonal, and spatial fluctuations in wholesale egg prices in the Hyderabad market from August 2000 to July 2009. According to the findings, the wholesale egg price increased by four to five paise per month. Between the months of March and April, the monthly egg price index was at its lowest, then continued to grow, peaked in June. It then began to decline, reaching its lowest point during the months of August and September. In the months of November to January, the monthly price index was found to be higher.

Changule *et al.* (2012) investigated sunflower market arrivals and price behaviour in Maharashtra's Latur district in 2010-11. The highest market arrivals index was 297.05 percent in January and the lowest was 16.02 percent in September, according to the results. In the month of October, the price index reached its highest point of 93.58 percent.

Salam *et al.* (2012) investigated the scale of seasonal price fluctuations and spatial price interactions of major cereal crops such as boro paddy and wheat in various Bangladesh markets. It was discovered that prices fluctuated in various months of the year while calculating seasonal price fluctuations of selected crops. For boro paddy, the difference between peak and trough prices was greater than for wheat. The coefficient of difference for boro paddy was also higher than for wheat. The empirical assessment of geographic price linkage using the Engle-Granger co-integration approach revealed that selected regional markets in Bangladesh were well integrated. It was determined that information about price changes was delivered thoroughly and instantly to other Bangladesh markets.

Kakde *et al.* (2013) investigated the seasonal variation of arrivals and prices of selected pulses in all APMCs of Akola district, namely Akola, Akot, Balapur, and Telhara From 1987 to 2006. In all of the selected markets, maximum prices indices were obtained in the pre-harvest months of April, May, and June, and minimum prices indices were obtained in the post-harvest months of September, October, November, and December. In all of the sample markets, monthly seasonal indices for selected pulses arrivals were higher immediately after harvest, while price indices for selected crops were lower during peak arrival months and vice versa.

Singh *et al.* (2013) investigated the seasonality of rapeseed and mustard prices and arrivals in Rajasthan's Bharatpur district. They discovered that higher arrival indices are reported in the months of March to May, and lower indices are recorded in the months of June to February. Farmers immediately sold rapeseed and mustard after harvest, resulting in a surplus of rapeseed and mustard on the market from March to May. The price indexes and the arrival indices had an inverse relationship.

Naidu (2014) studied the behaviour of market arrivals and cotton prices in Warangal, Andhra Pradesh. According to the study, market arrivals were low in September and high in November, while prices were low in November and high in September. Arrival and price cyclical indexes were closer to one, but a well-defined cycle could not be detected. Except for the year 2010-11, the correlation coefficient between monthly arrivals and prices was high. The highest and lowest predicted prices were observed in September and October, respectively, while the highest and lowest predicted arrivals were observed in November and September, respectively.

Govardhana *et al.* (2014) looked at the patterns and seasonal fluctuations in rice market prices in Andhra Pradesh's Guntur district and the state as a whole. The seasonal indices were created using a 12 months moving average system. The annual average wholesale price patterns of rice from 1990-91 to 2009-10 have seen a substantial rise over the years in both the Andhra Pradesh and Guntur markets, according to the findings. The annual rise in wholesale rice prices in Andhra Pradesh was Rs. 44.53 per quintal, while it was Rs. 49.38 per quintal in the Guntur market. In Andhra Pradesh and Guntur district, the month-wise seasonal index was lowest in April-May and highest in September and October, respectively. Thus, the farmers may have received a better price by postponing the selling of their produce from January to June to later in the year.

Kumar *et al*. (2016) found that direct marketing of onions was the most profitable of all marketing channels in the state of Haryana. Since there were no intermediaries between the manufacturer and the final buyer, this was the case. Onion marketing was found to be extremely seasonal in nature. Prices and arrivals, on the other hand, moved in opposite directions. The arrival indexes were at their peak in May and June. Because of inadequate storage facilities and urgent cash requirements, the majority of farmers sold their produce immediately after harvest, resulting in onion growers receiving the lowest prices for their produce. As a result of the study, it was recommended that the producer be supported with sufficient scientific storage facilities in order to distribute the sale over the year with minimal quantitative and qualitative losses.

Sudhakarrao *et al.* (2016) used monthly time series data for sixteen major markets from eight districts in Marathwada region of Maharashtra for a total of twenty years, from 1991-92 to 2009-10, to study the arrivals and price fluctuations in oilseed crops over time in soya bean and safflower. The findings revealed that peak soybean and safflower arrivals occurred in October to December and March to May, respectively. Soybean and safflower price indexes reached their peak levels in December and June, with coefficients of variation of 29 percent and 19 percent, respectively. In the Latur market, there were the most arrivals and the highest prices for soybeans.

Singh *et al*. (2017) studied the arrival of potatoes on the market and their price behaviour in the Uttar Pradesh district of Agra. The research reveals that market arrival and prices have an opposite relationship. They analysed the variation in potato arrivals and prices from 2006 to 2015 and found that the year 2013 had the highest retail arrival and the year 2006 had the lowest. During January, February, and March, the monthly variability measurement revealed a major association between prices and arrivals. The highest mean market arrival was in January and the lowest in October, although the highest mean market price was in November and the lowest in February, with the largest price variation in October.

Ali *et al.* (2018) investigated the prices and arrivals of apple fruit in Jammu's Narwal market according to the study, both prices and arrivals of apples in Narwal market showed positive patterns. The highest market arrival was in October and the lowest in April, although the highest price was in April and the lowest in August. August to January is the major season for the entry of local and non-local apples in the market from other regions and states.

Chaudhary *et al.* (2019) conducted a study on the behaviour of market arrivals and prices of selected vegetables (cauliflower, radish, tomato, and potato) in Himachal Pradesh's Baijnath market, and found that monthly arrivals of cauliflower, radish, tomato and potato increased significantly over time. Over the time span under scrutiny, the monthly prices of all vegetables increased significantly. In tomato, the minimal variability in market arrival of around 16percent was caught. For tomato, there was also minimal variation in price. The introduction of vegetables in the market has a huge effect on their prices. Both vegetable arrivals and prices were inversely related to one another.

Saha. (2020) investigate the trends in potato arrival and price in four major Indian markets, as well as the CAGR, seasonality, and variability associated with them. Secondary data was gathered from www.agmarknet.gov.in for this study. The data was collected from March 2009 to March 2019 and used to conduct the analysis. The linear trend in arrivals and nominal prices was positive across the markets, but it was negative for real prices, with the exception of Bangalore (5.50/q per annum). In most months, the CAGR for arrival in all four markets was positive, while the CAGR for real prices was negative. The main season for potato arrival in various markets was December to March, and the price index was highest during this time. The market in Agra has the most arrival variability, while the market in Azadpur has the most price variability.

2.2 Studies on market integration and price transmission among them.

Nasurudeen and Subramaian (1995) investigated the nature of price integration in the Mumbai market for oils and oilseeds. The findings revealed that the assumption of total oil price integration could not be embraced in its entirety. With the exception of castor oil, most price integration was bidirectional. It was also known that the price of groundnut oil has an impact on the price of all edible oils. Vertical integration confirmed the hypothesis that price increases in oilseeds were related to price changes in their oil and cake. In comparison to horizontal integration in oil prices, vertical integration in oilseed prices was even faster**.** By quickly adjusting to price changes, the Mumbai oilseed market demonstrated the characteristics of an ideal market.

Kar *et al*. (2004) studied market infrastructure and market integration for fruits. Data were obtained from different secondary sources. ADF test for unit root testing was carried out to analyze market integration and to develop the stationary pricing details of the different markets. The Co-integration worked out to identify economic relationship between markets. The lag price of the Bangalore and Calcutta Markets has been integrated into many markets, including Delhi and Mumbai. Similarly Delhi, Chennai and Mumbai apple prices were linked with lag price of Calcutta and Chandigarh. The price of Calcutta apples on the market was related to Delhi's lag prices.

Reddy *et al.* (2012) investigated the pricing pattern and integration of wholesale onion markets in metro cities and they noticed a rising trend in arrivals and prices over the study period. The majority of the markets were well integrated and the results showed that arrivals were not the only factor influencing prices; other variables such as varieties, appearance, moisture content, colour, and other characteristics of the given and other markets also influenced prices. The development of warehousing facilities at the primary market, as well as the availability of credit against warehouse receipt, helped to reduce fluctuations in arrivals and prices.

Reddy (2012) conducted research on chickpea market integration in North India. Monthly wholesale price data for chickpea for twelve markets were gathered from different publications of Agriculture, a journal published by the Ministry of Agriculture, Government of India, from 2003 to 2010. Just three of the twelve markets were co-integrated, suggesting a lack of integration in the Indian chickpea market. The price adjustment mechanism from short-term disequilibrium to long-run price equilibrium is very sluggish, according to the terms of the error correction model (ECM). Overall, the study discovered signs of poor co-integration in the North Indian chickpea markets.

Sekhar (2012) analysed the status of agricultural market integration in India and found that commodity goods which are not subject to Interstate restrictions or regional movement restrictions such as gram, edible oils tend to be well integrated than commodities facing such restrictions of movement as Rice. There is good integration between states and regions of rice markets but there is less interregional and international integration, but both domestically and internationally well-integrated markets are gram, tea, coffee and edible oil. In a market other than rice, the dissipation time of the price shock is shorter. It takes some time to change the rice market.

Ajjan *et al.* (2013) investigated the integration of chickpea markets In India. Monthly modal prices of chickpea in the regional markets of Andhra Pradesh (Kurnool), Tamil Nadu (Udumalpet), Maharashtra (Akola), Rajasthan (Udaipur), Karnataka (Bidar), and Gujarat (Dhandhuka) were used to examine market integration. ADF, Johansen's Co-integration, and Pair-wise Granger Causality tests were performed for each market seasonal index. The findings indicated that there were price linkages between the markets, implying that chickpea markets in India are integrated.

Khatkar *et al.* (2013) studied the degree to which wholesale mustard prices in Haryana and Rajasthan were co-integrated. Johansen and Granger Causality tests were used in this analysis, and the speed of change of deviations in long run equilibrium in mustard markets was measured using the Vector Error Correction Model. The study relied on monthly wholesale price results. Out of the four markets studied, two were found to be integrated. The pairwise Granger Causality tests for Hisar and Sirsa markets were statistically significant, implying that markets exert mutual influence on one another. On the other hand, the Sri Ganganagar market had a one-way impact on the Rewari market. Based on the results of a price volatility survey, the Sirsa market was determined to be the leading market. In comparison to Hisar and Rewari markets, price volatility in mustard prices was comparatively higher in Sirsa.

Patil *et al*. (2013) used Agmarknet to collect data on monthly modal prices of arecanut from seven representative markets in Karnataka state to assess the existence of market integration in arecanut. The presence of market integration was tested using a co-integration and error correction model, and the study's findings showed that the arecanut markets in the state are integrated with a high rate of adjustment. As a result, it can be concluded that integrated arecanut markets have price transmission efficient.

Reddy and Reddy (2013) investigated the co-integration of groundnut pod, oil, and cake (Groundnut complex) wholesale prices in India's major markets. For the research, 11 markets for pods, 10 markets for oil, and 5 markets for cake were considered. Just 4 of the 11 groundnut pod and 10 groundnut oil wholesale markets were co-integrated, although only 2 of the groundnut cake markets were integrated. It was observed that information for groundnut oil and cakes was flown from major export/import centers like Mumbai and Chennai to producing centers, whereas market information for groundnut pods was flown from major production centers like Nandyal and Rajkot to terminal markets, implying that price discovery for oil and cakes takes place in terminal markets, whereas price discovery for pods takes place in production markets.

Sendhil *et al.* (2013) used Johansen's co-integration methodology to investigate the co-integration and price transmission between futures and spot market prices, finding a co-integrating relationship between chickpea, wheat, and maize futures and spot prices. There was no co-integration between two prices in the case of barley, indicating inefficiency in its trading, which was attributed to higher transaction costs. In terms of price transmission, the results for most food grain contracts showed efficiency in futures trading performance.

Beag and Singla (2014) studied market integration in five major apple wholesale markets Ahmadabad, Bangalore, Delhi, Hyderabad, and Kolkata. Long-run equilibrium was confirmed in the analysis. Delhi was discovered to be a price-setting market. With a bidirectional causal relationship with other markets, Hyderabad was found to be the most competitive. The study's main consequences included the development of a network of agricultural wholesale markets across the country that were almost equal distance apart in order to improve market integration and price transmission.

Shrestha *et al.* (2014) investigated the effects of tomato market price co-integration on Nepalese farmers. According to the report market co-integration is hampered by inadequate marketing resources, a shortage of facilities, entry hurdles and inefficient information services. Market integration has a favourable influence on market performance and competition. Both three markets had stationary price series and the Chitwang and Morang markets were well integrated with the Kathmandu market. The method of price change in the source market was much quicker than in other markets.

Sendhil *et al.* (2014) investigated onion price integration of spatially separated markets. The research used the co-integration test to see whether onion markets in India have a general linear deterministic pattern and if the rule of one price still holds true in light of recent price increases. The wholesale regular prices of major onion markets across the country from January 2010 to March 2011 were used as the study's source. The existence of unit root in the time series data was tested using the Augmented Dickey Fuller test statistic. This study's analytical findings showed the existence of a unit root and deep geographic convergence between major markets. The analysis also showed that in Indian onion markets, the rule of one price holds true.

Singh (2014) studied the extent of market integration in the onion and potato markets in South Gujarat. All of the chosen market pairs had a positive correlation co-efficient in monthly wholesale prices for potato and onion that was substantially different from zero. In these markets, the prices of onions and potatoes were associated with those of the corresponding market. The findings revealed that there was significant market integration among selected market pairs, owing to product movement from one market to another. The findings showed that market intelligence and coordination within markets required to be strengthened, as this would offer a stronger platform for directing the farmers in marketing the produce.

Timothy *et al.* (2014) conducted a study to see whether the sugar markets in the chosen areas were integrated or not. As a result, the objective of this paper is to see whether there is some integration among the sugar markets that have been chosen. From January 2008 to December 2012, secondary data on average monthly sugar prices was collected. The Co-integration model was used to interpret the data. The findings showed that road networks, communication networks, consumers purchasing power, and market distance all had a significant impact on market integration. The findings led to policy recommendations to improve sugar market integration in the research areas.

Darekar *et al*. (2015) performed a co-integration and causality study of several onion markets in Western Maharashtra and discovered that co-integration implies long-run price adherence. Pune and Pimpalgaon are the price-determining markets. Yeola was considered to be more effective than the others because it depicted the most bidirectional causal interactions with other markets. The study's main recommendation is that a network of agricultural wholesale markets be built around the region at approximately equal distances from one another to improve market integration and price transmission.

Burark *et al.* (2015) used Johansen's multivariate co-integration test to look at co-integration across four major wholesale soybean markets in Madhya Pradesh and Rajasthan from 2003 to 2014. It was found that all of the preferred markets were co-integrated. All of the selected markets, namely Baran, Kota, Ratlam, and Ujjain, were found to be co-integrated. The pairwise granger's causality test for chosen markets was significant at the 1percent level of significance, suggesting that the markets had a lot of reciprocal impact on each other. Infrastructure facilities and a market information system were proposed as ways to boost the marketing system's performance.

Wani *et al.* (2015) analysed the market integration and price forecasting for apples In India. The study found that having a reasonable understanding of potential prices can help producers make sound business decisions in order to maximize profits. Market integration and price forecasting aid in price stability by removing market imperfections and achieving market performance, as well as aiding in the selection of the most competitive and productive market. The selected five apple markets are deeply entangled and converge on a long-run equilibrium. The price forecasted varied by less than 10percent from actual market price, according to the results.

Kumar *et al.* (2016) A study of the spatial growth of wholesale potato markets in Uttarakhand found long-term integration, which may be attributed to the fact that potato production is more concentrated in mountains than other vegetables. They also observed that the greater the distance between two points, the lower the integration. Low integration was triggered by a lack of timely access to pricing information, a lack of sufficient transportation services, product features, and a large distance between markets. It has been noted that while potato markets in Uttarakhand are long-run integrated, short-run market integration is relatively limited. As a result, price data transmission in potato markets is sluggish, and price shifts in different areas are not responsive to each other.

Vasanthi *et al.* (2017) conducted a spatio-temporal market integration study for tomato in Karnataka, found that three of the four main markets, namely Mysore, Kolar, and Chintamani, were well integrated with a high degree of price correlation, with the exception of Bangalore. Kolar and Chintamani market had the fastest disequilibrium change (52 percent), led by Mysore and Chintamani market (49 percent). The presence of necessary market infrastructure in Mysore and Kolar markets, such as grading, scientific storage, banking facilities, good road connectivity, and boarding facilities for farmers, are the reasons for the quick adjustment.

Ahmed and Singhla (2017) investigated market integration and price transmission in some of India's major onion markets. The analysis found that, with the exception of Kozhikode, all wholesale market patterns were symmetrical, and that supply shock was the source of the sudden price rise. Both of the market pairs were found to be well integrated, indicating a long-term relationship in onion prices. Except for Mumbai and Kozhikode, price shocks in one market are easily spread to other markets, meaning that they are price followers. Overall, the study's findings indicate that regional onion markets are closely connected, reducing government interference.

Salmensuu (2017) used co-integration relations and Engle-Granger style error correction models (ECM) for the wholesale potato markets of three Indian regions. The chosen setting allows for examination of how these market areas vary in their return to the co-integrating link, in addition to the normal outcome of the presence of error correcting mechanisms in Indian potato markets. The northern area's slower return to equilibrium, 8.0–8.6 weeks compared to 5.0–6.3 weeks, set it apart from the other market relations studied. The findings could mean that the Delhi and Agra markets are major hotspots for speculators, with speculators manipulating potato prices further away from their normal price relation. Between the markets surveyed, short-run or same-week elasticity ranged from 0.12 to 0.34. Elasticity’s in the long run ranged from 0.55 to 1.11.

Vigila *et al*. (2017) conducted an economic study of co-integration of potato markets in Tamil Nadu, and they concluded that there is a bidirectional interaction between the Tamil Nadu and Gujarat potato markets, and that shifts in market price in one of them have a major effect on the other in the short term, but that in the long run, all the markets have reached equilibrium. It also showed that the percentage of the speed of change towards equilibrium in the Tamil Nadu market is very limited, and that the Gujarat market has a large effect on the Tamil Nadu markets.

Sharma A *et al.* (2021) used Johansen's Co-integration Test, Granger's Causality, and Impulse Response Function to investigate the degree of spatial market integration and price transmission across five major apple markets in the country, viz. Shimla, Chandigarh, Delhi, Bengaluru, and Mumbai. The findings of the study support the co-integration and interdependence of India's apple markets. Ganger's Causality Test was used to get more information on whether and in which direction price transmission occurs between market pairs, and it confirmed Shimla as the price determining market because it has causal relations with all of the selected markets. All of the selected markets responded well to a standard deviation shock given to any other market, according to the Impulse Response Function. The study's main implication is that the government should continue to improve market integration by effectively disseminating price and arrival data and developing communication channels within the markets.

2.3 Studies on price volatility.

Jordaan *et al.* (2007) investigated the price volatility of white maize, yellow maize, and sunflower seed and discovered that it varies over time, implying that the GARCH approach should be used in these cases. Wheat and soybean prices were found to have consistent volatility over time. The standard error of the ARIMA process, which was 0.01190 and 0.01657, respectively, is used to measure price volatility in wheat and soybeans.

Kuwornu *et al.* (2011) investigated that price volatility is required for the development of bidding strategies or negotiation skills in order to maximize profit. Over the period 1970 to 2006, the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) regression model was used to forecast food prices in Ghana. The data used was the Ghana Ministry of Food and Agriculture's monthly wholesale prices for maize, millet and rice. The empirical findings revealed that food prices are highly volatile, with prices steadily increasing over the study period. According to the results of the out-sample forecast, maize, millet and rice prices will rise by 23percent, 11percent and 10percent respectively, in the coming month.

Chaudhari and Tingre (2012) discovered pigeon pea price movement, including seasonal variation and price volatility, in major pigeon pea markets of India. The findings revealed that pigeonpea prices were higher in all selected markets during the months of June to August. Price volatility was high in the markets of Akola, Latur, and Thandur.

Burark *et al.* (2013) investigated the price volatility in domestic markets of coriander in Rajasthan during 2009-10 through GARCH model. The findings revealed that price volatility of coriander prices in the Baran market was higher than in the Kota and Ramganj markets.

Hemanth (2013) used ARCH-GARCH analysis to examine chickpea price series in various markets, i.e., Anupgarh, Bikaner, Hanumangarh, Padampur, Pilibanga, Sri Ganganagar and Sangaria. The sum of Alpha and Beta values indicated the presence of persistent fluctuation. The presence of persistent volatility in the market is implied by a value close to one. Because the total Alpha and Beta values were less than 0.34. The results confirmed that there was no volatility in chickpea prices in these markets.

Jharjhria *et al.* (2013) used time series data from 2008-09 to 2010-11 to investigate persistence and asymmetry in coriander prices using the GARCH model. The empirical findings revealed that coriander prices fluctuate over time and that there is evidence of long-term persistence and price volatility clustering.

Sendhil *et al*. (2013) looked at the efficiency of futures trading in wheat, chickpea, maize, and barley In terms of price volatility. The results of the GARCH model revealed that different models of different orders fit different crops. During 2009-10, the highest GARCH order was found for wheat (2, 1) and maize (2, 1). The sum of alpha and beta coefficients for the rest of the commodities, regardless of study period, were estimated to be closer to one, indicating that spot prices of selected food grains shows persistence volatility.

Jalikatti *et al*. (2014) attempted to forecast onion prices in the Bijapur district of Northern Karnataka. The study's time series data on monthly onion prices was gathered from the Bijapur APMC Market's registers from 1996-97 to 2010-11. The Autoregressive Integrated Moving Average (ARIMA) model forecast a price rise in 1998, 1999, 2010 and 2011. The year-to-year alternative decline in demand and the lack of sufficient storage facilities may be the causes of such a sharp price rise. In the coming years, the expected price values showed an upward trend.

Patil *et al*. (2014) used ARCH-GARCH analysis to determine whether price fluctuations in green gram prices existed in Akola, Latur, Amravati, and Jalgaon markets of Maharashtra. The sum of Alpha and Beta for Akola, Latur Amravati and Jalgaon markets, respectively, was not close to 1, i.e. 0.34, 0.35, 0.33, and 0.35, indicating that the volatility shocks were not quite persistent in these markets.

Sendhil *et al.* (2014) carried out a price volatility survey in agricultural products using the GARCH model. The study found that supply shocks were the primary cause of agricultural products price volatility. Future trading can be a way to mitigate price volatility in certain commodities, but not all. The supply and demand function elasticity coefficient, as well as the variances of these supply shocks, determine the magnitude of volatility. Low volatility was observed in the spot prices of cumin, chickpea and mustard right from the start of future trading. Low volatility in price time series was observed in corn, soybean, cotton seed, castor, palm oil, cumin, and chilli during a period of increasing overall price levels.

Bhardwaj *et al.* (2014) conducted an observational analysis of the ARIMA and GARCH models in Gram price forecasting, finding that the GARCH model had lower AIC and SIC values than the ARIMA model, as well as lower forecast errors. When data series contain volatility, the ARIMA model was found to perform poorly. The GARCH model performed well because it can capture volatility and there was little disparity between forecasted and actual prices. As a result, they came to the conclusion that GARCH is a superior model for volatile data than ARIMA.

Devi *et al*. (2015) used ARCH-GARCH analysis to analyze the price volatility of chill in India's major markets. Guntur, Khammam, Virudnagar, and Nagpur markets were purposefully chosen for the study. The secondary data on monthly modal prices (Rs/Qtl) was obtained from the respective market committees' records. From 1997 to 2011, chilli prices in the Guntur market showed wide variations, ranging from Rs.1000 in 1997 to Rs.8800 in 2011. In Virudnagar market, the price variation coefficient was 32.4 percent. Starting in 1997, the price behaviour of selected crops in Nagpur compared to Guntur and Virudnagar took on an entirely new dimension until 2000. Chilli prices in all markets showed consistent fluctuations over time, with the most pronounced fluctuations in the Nagpur market. Chilli prices fluctuated over time in all markets, with the most extreme fluctuations in the Nagpur market.

Lama *et al.* (2015) predicted price volatility in three price series, namely domestic and international edible oil price indices, and the international cotton price 'Cotlook A' index. The findings showed that both domestic and international edible oil price indices had high persistent volatility, with the sum of a and b close to one.

Rahaya (2015) studies the volatility analysis and volatility spillover analysis of Indonesia's coffee price using the ARCH/GARCH and EGARCH model found that GARCH (1,1) model indicated better results for coffee prices volatility. The results further revealed that the return price volatility of Indonesia's process coffee was high.

Solanki and Sharma (2016) used ARCH, GARCH, and EGARCH for predicting price volatility in cumin prices, and discovered that EGARCH forecasted price volatility better than ARCH model, and it also better than GARCH model in terms of modelling and price forecasting, since EGARCH allows for the testing of volatility in time series data and can also capture asymmetric volatility.

Shireesha *et al.* (2016) looked into the price volatility of turmeric in the country's major markets, as well as future prices. The price series of Duggirala ($\alpha+\beta=0.97$) and Nizamabad ($\alpha+\beta=0.93$) markets showed the presence of price fluctuations as indicated by the sum of Alpha and Beta coefficients that were closer to one, whereas the volatility shocks in the remaining markets (Kadapa, Sangli, and Erode) were not quite persistent. The sum of Alpha and Beta coefficients ($\alpha+\beta=0.98$) was found to be closer to one, indicating the persistence of volatility in futures prices.

Kumari *et al.* (2017) attempted to investigate the volatility of cotton prices in Telangana's major markets. To determine the volatility, an ARCH-GARCH analysis was performed. The results show that the sum of Alpha and Beta is not close to 1 in any of the selected markets. This clearly shows that volatility shocks in major cotton markets are not very persistent.

Solanki *et al.* (2017) used monthly data to investigate the efficiency of the ARIMA and GARCH models for mustard price forecasting. The study found that the EGARCH model forecasted uncertainty better than the ARIMA model, and that EGARCH was used in addition to the ARCH and GARCH models to catch the data's asymmetry pattern. In terms of modelling and forecasting, the EGARCH model has outperformed the other methods for the current data collection. Since the EGARCH model can detect asymmetric volatility, it is a better model for forecasting mustard prices.

Mallikarjuna *et al.* (2019) performed research to estimate the price of black pepper in one of Karnataka's key marketplaces, since the state ranks first in India for pepper production. The Gonikoppal market in Kodagu district was chosen with care since it has the state's greatest acreage and productivity. For the years 2008-09 to 2017-18, the Karnataka State Agricultural Marketing Board, Bangalore, and Karnataka state gathered monthly black pepper prices in Gonikoppal market. Software such as SPSS, Gretl, and EViews were used to apply time-series models such as ARIMA and ARCH to price data. The stationarity and volatility of the time-series were tested using the Augmented Dickey-Fuller test and the Heteroscedasticity Lagrange's Multiplier test, respectively. The best predicted model was selected using the lowest Akaike's Information Criterion (AIC) and Schwartz Bayesian Information Criterion (SBIC) values. However, the model's prediction power, performance, and quality were assessed using the Root Mean Square Error (RMSE) and Mean Absolute Prediction Error (MAPE) with the lowest error value (MAPE). The ARIMA model has a greater prediction accuracy than the ARCH family models among the evaluated models. The ARIMA (0, 1, 1) provides an excellent match for projecting the price of black pepper based on the findings.

Kaur (2021) examines the price volatility of staple agricultural commodities for households and services, using consumer price index monthly time-series data (2012 as a base year) from the RBI from January 2019 to December 2020, and analysis has been carried out using an econometric GARCH model, followed by stationarity tests, heteroscedasticity tests, and time autocorrelation tests. The results show that some items have significantly higher price volatility for the specified time period, as evidenced by the sum of coefficients estimated using Econometric model analysis.

Research Methodology

Chapter –III

REAEARCH METHODOLOGY

The methodological approach, i.e., the formal, theoretical, and empirical approaches to be used, is based on all types of research works to be evaluated qualitatively. It includes topics such as stages, analytical models, paradigms, quantitative and qualitative methods in general. It includes the tool that offers analytical support for understanding which procedures sets of methods or best practices to be used for a particular research. The present chapter includes the selection of crop period for which study is undertaken, the selection of market, nature and sources of data, the tools and technique used. It encompasses following sections *viz.*

3.1 Selection of vegetable

3.2 Selection of markets

3.3 Nature and source of data

3.4 Analytical tools and techniques employed

3.1 Selection of vegetable

Onion was purposively selected for present study because it is the major vegetable in terms of production and it is the most important vegetable in the Indian diet. Every household in India consumes onion in extensive manner. Onion shares 13.58percent of the total vegetable production according to the 1st advance estimates of Horticulture, 2020-21.

3.2 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, 2020). 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.

3.3 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 2006 to December 2020 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.

3.4 Analytical Tools and Techniques Employed

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

3.4.1.1 Linear trend

For computing linear trend, price and market arrival of the major markets of onion from the period January 2006 to December 2020 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

3.4.1.2 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.

3.4.1.2.1 Simple Averages method of Seasonal Index

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

I. Arrange the data by years and months

II. Compute the monthly averages for i^{th} month for all the years. (i^{th} month, i = 1,2,……12 represents Jan, Feb, …..Dec respectively)

III. Compute the average of monthly averages

IV. Seasonal indices are for different months are obtained by expressing monthly averages as percentage of $\overline{X}$

V. Thus, seasonal index for i^{th} month = $(\frac{Xi}{\overline{X}} \times 100)$; i = 1, 2, 3…12

3.4.1.3 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:

$$IX = CV \times \sqrt{1 - R^2}$$

Where,

IX = Instability index (in percent)

CV = coefficient of variation (in percent)

R^2 = Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom

3.4.1.3.1 Coefficient of Variation (CV)

The Coefficient of Variation is a statistical measure of the relative dispersion of the data points in a data series around the mean (Panse and Sukhatme, 1989). It can be calculated as:

$$CV = \left(\frac{Standard\ deviation}{Arithmetic\ mean}\right) \times 100$$

3.4.1.3.1 Arithmetic Mean (AM)

Arithmetic mean of a series of observations locates a central representative value around which the values of the series are distributed, hence it is a measure of central tendency (Panse and

Sukhatme, 1989). It can be calculated as the ratio of sum of observations and the number of observations:

$$\text{AM} = \frac{\text{Sum of observations}}{\text{Number of observations}}$$

3.4.1.3.2 Standard Deviation (SD)

Standard deviation of a series of observations tells how the observations deviate from its average value, and hence known as a measure of dispersion. It is used to find the confidence interval within which the value of a statistic lies (Panse and Sukhatme, 1989). It can be calculated as:

$$\text{SD} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Xi - \overline{X})^2}$$

Where

SD = Standard Deviation

n = Number of observations

Xi = each observation from the population

$\overline{X}$ = Population mean

3.4.2 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.

3.4.2.1 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

$\Delta Y_t = Y_t – Y_{t-1}$

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.

3.4.2.2 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 analyse 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:

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

Where,

Y_t= vector of price time series

ΔY_t = first order difference and matrix, $\Pi = \alpha\beta'$ 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.

3.4.2.3 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:

$$X_0 = \sum_{i=1}^{n} \alpha i\, Y0 - i + \sum_{j=1}^{n} \beta j\, Xo - j + \mu 10$$

$$Y_0 = \sum_{i=1}^{n} \lambda i\, Y0 - i + \sum_{j=1}^{n} \delta j\, Xo - j + \mu 20$$

Where,

μ_{10} & μ_{20} are error terms

t = time period

X_0 and Y_0 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.

3.4.3 Objective 3 -To analyse the price volatility of onion markets

In fact, instability in the prices of agricultural goods emerges from the supply shocks. Together with short-term demand and supply elasticity, these stresses result in severe market swings. Product markets typically show that market pricing knowledge, hedging, speculation, and product physical distribution are the key factors affecting price volatility. Increasing instability in primary agricultural commodity prices has made speculation commonplace in commodity markets, with serious implications for the volume of trade. This feature can justify utilizing information based processes to model the price volatility trend shown in certain commodities. In price time series several models capture variability. The present study make use of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to measure volatility levels in onion markets.

3.4.3.1 GARCH Model

In Auto Regressive Conditional Heteroscedasticity (ARCH) model, the conditional variance of the error term depends on the prior error term of different lags. But the problem with this model is that, at a greater lag the model consists of several parameters which complicates and lengthens the assessment. So, a more parsimonious model is therefore Generalized Auto

Regressive Conditional Heteroscedasticity (GARCH), where the conditional variance of the term of error term depends not only on the prior squared error but also on its conditional variance in the previous period. It is used to measure the extent of volatility in agricultural commodity prices.

GARCH (i, j) model as defined below:

$$h_t = a_0 + \sum_{i=1}^{q} ai\epsilon^2_{t-1} + \sum_{j=1}^{p} bjh_{t-j}$$

Here conditional variance h_t at time t depends not only on the squared error term in the previous time period but also on its conditional variance in the previous time period

The sum of (a_i+b_j) gives the degree of persistence of volatility in the price series. The closer the sum to one, the tendency for price volatility to persist for longer time is greater in the variable under consideration.

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

On the basis of the objectives of the study, the empirical findings have been divided into three categories. A thorough examination of the trend, seasonality, and variability in onion prices and arrivals in the major markets is presented in the first part. The second section examines the level of market integration and price transmission among key onion markets. Price volatility of onion in major markets presented in third section.

4.1 Objective 1 - To analyse 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. As previously stated that a number of variables contribute to the price instability of vegetables, with changes in market arrivals playing a significant influence. As a result, there's a need to figure out how pricing and market arrivals have changed over time.

An attempt has been made in this part to assess the trend, seasonal indices, and variability index of onion price and market arrival in their key markets over the years. For this purpose, daily price and market arrival data have been collected and we have monthly and annual data from the raw data.

4.1.1 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.

4.1.1.1 Linear trend in arrivals of onion in sample markets

The linear trend was used to calculate the long-run movement of market arrivals and prices of onion in the selected markets during the study period, and the results are shown in Table 4.1

and depicted in Figure 4.1 to 4.4. 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 4.1 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

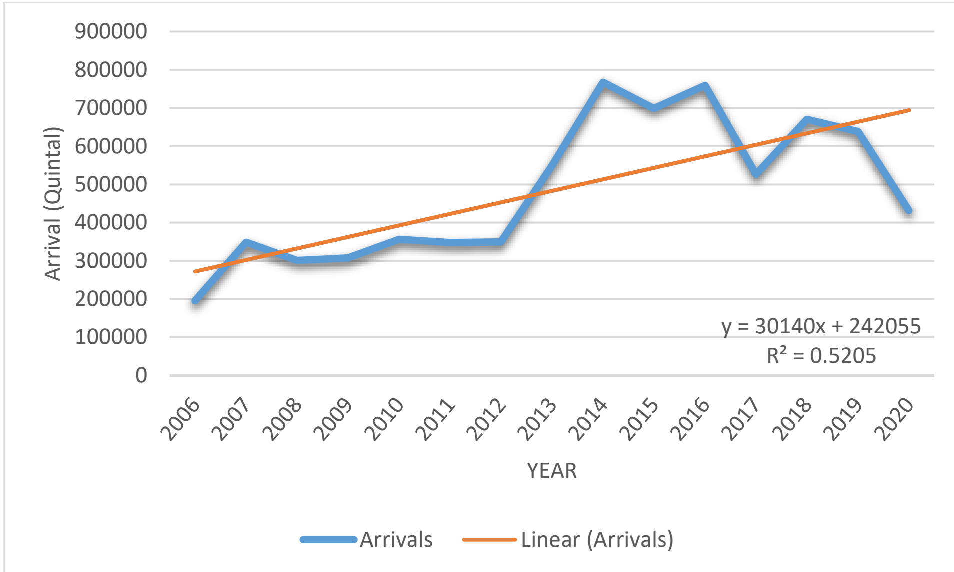


Fig 4.1 Linear trend in arrivals of Onion in Bengaluru market

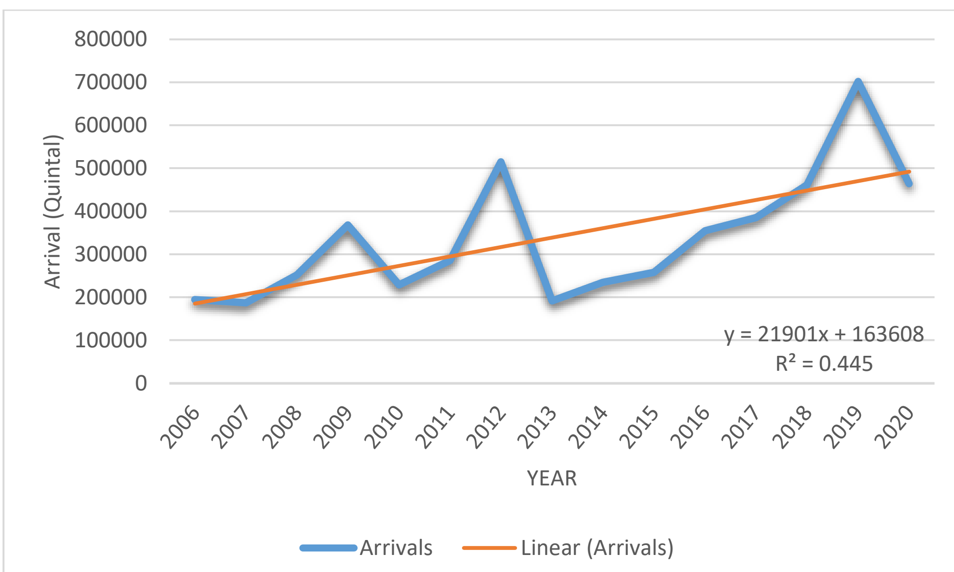


Fig 4.2 Linear trend in arrivals of Onion in Mumbai market

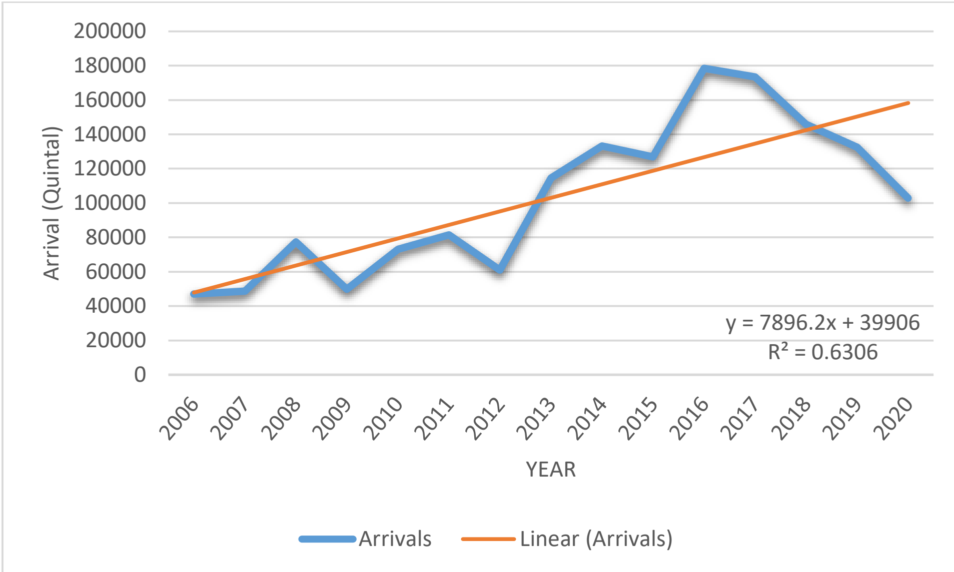


Fig 4.3 Linear trend in arrivals of Onion in Ahmedabad market

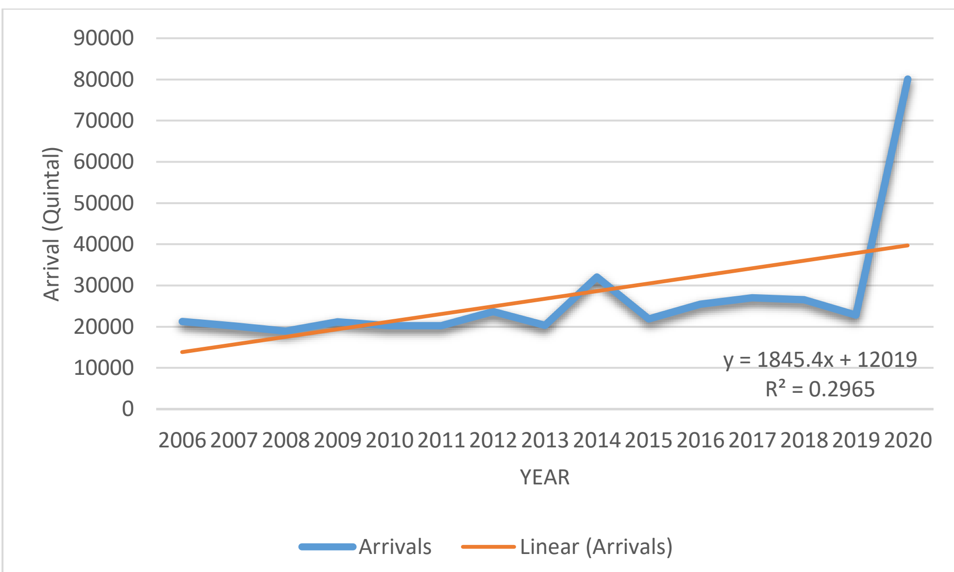


Fig 4.4 Linear trend in arrivals of Onion in Pune market

4.1.1.2 Linear trend in prices of Onion in sample markets

The linear trend for onion price in selected market is presented in the Table 4.2 and in Fig 4.5 to 4.8. 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 arrivals 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 4.2 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

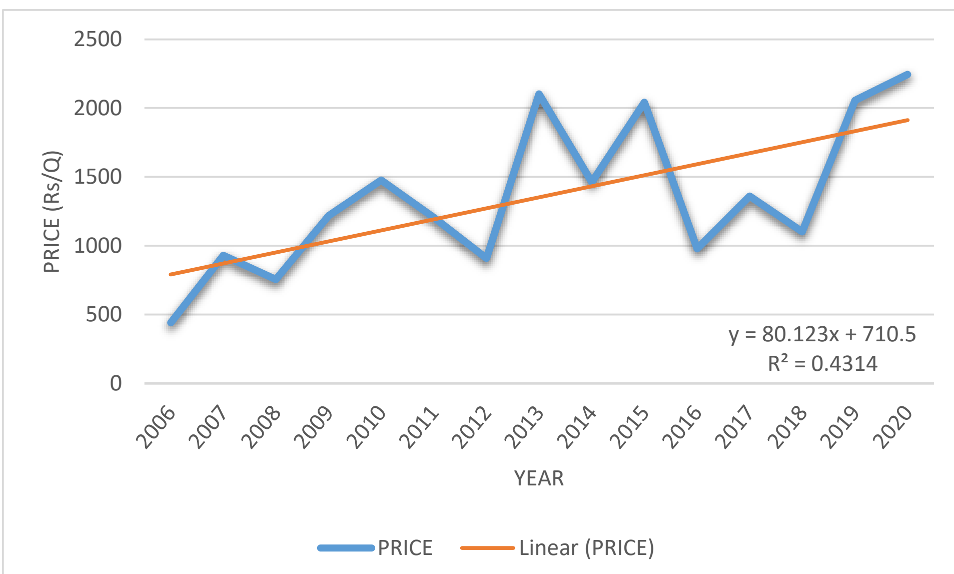


Fig 4.5 Linear trend in prices of Onion in Bengaluru market

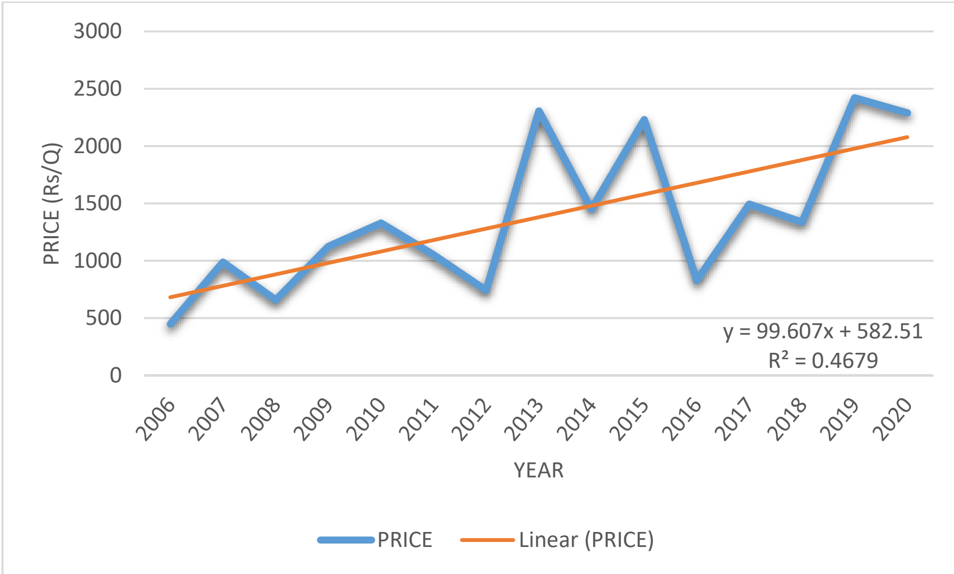


Fig 4.6 Linear trend in prices of Onion in Mumbai market

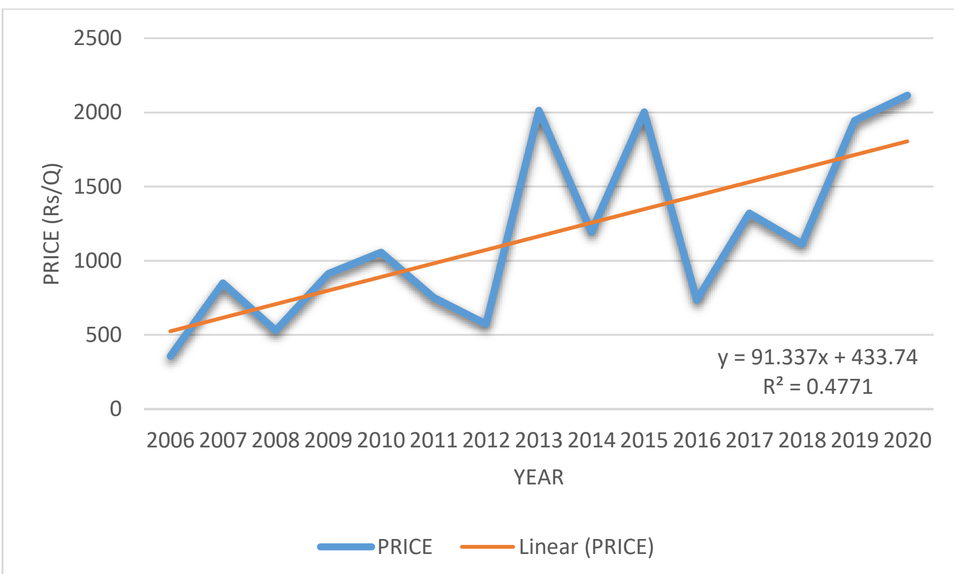


Fig 4.7 Linear trend in prices of Onion in Ahmedabad market

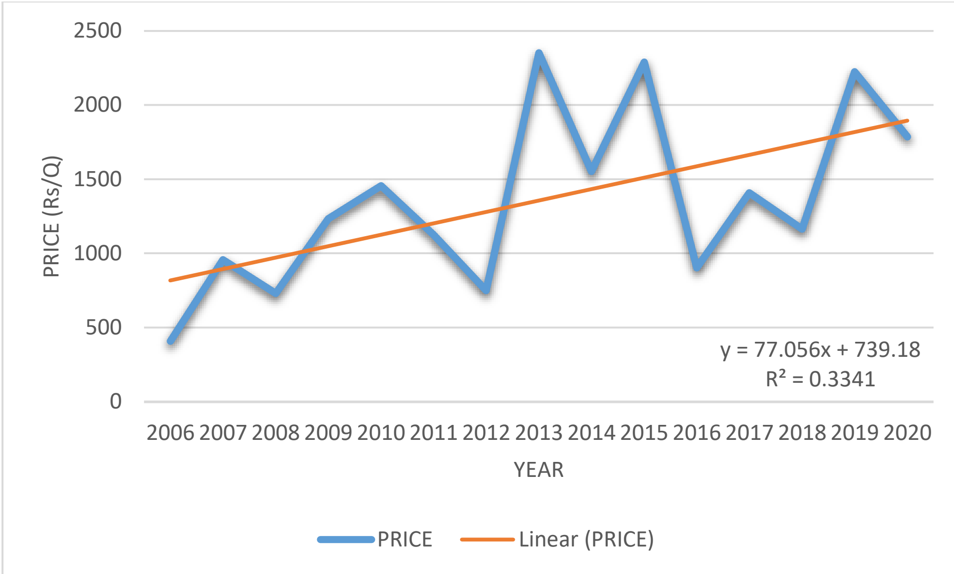


Fig 4.8 Linear trend in prices of Onion in Pune market

4.1.2 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 a year-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 has 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 2006 - December 2020. 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.

4.1.2.1 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 4.3 and depicted in Figure 4.9 to 4.12. 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 was 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 shows 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). The arrivals in the Pune market is increasing from the month of December to March, the seasonal indices are more than 100 during these months. 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 4.3 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

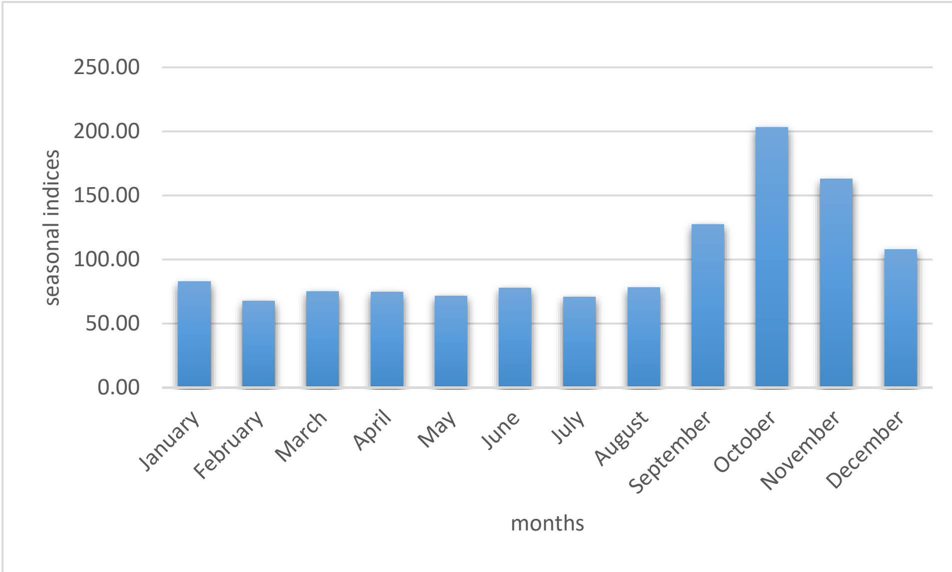


Fig 4.9 Seasonal indices of arrivals of Onion in Bengaluru market

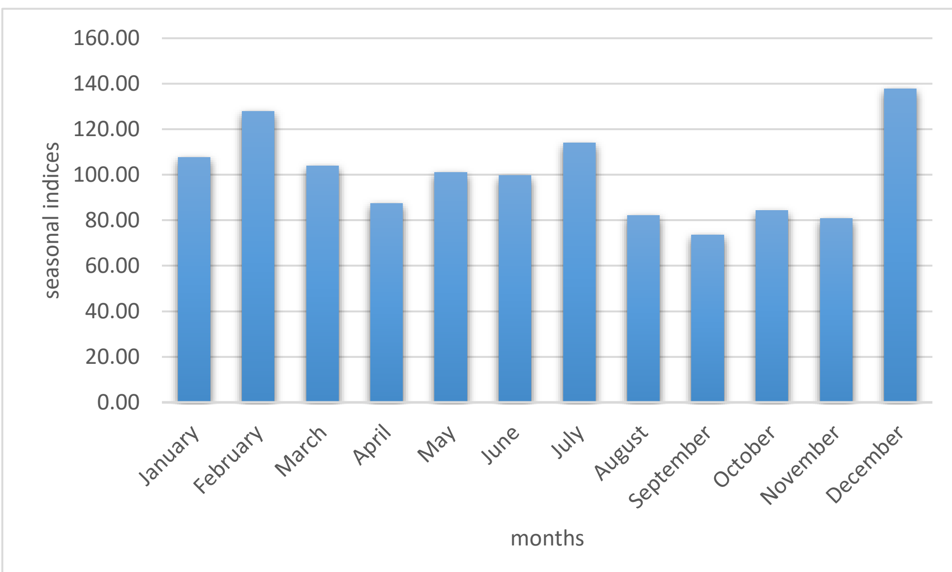


Fig 4.10 Seasonal indices of arrivals of Onion in Mumbai market

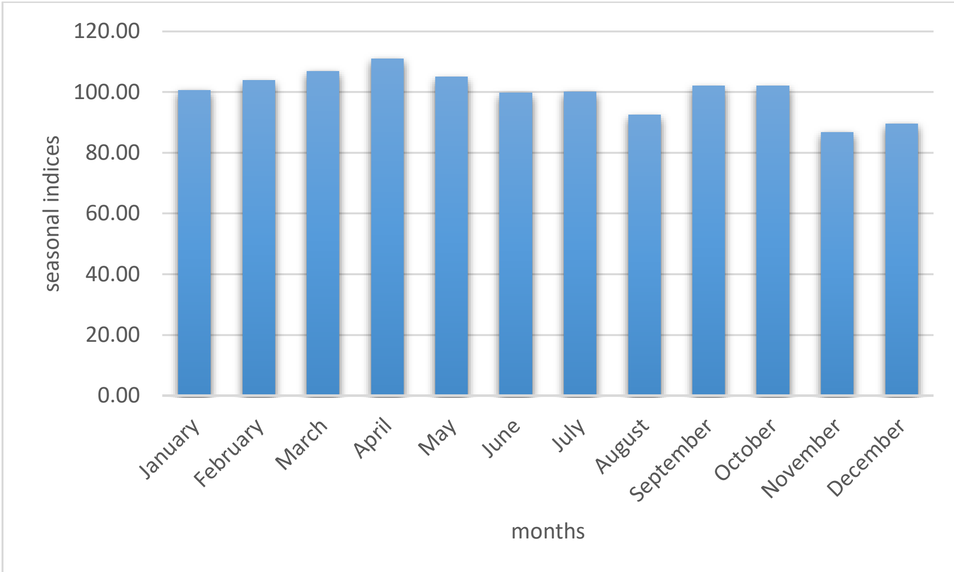


Fig 4.11 Seasonal indices of arrivals of Onion in Ahmedabad market

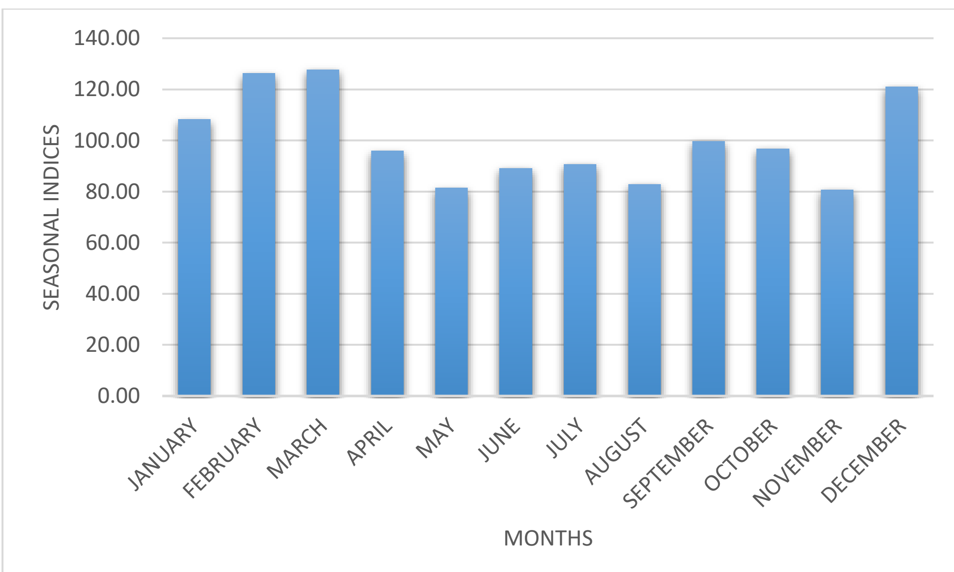


Fig 4.12 Seasonal indices of arrivals of Onion in Pune market

4.1.2.1 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 4.4 and depicted in Figure 4.13 to 4.16. The seasonal indices in the Bengaluru market was 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 4.4 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

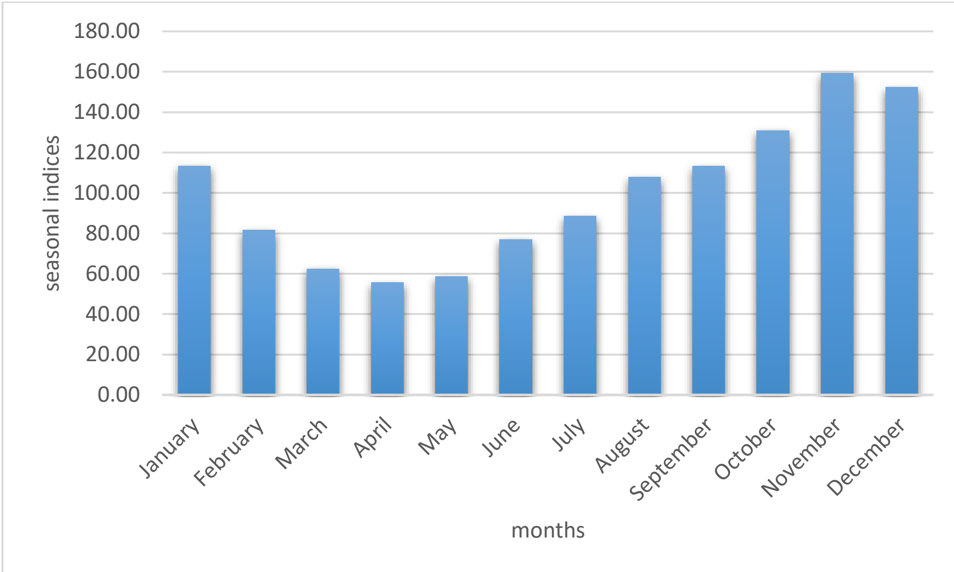


Fig 4.13 Seasonal indices of prices of Onion in Bengaluru market

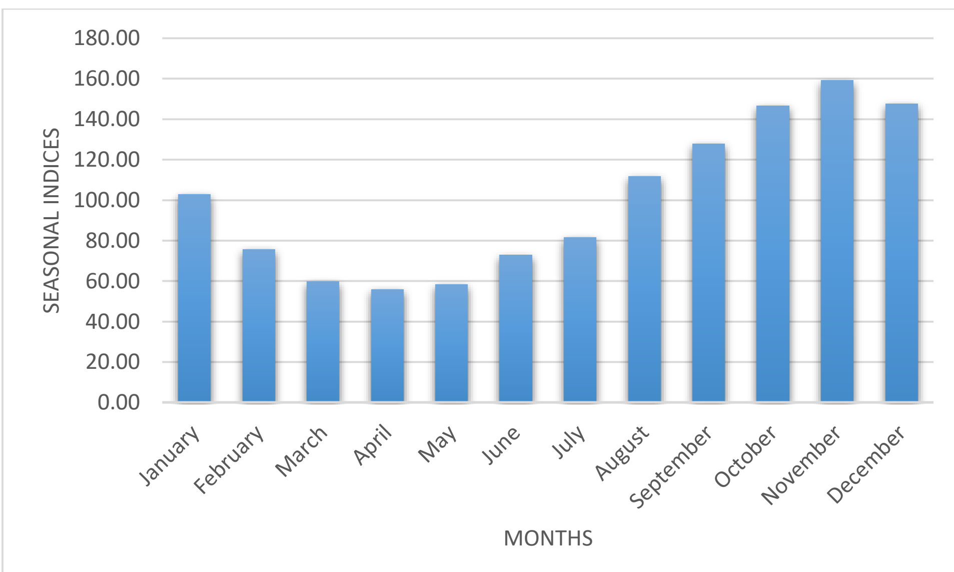


Fig 4.14 Seasonal indices of prices of Onion in Mumbai market

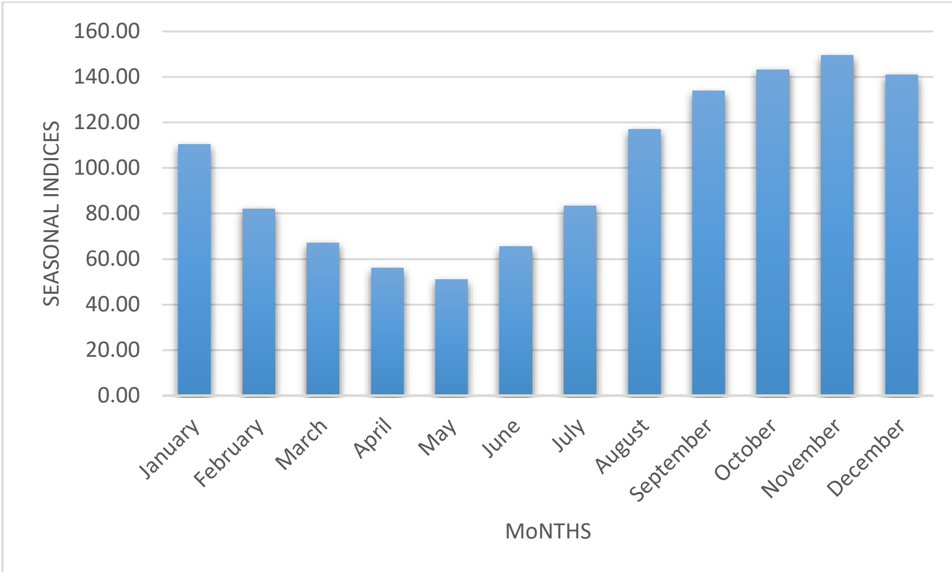


Fig 4.15 Seasonal indices of prices of Onion in Ahmedabad market

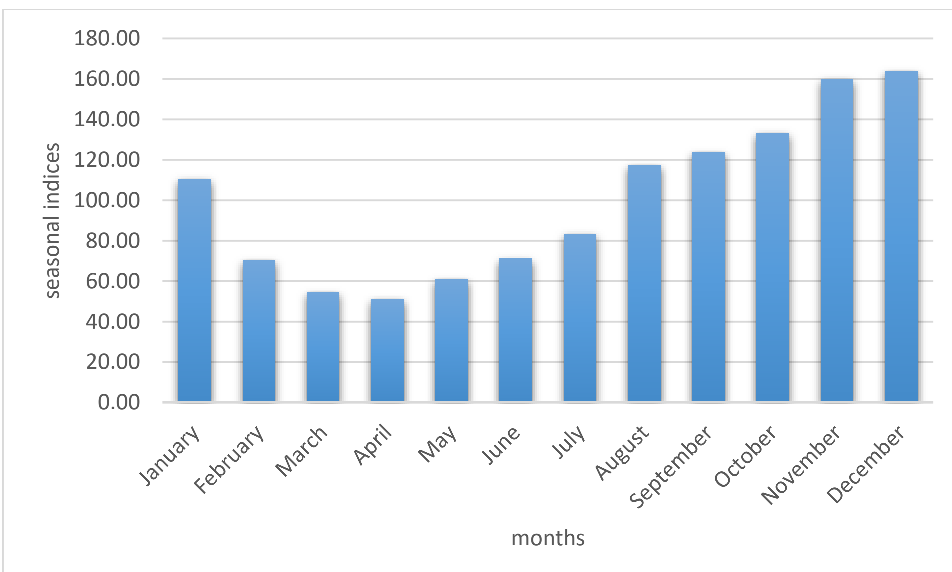


Fig 4.16 Seasonal indices of prices of Onion in Pune market

4.1.3 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 2006 to December 2020 are presented in the Table 4.5. 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 4.5 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

4.2 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 analysing 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.

4.2.1 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 to be 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 4.6 and Table 4.7 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 stationary at first difference. These results are in accordance and similar with Sendhil (2014).

Table 4.6 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 4.7 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 4.17 to 4.24.

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.

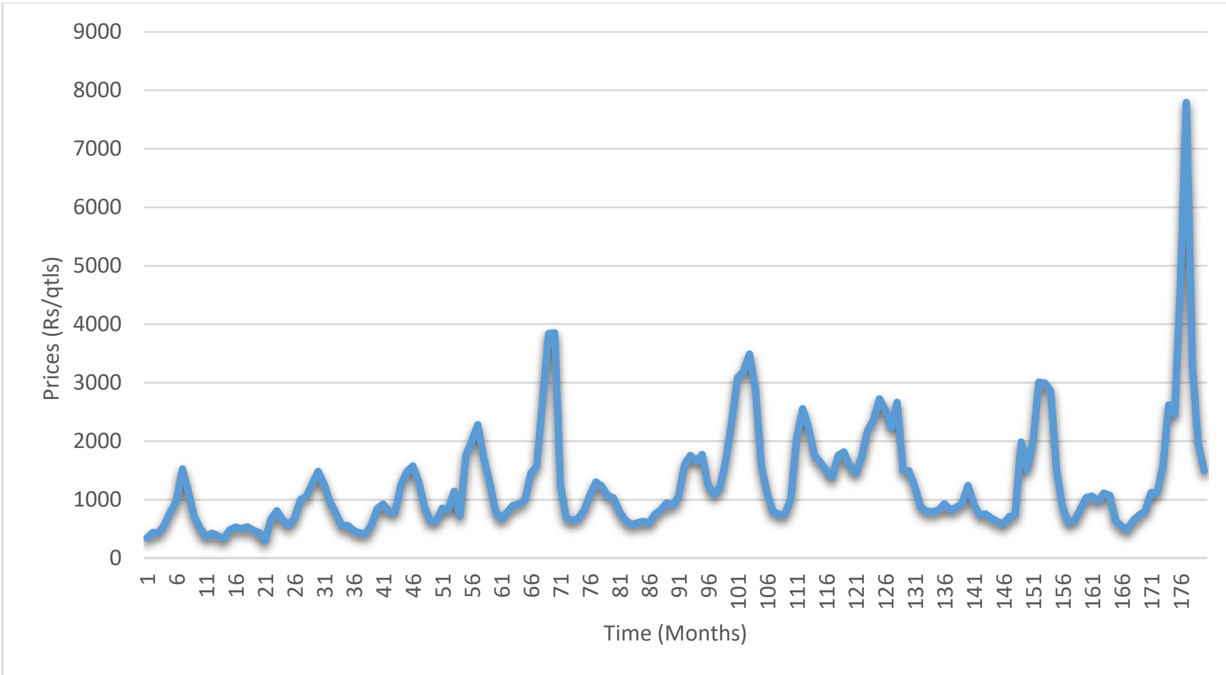


Fig 4.17 Time plot of level series of prices of Onion in Bengaluru market

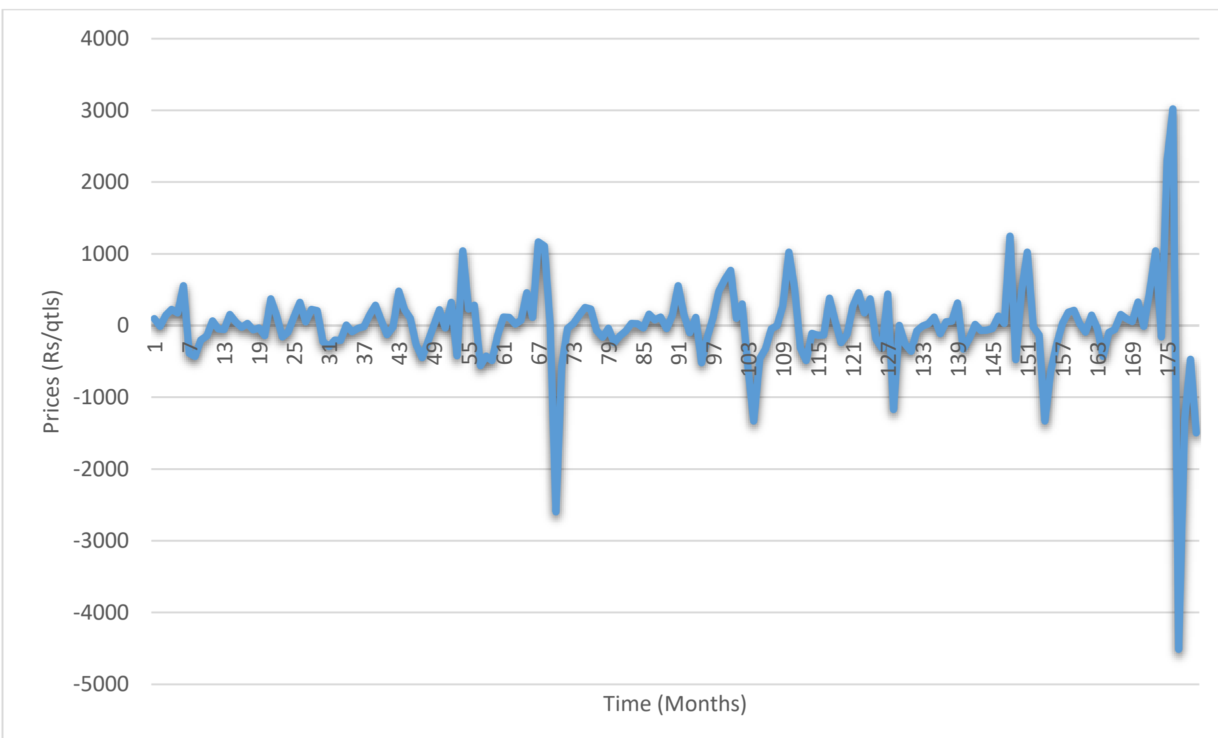


Fig 4.18 Time plot of differenced series of prices of Onion in Bengaluru market

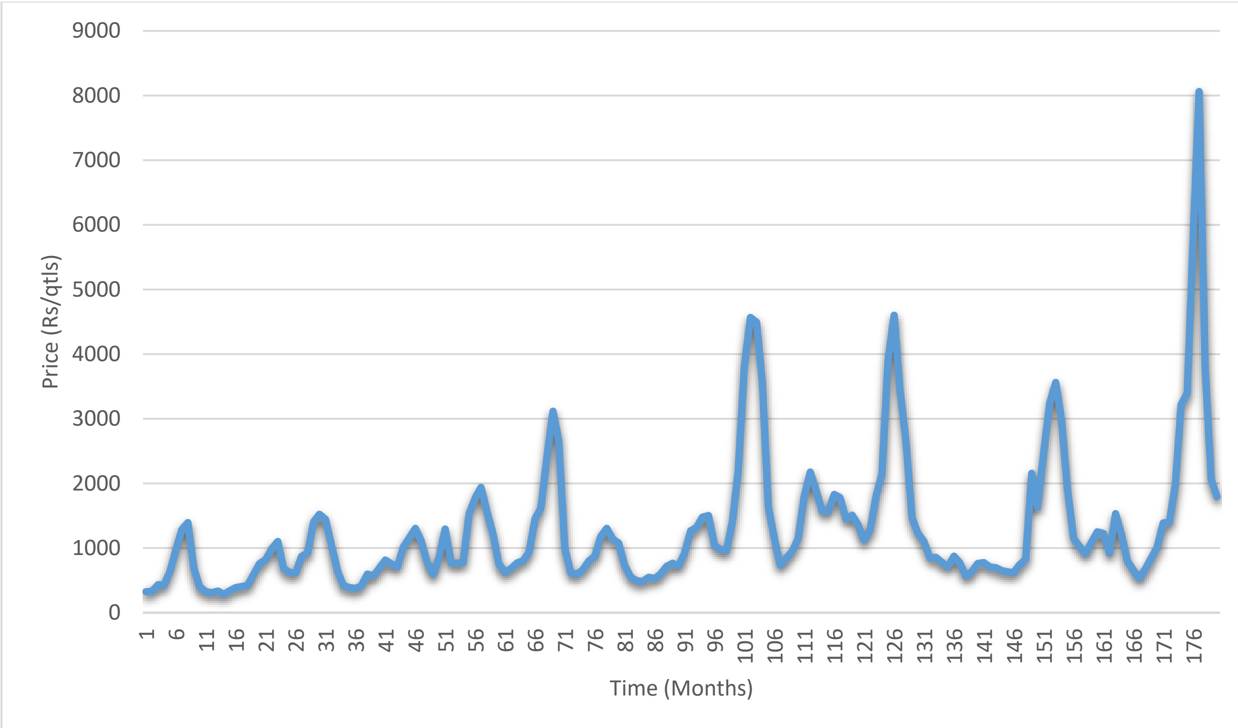


Fig 4.19 Time plot of level series of prices of Onion in Mumbai market

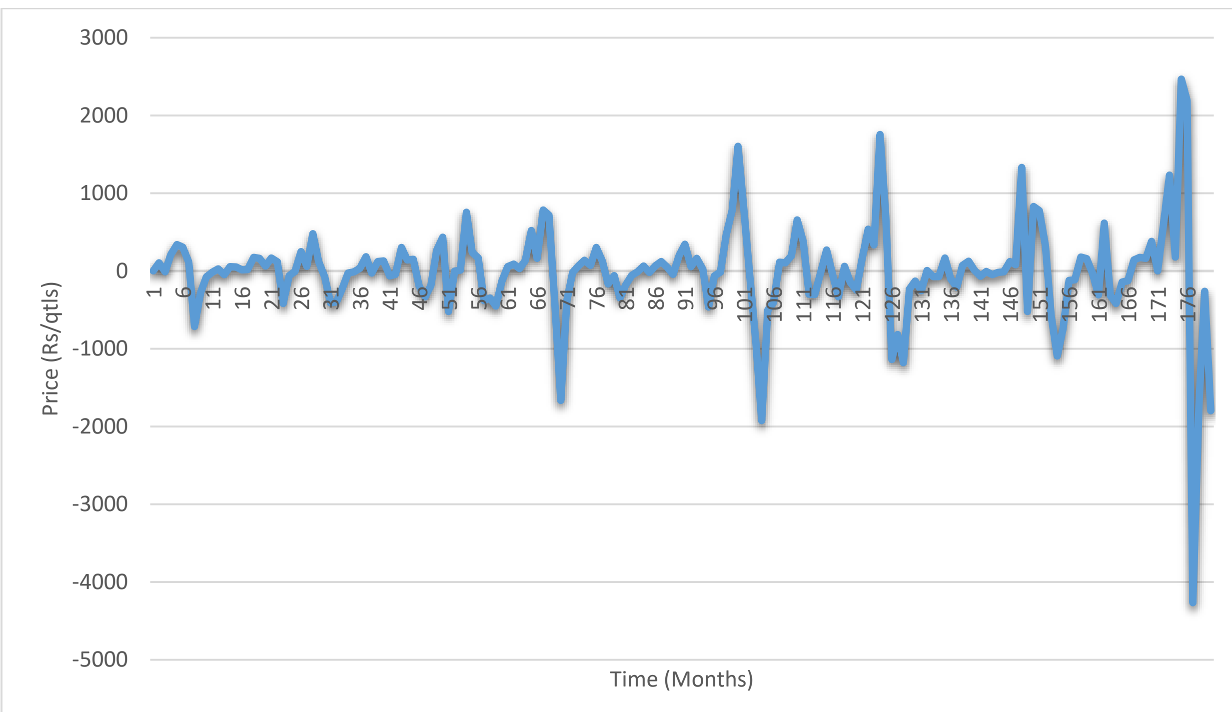


Fig 4.18 Time plot of differenced series of prices of Onion in Mumbai market

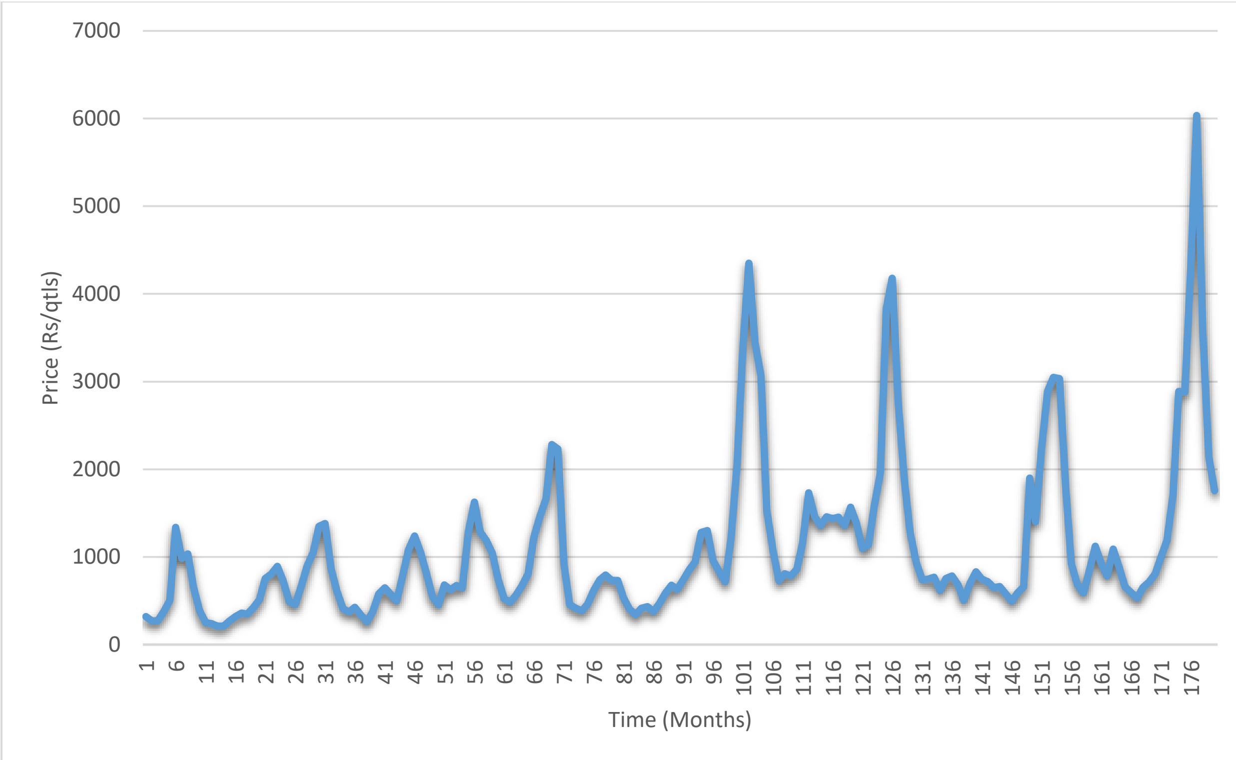


Fig 4.21 Time plot of level series of prices of Onion in Ahmedabad market

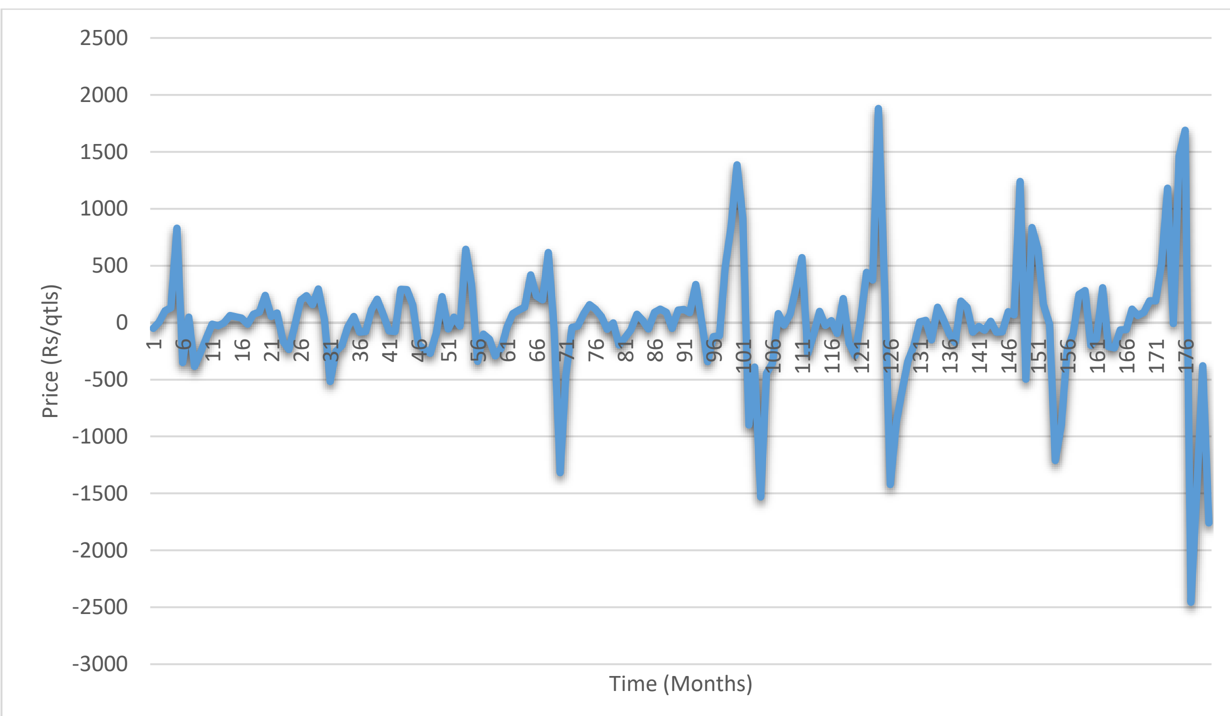


Fig 4.22 Time plot of differenced series of prices of Onion in Ahmedabad market

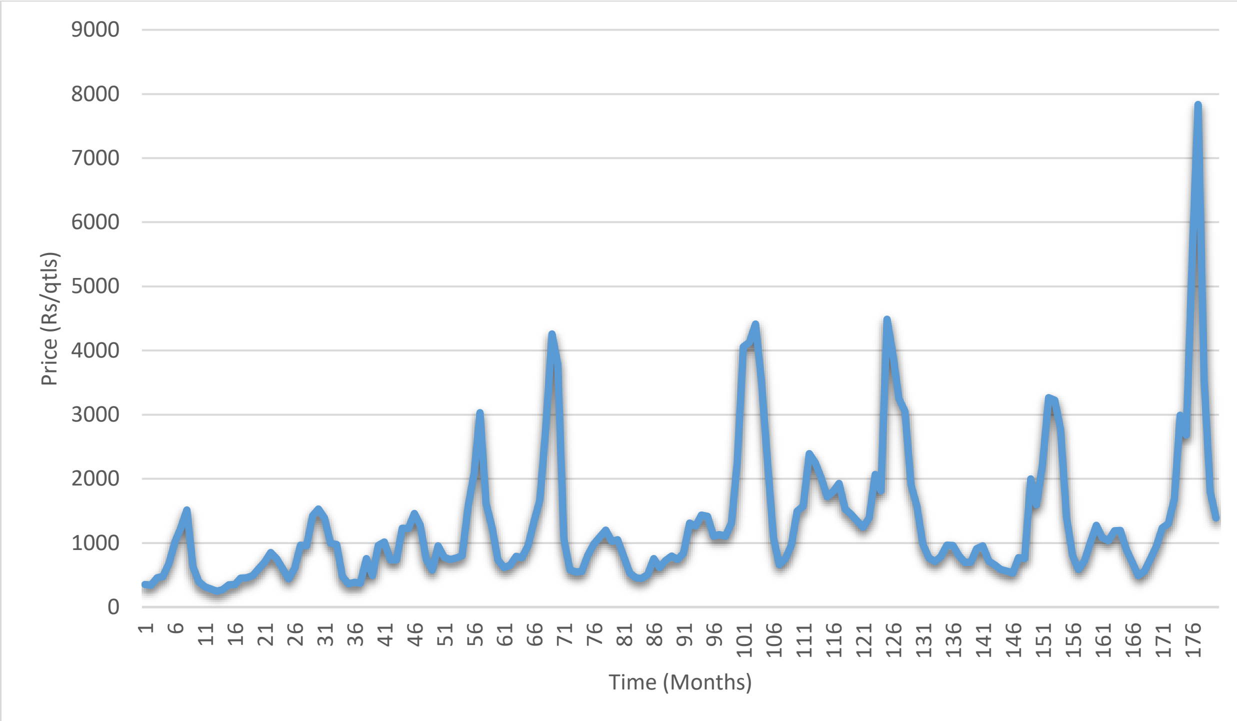


Fig 4.23Time plot of level series of prices of Onion in Pune market

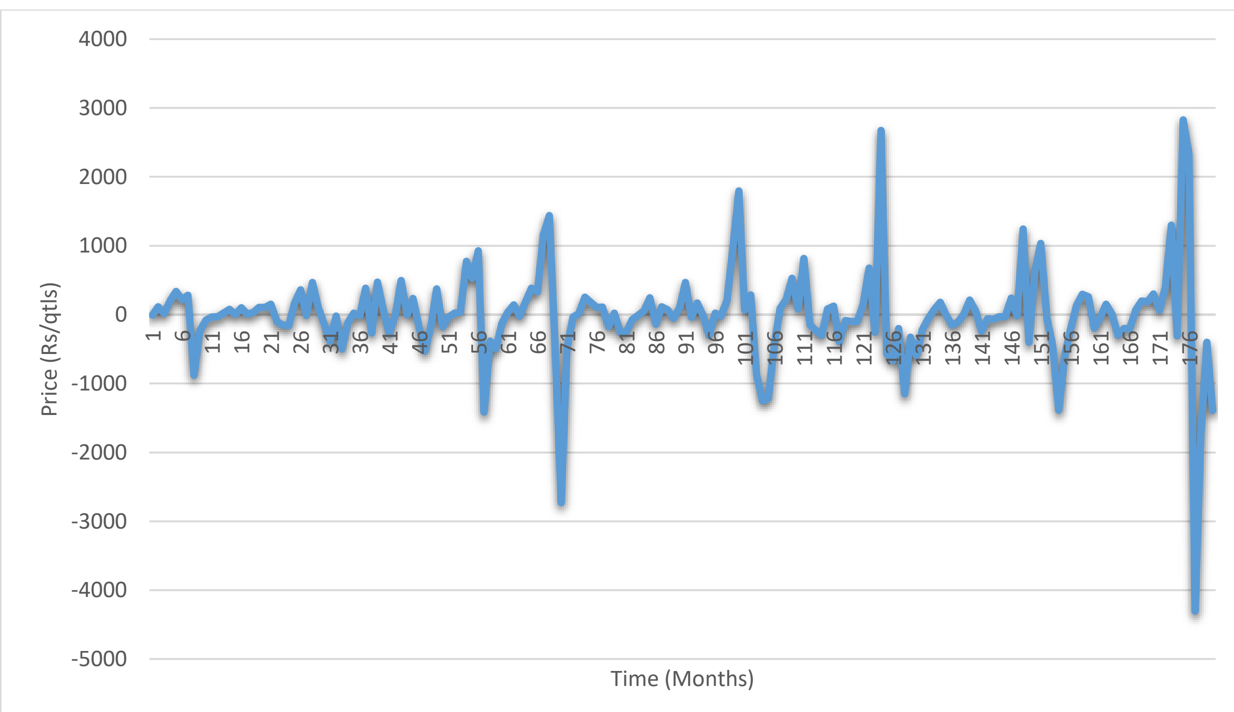


Fig 4.24 Time plot of differenced series of prices of Onion in Pune market

4.2.2 Johansen co-integration test

The integration among selected onion markets were analysed through applying the Johansen co-integration procedure to the time series monthly price data for years from 2006 to 2020. The results of Johansen co-integration test for the onion markets have been presented in the Table 4.8 and 4.9. Two types of table 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 Eigen value) 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)

Table 4.8 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 4.9 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

4.2.3 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 4.10 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 4.10 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

4.3 Price volatility of onion prices in major markets

Volatility symbolizes sudden unexpected upswing and downswing in any series. An attempt has been made here to capture the volatility in price series of onion in major markets (Bengaluru, Mumbai, Ahmedabad and Pune) of India. The sum of Alpha and Beta coefficients indicates the degree of volatility in onion prices that persists. The closer the sum is to 1, the more likely volatility will persist for a longer period of time. If the sum is greater than one, the series is explosive and has a tendency to move away from the mean value**.**

Price volatility was influenced more by acreage adjustments driven by lagged prices, production fluctuation in different states, rainfall distribution, export demand and prices of contending crops, when all or some of these factors were active onion prices exhibits volatility. If farmers are given the right market advice, they can avoid price volatility and they can take advantage of the same for the additional net returns.

4.3.1 ARCH-LM test

The underlying premise of the Box-Jenkins method is that residuals do not change over time. As a result, the ARCH – Lagrange multiplier (LM) test was conducted. The results are summarized in Table 4.11. The results confirmed the presence of the ARCH effect in all of the price series of the selected markets.

Table 4.11 Results of ARCH-LM test on price series of selected Onion market

Markets	**Coefficient**	**Prob. Chi-Square(1)**	**ARCH effect**
Bengaluru	64.73	0.0000	Present
Mumbai	57.97	0.0000	Present
Ahmedabad	38.47	0.0000	Present
Pune	44.68	0.0000	Present

4.3.2 Generalized Autoregressive Conditional Heteroscedasticity (GARCH)

4.3.2.1 GARCH estimates for Bengaluru market

4.3.2.1.1 Auto regressive (AR) process identification

The results of AR processes with different lag lengths are presented in table 4.12. Because it has a lower Akaike Information Criterion (AIC) of 14.56 and a lower Schwarz Information Criterion (SIC) of 14.65 and an adjusted R^2 value of 0.68, the AR process with one lag length was found to be the best of all.

Table 4.12 Identification of AR process in price series of Bengaluru market

	AIC	SIC	Adjusted R^2	Significance
AR(1)	14.56	14.65	0.68	Yes
AR(2)	15.05	15.15	0.63	Yes
AR(3)	15.22	15.31	0.56	Yes
AR(4)	15.25	15.35	0.49	Yes
AR(5)	15.27	15.38	0.43	Yes

4.3.2.1.2 GARCH modelling

The most fitting model was determined to be the GARCH model with the lowest AIC and SIC values. The AR (1)-GARCH (1, 1) model was found to be the best fit for the Bengaluru market price series. The significant ARCH and GARCH terms in the GARCH model clearly imply that the variability in the current period is dependent on the fluctuations in the previous period and on the conditional variance for Bengaluru market price series. The degree of persistence of price series volatility is indicated by $\alpha + \beta$ coefficients, with 0.83 indicating a more volatile price series.

4.3.2.2 GARCH estimates for Mumbai market

4.3.2.2.1 Auto regressive (AR) process identification

The results of AR processes with different lag lengths are presented in table 4.13. Because it has a lower Akaike Information Criterion (AIC) of 14.93 and a lower Schwarz Information Criterion (SIC) of 15.02 and an adjusted R^2 value of 0.57, the AR process with one lag length was found to be the best of all.

Table 4.13 Identification of AR process in price series of Mumbai market

	AIC	SIC	Adjusted R^2	Significance
AR(1)	14.93	15.02	0.57	Yes
AR(2)	15.39	15.48	0.46	Yes
AR(3)	15.56	15.65	0.39	Yes
AR(4)	15.61	15.70	0.30	Yes
AR(5)	15.63	15.72	0.22	Yes

4.3.2.2.2 GARCH modelling

The most fitting model was determined to be the GARCH model with the lowest AIC and SIC values. The AR (1)-GARCH (1, 1) model was found to be the best fit for the Mumbai market price series. The significant ARCH and GARCH terms in the GARCH model clearly imply that the variability in the current period is dependent on the fluctuations in the previous period and on the conditional variance for Mumbai market price series. The degree of persistence of price series volatility is indicated by $\alpha + \beta$ coefficients, with 0.91 indicating a more volatile price series.

4.3.2.3 GARCH estimates for Ahmedabad market

Auto regressive (AR) process identification

The results of AR processes with different lag lengths are presented in table 4.14. Because it has a lower Akaike Information Criterion (AIC) of 14.94 and a lower Schwarz Information Criterion (SIC) of 15.03 and an adjusted R^2 value of 0.62, the AR process with one lag length was found to be the best of all.

Table 4.14 Identification of AR process in price series of Ahmedabad market

	AIC	SIC	Adjusted R^2	Significance
AR(1)	14.94	15.03	0.62	Yes
AR(2)	15.41	15.50	0.55	Yes
AR(3)	15.54	15.63	0.46	Yes
AR(4)	15.60	15.69	0.39	Yes
AR(5)	15.71	15.81	0.28	Yes

4.3.2.2.2 GARCH modelling

The most fitting model was determined to be the GARCH model with the lowest AIC and SIC values. The AR (1)-GARCH (1, 1) model was found to be the best fit for the Ahmedabad market price series. The significant ARCH and GARCH terms in the GARCH model clearly imply that the variability in the current period is dependent on the fluctuations in the previous period and on the conditional variance for Ahmedabad market price series. The degree of persistence of price series volatility is indicated by $\alpha + \beta$ coefficients, with 0.88 indicating a more volatile price series.

4.3.2.4 GARCH estimates for Pune market

Auto regressive (AR) process identification

The results of AR processes with different lag lengths are presented in table 4.15. Because it has a lower Akaike Information Criterion (AIC) of 15.23 and a lower Schwarz Information Criterion (SIC) of 15.32 and an adjusted R2 value of 0.59, the AR process with one lag length was found to be the best of all.

Table 4.15 Identification of AR process in price series of Pune market

	AIC	SIC	Adjusted R^2	Significance
AR(1)	15.23	15.32	0.59	Yes
AR(2)	15.51	15.60	0.46	Yes
AR(3)	15.66	15.75	0.39	Yes
AR(4)	15.71	15.80	0.32	Yes
AR(5)	15.75	15.87	0.27	Yes

GARCH modelling

The most fitting model was determined to be the GARCH model with the lowest AIC and SIC values. The AR (1)-GARCH (1, 1) model was found to be the best fit for the Pune market price series. The significant ARCH and GARCH terms in the GARCH model clearly imply that the variability in the current period is dependent on the fluctuations in the previous period and on the conditional variance for Pune market price series. The degree of persistence of price series volatility is indicated by $\alpha + \beta$ coefficients, with 0.94 indicating a more volatile price series.

Table 4.16 Results of GARCH estimates for selected market

Parameter	Bengaluru	Mumbai	Ahmedabad	Pune
α	0.48	0.58	0.65	0.78
β	0.35	0.33	0.23	0.26
$\alpha + \beta$	0.83	0.91	0.88	0.94
Volatility	High	High	High	High

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

Vegetables are the most important horticultural sector, accounting for 59.28 percent of total horticulture production in the country (Anonymous, 2021). It is also one of the largest and fastest-growing sectors of the food processing industry. Vegetables have a shorter crop period than other crops and can be grown in a variety of climates. Vegetables play an important role in ensuring nutritional security. Because of its economic viability, high yield, high dietary value and ability to generate on-farm and off-farm employment, it is an important part of Indian agriculture.

One of the most important spices and commercial crops is onion. Onions are consumed round the year by all sections of people around the world. Onions were used in almost every kitchens in India for cooking a variety of foods and as a spice in the preparation of vegetarian and non-vegetarian curries. It is valued for its distinctive pungent flavour and is an essential ingredient of the foods of many regions. To add flavour and taste to Indian cousins, onions are used either in raw or dehydrated form. Onions have played a significant role in helping farmers to make a significant profit. Onions can be grown in a variety of climates and have a large supply due to their short crop duration. However, market arrival and prices of onion are uncertain due to seasonality of production and perishability. Arrival fluctuations are a major cause of price fluctuations in vegetables.

Onions were cultivated all over the world. In 2019, onions were cultivated on 5.19 million hectares of global crop land, producing 99.96 metric tonnes of onion with an average productivity of 19.25 quintals per hectare (FAOSTAT, 2020). India's vast production base creates immense export opportunities for the farmers. Bangladesh, Malaysia, United Arab Emirates, Sri Lanka and Nepal are the major export destination of Onions from India (APEDA, 2020). China, India, Egypt, the United States of America, Iran and Turkey are the world's major onion producing countries. China is the world's top onion producer. India is the world's second-largest onion producer. In India the major onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan and Gujarat (Monthly Report Onion, GOI, 2020).

The onion is India's most consistent foreign exchange earner and it is consumed by almost every household in the country. Onion is the most important commercial crop and it frequently aids farmers in making a profit. In the line of "Operation Flood," the Indian government launched "Operation Greens." The scheme was launched to control the supply and price of tomato, onion and potato, as well as to reduce the demand gap. The programme is expected to cost Rs.500 crores.

Larger fluctuations in market arrivals are observed due to seasonal production, and fluctuation in market arrivals contributes to price instability and fluctuations. High price volatility frequently results in low price growth and these price fluctuations also act as a major impediment to agricultural development. High price fluctuation and variation in price frequently causes farmers to suffer by affecting their income level, as well as consumers. Price fluctuations play a significant role in causing uncertainty in the revenue earned by producers and the price paid by consumers. Price fluctuations not only cause income insecurity, but they also make agricultural investment insecure. The presence of price fluctuations indicates that the market is inefficiently functioning.

One of the indicators of the existence of efficient markets is a high degree of market integration. Market co-integration has a positive relationship with market efficiency and competitiveness. When markets are well integrated, prices move together and fluctuations are reduced.

With the above discussion, the following objectives for the current study were chosen.

1. To analyse 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.
3. To analyse the price volatility of onion markets.

Secondary data was gathered primarily from www.agmarknet.got.in and a few other sources as needed. Linear trend, simple average for calculating seasonal indices, Cuddy-Della-Valle index for variability, Augmented Dickey-Fuller test for checking stationarity of time series data, Johansen co-integration test for checking co-integration among markets and Granger Causality test for price transmission between markets were among the analytical tools used. To study the volatility Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was used.

In all the selected onion markets, the trend in market arrival and prices were found to be positive. This indicates, over time all of the markets showed an increasing trend in both onion arrivals and prices. The highest annual increase in onion arrivals was found in the Bengaluru market (30140qtls/annum), while the lowest was found in the Pune market (12019qtls/annum). According to adj-R^2, the contribution of time to price change ranged from 63 percent to 29 percent in these markets. The highest annual increase in onion prices was found in the Mumbai market (Rs.99.61/qtls), while the lowest was found in the Pune market (Rs.77.06/qtls). The adj-R^2 for the price series data was ranging from 33 percent to 47 percent. Due to high volatility of price series data as compared to market arrivals series data, trend line has captured more in case of arrivals than in price series data.

Seasonal indices of market arrival were higher during peak crop harvesting season in most of the markets, with the exception of one or two where higher arrival indices coincided with the lean season, which could be due to high price, because the result revealed price remains higher during the lean period. The result revealed a negative relationship between arrival and prices, as heavy arrivals resulted in price declines, particularly during the harvest season's peak months. As a result, appropriate infrastructure, such as scientific storage facilities on the market yard and market information dissemination, must be developed.

Variability was calculated through Cuddy-Della-Valle index, the variability in both arrivals and prices was high in all the selected markets except in the arrivals of Ahmedabad market (35.03percent). Price fluctuations are also a significant impediment to agricultural development. This high price fluctuation and variation in price frequently causes farmers to suffer by affecting their income level, as well as consumers. Price fluctuations play a significant role in causing uncertainty in the revenue earned by producers and the price paid by consumers

The test of stationarity of the price series data is required to examine the market integration. The data was tested for stationarity using the Augmented Dickey Fuller test. The price series of all the selected onion markets were non-stationary at the level and stationary at the first difference form.

Since it met the criteria for performing the Johansen Co-integration test, the test was used to determine whether or not integration exists among the markets. The result of the Johansen Co-integration test revealed that among all market combinations, there was at most three co-integrating equations, indicating that markets were integrated. All onion markets were found to be well integrated with one another. Focusing on the development of road network, the improvement of existing roads, better communication facilities and other market-related infrastructure could improve the extent of market integration even more.

The Granger Causality test was used to study the direction of price transmission among the markets, as the Johansen co-integration test proved the presence of integration among the markets. The results of the Granger causality test revealed that most of the market combinations have bidirectional price transmission relationships, with the exception of one or two where only one transmits price to the other. Information about price changes in one market was widely disseminated, possibly as a result of quick absorption of price signals, logistical advantages, good communication facilities, and transportation services. The transfer of price signals from one market to another is also enabled by increased market integration.

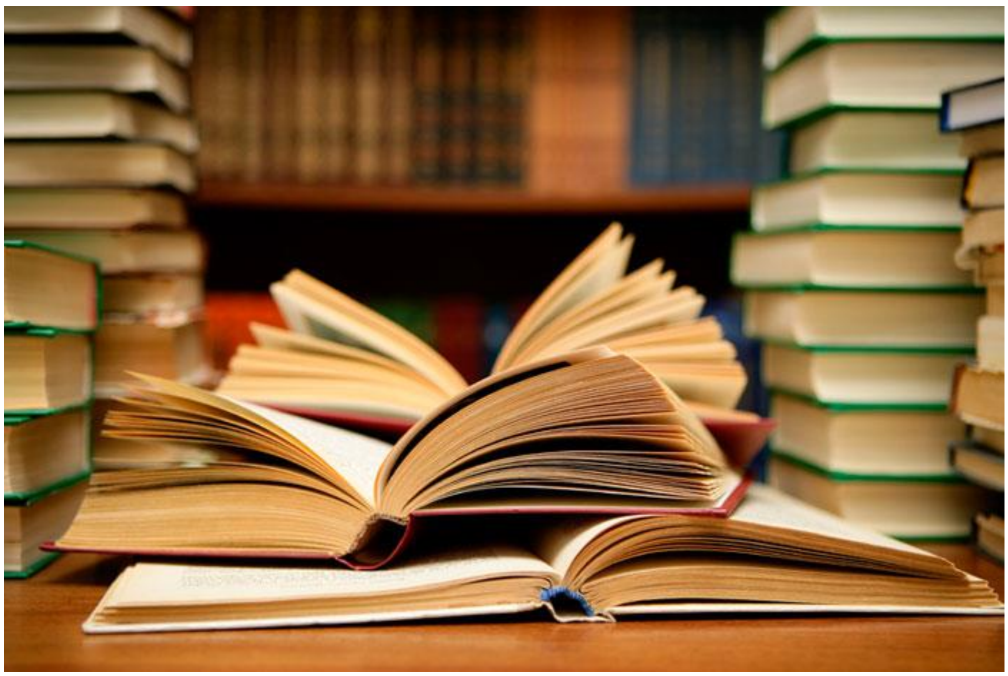
The ARCH-LM test was used to determine the ARCH effect in each of the four price series. The ARCH-LM test revealed that the ARCH effect was present in all price series. As a result, the GARCH test was used to determine the volatility. Out of the four price series, the Pune market price series has the highest $\alpha+\beta$ value (0.94), indicating that it was more volatile than the other three, whereas the Bengaluru market price series has a $\alpha+\beta$ value of 0.81, indicating that it was also volatile but less volatile than that of Pune market price series. Among these price series, the Bengaluru market price series was the least volatile.

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

1. Significant seasonality in onion prices signalled the opportunity for onion growers to increase their revenue by focusing on marketing during lean periods. To do so, early or late maturing onion varieties must be developed and adopted, as well as cold storage infrastructure must be strengthened or created. From the available primary season varieties, production techniques can be developed to achieve early or late harvest.
2. Despite the fact that all of the markets are spatially integrated with one another, but all of the markets do not transmit price to other markets. Some markets failed to transmit prices

to other markets. Bidirectional price transmission was not present. Poor market intelligence, a slow transition between market information and poor physical infrastructure could be the contributing factors. The policy intervention calls for the computerization and networking of market intelligence wings in all markets, as well as the establishment of an online marketing system.

3. The market price information should be made widely accessible by electronic and print media to stakeholders.
4. To reduce vulnerability of onion growers, policies should enhance market functioning and better equip the country to deal with the negative effects of extreme volatility.



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