A STATISTICAL STUDY OF VARIATION IN ARRIVALS AND PRICES OF POTATO IN THE SELECTED MARKETS OF KARNATAKA

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I. INTRODUCTION

Potato is an edible starchy tuber produced by certain plants of the Genus – Solanum and family – Solanaceae. The common white potato (*Solanum tuberosum* L.) is a native of the Peru-Bolivian region in the highlands of South America, where it has been consumed for more than 8000 years. Potato was navigated to Europe in the 16th Century by Spanish explorers as a botanical curiosity. It was introduced into Europe on two occasions, firstly into Spain in about 1570 A. D. and secondly into England in 1590 A.D. through Spanish introduction and thereafter, it diffused throughout Europe and Asia. During the 19th century, it had spread throughout the European continent, providing cheap and abundant food for the workers of the Industrial revolution.

The Portuguese introduce Potato to India in the early part of the 17th century. Today, potato is the 4th most important food crop in the world exceeded only by wheat, rice and maize for human consumption. In India Potato ranks fifth in area under cultivation, fourth in production tonnage. Apart from India it is cultivated in about 130 countries sustaining three-fourths of the world population. Some of the leading potato producing countries are China, Russian Federation, Ukraine, Poland, Belarus, US, Germany, Turkey and the Netherlands. India is the fourth largest potato producing country with a production of 25 million tonnes from 1.34 million hectares. India's productivity of 18.6 million tonnes per hectare is higher than the world average of 16.4 million tonnes per hectare. In India potato is grown mainly in the Indo-gangetic plains, consisting of the states like Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and the Union Territory of Delhi which is considered as the potato bowl of the country.

In most of the developed countries and in several developing countries in South America, potatoes enjoy the status of staple food. But, it is still considered as a vegetable in Asia and Africa. A large portion of potato is consumed in processed form in developed countries whereas in the developing countries a small portion of potatoes is consumed in processed form. This holds much promise for diversifying potato consumption in developing countries.

Potato is wholesome and nutritious food. It seems somewhat paradoxical that in a developing country like India where the population continues to grow and the demand for food is increasing, potato has not yet been recognized as a food crop. Renowned agricultural scientist Dr. M. S. Swaminathan wrote "If India wishes to achieve food security, its agriculture has to produce more food from diminishing per capita arable land and generate more livelihood opportunities and income" (The Hindu Survey of Indian Agriculture, 1997).

Increasing pressure on land required farmers to identify efficient and high productivity crops like potato (Paroda, 1999). Potato can produce more food per unit area and per unit time than wheat, maize or rice. This tuber, which has sustained ancient civilization, continues to remain a major food crop throughout the world, should no longer be considered as a vegetable, instead and be treated as a food crop to supplement the traditional cereal diet (Ezekiel and Shekhawat, 1999). However, potato consumption per capita in India (14.8 kg/head/year) is one of the lowest in the world (Paroda, 1999), since potato is not a part of the traditional diet and is consumed primarily as a vegetable, rather than the staple food. There is a great deal of consumer apprehension and miscomprehension about the nutritional value of potato.

Potato protein has well-balanced amino acid content and the biological value of its protein is comparable to that of eggs and milk. Yet, Potatoes are blamed for causing obesity and are considered by other people to be dangerous because they contain several glycoalkaloid compounds (Parods, 1999). Despite their nutritional value (Pandey *et al*., 1999) 50-60 per cent of consumers were advised by their doctors not to eat potatoes during illness. Quite obviously, there is an immediate need to educate the masses on the nutritional value of potatoes to encourage greater consumption (Paroda, 1999). The medicinal use of potato is also mentioned in our Ayurvedic literature (1000-1500 BC).

The area under potato cultivation in India in 1950 was 0.24 million ha that increased to 1.34 million ha in 1999-2000 with Uttar Pradesh topping the list with acreage of 4.63 lakh

ha producing 10.46 million tonnes. Karnataka stands 8th in area and production with 39300 ha and 5.02 lakh tones, respectively.

Potato processing is very old and has been practiced in the highland of Peru-Bolivia for 2000 years by the Inca Indians who created chuno and papa seca, the naturally freeze dried and dried forms of potato. In India, potato processing on commercial scale was first started by Col. Rennick in 1911, who established a factory at Narkanda in Himachal Pradesh to produce potato meal.

The demand for processed potato is likely to increase in India due to increased urbanization, preference for fast foods, rising per capita income and because of increased demand for convenience food. The most popular processed products are chips and French fries. Processing is mainly confined to developed countries and it is only in its infancy in most of the developing countries with the exception of China (12%), Korea (6%) and Mexico (8%). In India, processing of potatoes constitutes less than 0.5 per cent of the annual production. Potato can also be processed into a variety of products ranging from potato powder, potato starch, frozen potato flakes, potato preserved in vinegar granules, baby food and alcohol. Expansion of processing industry is also desirable to avoid gluts and the consequent difficulty of storing large quantities of potatoes during periods of extremely high temperatures. With the growing realization that processed potatoes fetch considerable higher returns than fresh potatoes, processing activity is likely to look up sharply in the coming years. There is considerable scope for expansion of this processing industry in India.

Technologically, Indian potato is highly competitive in the world market as the potato production is free from prohibited disease like Wart, Black Scab, Ring rot, Ruber moth and nematodes which are the barometer of phytosanitary standards. Indian farmers are now competent to produce export quality potatoes for the foreign market with adoption of moden technology for production of ware seed potatoes. Development of 35 improved varieties, the seed plot technique, potato seed production programme and zone-wise package of practices by CPRI during the last 52 years has lead to 5.7, 2.8 and 16 fold increase in area, productivity and production of potato, respectively in India. Potato is grown in India under short-day conditions in winter and harvested during the months from January to March when there is no fresh harvest of potatoes in most parts of the northern hemisphere making it strategic crop from export point of view. This makes India, technically efficient and economically feasible for exporting potatoes.

Fryer in the year 1675 mentioned potato as one of the common garden crops after a survey of Karnataka. Karnataka is one of the important potato growing states in peninsular India. Potato is one of the main crops in six of its twenty-seven districts. The state's agro-ecology favours its cultivation during two seasons a year. Potato is predominantly grown in Bangalore, Belgaum, Chikmagalur, Dharwad, Hassan and Kolar districts. It is mainly grown as *kharif* crop in Belgaum, Chikmagalur, Dharwad and Hassan districts, whereas its grown as a *rabi* crop in Kolar and Bangalore districts. The *rabi* crop is irrigated, whereas the *kharif* is totally rainfed. Potatoes produced in *kharif* account for the major proportion (70%) of the potatoes produced in Karnataka. Hassan district stands first in area followed by Belgaum and Kolar districts.

The major portion of the potato growing area is covered by rainfall in *kharif* season. The rainfall in the months of April to November influences the area coverage, total production, productivity and quality of the produce. During the *rabi* season, potato is cultivated only in Bangalore and Kolar districts where tube wells form the main source of irrigation for the crop. Intensive cultivation is followed to get maximum returns from the investment. Hence, the cost of cultivation is much higher compared to that of *kharif* crop.

Potato is sold by farmers in the regulated markets which were established by the Agricultural Produce Market Act of 1939. With the introduction of APMC and stringent market regulations, the farmers started receiving a higher share in the consumer's rupee. Exorbitant market charges by the intermediaries, unauthorized deductions in weight and prices, use of defective weights and measures and drawing large amount of produce as sample for which no payment was made to producers, were the malpracties widely prevalent before the introduction of the Act. The steady growth of arrivals of commodities in the regulated markets is the result of the improvement and beneficial effect of the regulated markets owing to which

the sale of agricultural produce in the village has been observe to dwindle over time. This has led to considerable improvement in the market structure, Conduct and performance. The major regulated markets for potato are Bangalore, Hubli, Belgaum, Hassan, Chikkaballapur and Kolar. Bangalore attracts the largest share of arrivals of potato among these markets. The major arrivals of potato in these markets are during October and March months corresponding to *kharif* and *rabi* crop harvest. During off-season potato from other states like Punjab and Uttar Pradesh arrive in these markets.

In Karnataka, potato is stored by farmers on the farm in local storage structures and in cold storage houses. The storage condition plays an important function of making available the produce in off-season. This practice also helps in preventing the glut in the market caused by dumping of the produce in the market immediately after harvest. Though, area planted and yields have increased steadily over the last decade, storage facilities are still limited. Existing cold storages in Karnataka have a capacity to store less than two per cent of the total output of potatoes in the state. Thus, farmers are left with only two alternatives; either sell their tubers immediately after harvest and create a glut in the market which subsequently results in lower prices for their produce or store them on farm. Inadequate storage is one major reason for immediate sale of the produce. In India about 90 per cent of cold storage capacity is exclusively utilized for storage of potato. Nevertheless, it is sufficient only for 46 per cent of the total potato production as against an ideal requirement of 50-60 per cent. But, cold stores provide a partial solution to potato marketing problems. Deficient cold storage facilities and rise in rental charges have made the farmer to come down to the practice of on farm storage.

The substantial increase in yield of potato has not correspondingly increased farmer's income' this is in the wake of existing market facilities, supporting market arrangement and procurement policies etc., which have not kept abreast with the increasing yield and they have denied farmers the benefit of increased yield levels.

In a predominantly agricultural economy like India's, prices play a pivotal role. Due to heavy dependence on natural factors the prices of the farm product fluctuate more than that of industrial goods. Hence, in a developing country like India, the human and political implications created by prices are enormous. They have profound effect on growth, equity and stability in developing economies and parallely affect the prices of non-farm goods. The net result of many a forces acting in different directions causes changes in prices which is associated with passage of time. The various factors affecting the demand and supply of different commodities require different lengths of time to influence the time changes. A change in prices of a commodity or group of commodities in a given market is termed as market fluctuations. Time is the basic accompanying variable in understanding price fluctuation. The fluctuating characteristics of agricultural prices enter directly in the decision frame of farmers, both in production and marketing decisions. Fluctuation or instability in prices is the greatest source of risk next only to weather in agriculture production system.

The variation in the market arrivals and price can be classified as temporal variation and spatial variation. Temporal variations are results of complex mixture of changes associated with trend, cyclical, seasonal and irregular components. Among these, the seasonal component is considered the most important. Spatial price variation refers to the variation in the prices observed in different markets and they occur due to the difference in the location of production and consumption centres. The inter relation between price movements in different markets mostly depends upon the nature and extent of competition, dissemination of market information and the attitude of market functionaries. The efficiency of any marketing system is determined by the degree to which the wholesale prices of a commodity in different markers are related to one another. Analysing such inter relationship helps us in understanding the efficiency of the marketing system.

Stable prices are important indicators of the level of economic growth and they depict the directions for future investments in the economy. Fluctuations in prices can be attributed to the instability of production, risk in production, level of adoption of technology, market infrastructure, supporting-marketing arrangements, Government policy with respect to price support policy, procurement policy, export-import policy etc. Price stability is a pre-condition for stabilizing production of semi-perishable crops such as potato. Hence, the need of the hour is to examine the constraints responsible for such fluctuation in prices and production of potato. Infact, economically damaging price fluctuations have been attributed to faulty policy

initiatives in India. The infrastructure facilities available are insufficient for effective handling of the present level of production. The supporting infrastructure like processing facilities, storage facilities, network of rail and road, marketing finance vis-à-vis other facilities is found to be inadequate. It is also important to workout the investment requirements on the creation of these facilities through which one can visualize the benefits accrued from stability in price and production.

Specific objectives of the study are

1. To analyze the trend in arrivals and prices of potato in selected markets of Karnataka
2. To forecast the arrivals and prices of potato in the selected markets
3. To know the co-integration of selected markets
4. To know the association between arrivals and prices of potato in the selected markets

II. REVIEW OF LITERATURE

Review of literature provides information to the researcher regarding the previous works done in their area of research and thereby helps them in identifying the theoretical framework and methodological issues relevant to the study. It provides the researcher a proper direction to carryout their research work and enables him to arrive at meaningful results. Keeping these facts in view, the available literature relevant to the objectives of the present study was reviewed and they are presented herein under the following headings.

2.1 Time series analysis

2.2 Co-integration

2.3 Price and arrivals and their relationship

2.4 Box-Jenkins model and its application

2.1 TIME SERIES ANALYSIS

The literature on time series analysis in general has been reviewed here.

As early as in 1925, Pearson explicitly described the different components of a time series. These components were;

a. A long-term or secular trend often termed as the growth element.

b. A wave like or cyclical element in which rise and fall correspond to prosperity and depression of a business cycle.

c. A seasonal movement or short-term fluctuations.

d. A random variation or irregular variation.

Decomposing an observation in a series into the above four components constitute the analysis of a time series.

An observation is generally considered to be the end result as a sum of these components or as a product of these components; the time series model accordingly termed as an additive or a multiplicative model.

Generally, a mathematical function is fitted over the whole courses of the time series by the least square principle for estimating the trend.

Anderson (1950) determined the presence of seasonal component through the technique of analysis of variance. He has further pointed out that the statistical inference would be facilitated when least square approach of seasonal adjustment was employed.

Blue Stone (1963) employed the Bureau of census method for seasonal adjustment and found that what he called “A-defined cycles”. For broiler chick placements a cycle of approximately 29 months was adjusted, while for broiler price of a cycle of 30 months was suggested.

Jorgenson (1964) developed the general linear statistical model for time series estimates of trend cycle and seasonal components and derived within the framework of this model, estimators which are unique, unbiased estimators and having minimum variance.

Tabin and Arther (1964) used a low pace fitted (simple moving average) of length six months for broiler chick prices and of length twelve months following hatchery supply floods and the resulting filtered series revealed cycles of approximately 30 months for both the series. A time difference of 12 to 18 months was found to exist between the peaks of the two series for 30 months cycle.

Lovelle (1966) viewed the problem as seasonal adjustment axiomatically and examined the logical implication of certain simple consistency requirement that might be applied in apprising alternative procedure for seasonal adjustment. He considered five such

criteria *viz.,* sum-preserving, product-preserving, idempotency, orthogenality and lemmetry to be latirfied by a good seasonal adjustment procedure.

Waugh and Miller (1970) employed a harmonic analysis to measure the length and amplitude of handling and prices of fish. A twelve month seasonal cycle was employed.

Weiss (1970) used spectral analysis empirically to identify the cyclical patterns in world cocoa prices. He hypothesized the existence of three cycles of 14-24 years, 13-24 months and the seasonal cycles. The results suggested that in addition to seasonal fluctuations there existed a periodic fluctuation in cocoa prices due to lags in production response in consumption response with length of 14 years and 22 months, respectively.

Parikh (1971) with the help of spectral techniques analysed short term fluctuations in coffee prices. The occurrence of 24 month cycles confirmed. The study revealed that various price series were coincident. He observed that though the broad features of the coffee cycle could be interpreted fairly as full understanding would require a simultaneous equation of economic model considering the response of production, consumption and stock to price changes. He used the original series, trend eliminated series and filtered series for coffee prices recorded in New York market, for various grades of coffee. The maximum lag used was n/5.

Gurumallappa (1972) observed a continuous rising trend in the price of groundnut for the period 1956 to 1968, while working of marketing of groundnut in Raichur district. The lowest and the highest seasonal indices were observed during the months of October and June, respectively.

Kupper (1972) made an investigation concerning the use of partial sum of Fourier series and spherical harmonics as regression models in important practical situation, where the usage of polynomial was subjected to criticism.

Kendall (1973) prescribed a criteria through regression for choosing between additive and multiplicative models. But, the criterion turned out to be in conclusive in many cases.

Multiplicative model is found to be more appropriate than additive model as seasonal, cyclical and random components, tends to remain more nearly constant in magnitude relative to trend than in absolute terms; which inturn would help us in computing both constant seasonal index and moving seasonal index as the case may be and to compare percentage fluctuations of the cyclical movements. It was further observed that the first component of time series *viz.,* trend is supposed to be smooth and hence to be approximated by a continuous function of time.

Purandara Rao (1974) studied the problems of arecanut in Karnataka during 1965-73. The seasonal indices were constructed from 12 months centered moving average for Mangalore, Shimoga and Sirsi, markets. The study indicated that the arrivals were maximum during harvesting seasons. Arrivals were peak between January and April in Mangalore, December and May in almost negligible in all the markets. However, the prices were at peak during August in Shimoga, September in Mangalore and Sirsi. No analysis was carried out to remove secular trend from data.

Chengappa (1980) subjected the data of the coffee industry pertaining to the period 1954-78 to spectral analysis and cross spectral analysis. He observed 24 month cycle in the domestic price of coffee at various levels. However, exports showed a 36 month cycles which he attributed to world coffee price fluctuation. His study revealed a high value of coherence both in the long frequency components and in short frequencies between sale prices and wholesale prices. However, this was not true of the forms and export prices. His analysis further revealed that quantities released do not respond readily to short-run price changes.

Eshwaraprasad (1989) studied the seasonal indices of arrivals and price turmeric in Guntur market for the period 1970-71 to 1985-86 by using the ratio of moving average movement. The results of the study indicated that the indices of arrivals were higher during March, April, May and June months in both bulbs and fingures and during these months, the price indices were on the lower side in both bulbs and fingures could be observed during September to February.

Ashok Kumar (1989) studied the price and arrivals and as arecanut from 1961-62 to 1986-87 in three major markets of Karnataka *viz.,* Mangalore, Shimoga and Sirsi. A 12 month centered moving averages were computed to study the trend behaviour of price and arrivals, polynomial regression equation was fitted to estimate the trend components (after removing the cycle affect). A harmonic analysis was done for the purpose of explaining intra-year fluctuations in the market. For testing significant difference in seasonal patterns over years, Friedman's two way ANOVA was used.

Agarwal and Sharma (1990) analysed the seasonal indices of pulse crops in Rajasthan during the period 1972-1987. The results of the study indicated that price indices were the lowest during peak arrival months (April, May months for gram and October, November months for, moong and ward pulse crops) and the highest during sowing months of the crop (October, November for gram and June, July for moth, moong and warm). Arhas depicted minimum prices during January, February, months and maximum in the month of October.

Naik *et al.* (1990) studied the short-term and long-term variation in the prices and arrivals of groundnut in Gadag and Ranebennur regulated markets in Karnataka. The results indicated that the arrivals were maximum in periods September-October and April-May in Ranebennur markets and during October-January in Gadag market. They concluded that farmers sold bulk of their produce immediately after harvest. The analysis of seasonal pattern in price showed the presence of seasonality over month and constancy and this pattern over years in both markets.

Singh *et al.* (1995) conducted study on seasonal variation in arrivals and their effect on price of wheat in Bihar. The study is based on secondary data obtained from four APMC of Bihar. Two markets each representing primary and secondary markets for wheat. The selected markets Sasasam and Mohania are primary markets and Dhanbad and Bokar are secondary markets. The study indicates that the seasonal variations in arrivals of wheat are more apparent in primary markets than in secondary markets. As much as on third of variations in annual arrivals of wheat is governed by the variation in price in both primary and secondary markets. However, wheat arrivals are more sensitive to their ruling price in secondary markets than that of primary markets.

Parmindar Singh *et al.* (2000) adopted linear equation and moving average to examine the trend as well as seasonal variation of arrivals and price of rape-seed and mustard in Haryana. The findings of the study of trend and seasonality in arrivals and price of rape-seed and mustard revealed that price of rape-seed and mustard from 1985-86 to 1995-96 showed general tendency of rising while the arrivals indicated great fluctuations from year to year in all markets. More than 50 per cent of arrivals arrived in peak season.

2.2 CO-INTEGRATION

Co-integration is a technique that is used to assess the market integration. Market integration is a relationship between two markets with regard to prices of a certain commodity. Markets are said to be integrated if price variation in one market associated with the price prevailing in other market and vice-versa. This is refluxed by correlation between prices of two markets with same period.

A conventional method of measuring integration between two markets *i.e.,* as to be expected through the computation of correlation coefficient between unadjusted price series of two markets. But since it is a biased measure of market integration, correlation coefficient between the market price series adjusted for trend is recommended as a better measure.

Farooq (1970) studied on market and performance of rice marketing system in East Pakistan. In order to know the relationship, he computed correlation coefficients between secondary markets between terminal and secondary markets and between terminal markets and found them to be 0.90, 0.86 and 0.80, respectively. Thus, it indicated that lesser the distance higher was the correlation and greater the degree of market integration.

Thamarajakshi (1971) analysed the relative growth of arrivals and price trend also the impact of demand on price by fitting two variable regression model. The others reported that the variation in price of cereals was governed by the relative response of the price to

differential growth rate of supply and demand. She also felt that the effect of income on price of rice, wheat and cereal grain was more patent that of their availability. The supply of rice was not only affected by its price, but also that of wheat and other grains.

Byln (1973) estimated the market integration by computing the correlation coefficients for the de-trended and de-seasoned data for eight markets in Punjab. The author pointed out that the average 'r' was equal to 'r' between Delhi and other markets indicating the dependence of Delhi prices on the prices of all other collecting markets. The study also showed the lower 'r' prices were lower and vice-versa.

Thakur (1974) studied food grain marketing efficiency in Gujarat. To estimate the market integration, he computed the correlation coefficients between wholesale prices of ten markets. He found that only three markets showed higher correlations between wholesale prices for paddy compared to bajra and jowar. The correlation coefficients of price series between different markets were high, which pointed out to a high degree of pricing efficiency.

Krishnaswamy (1975) studied the behaviour of market arrivals of (food) groundnut prices of Rajasthan. He observed that the six out of eight cases studied, the market arrivals were positively related to prices.

Singh and Arora (1975) examined the extent of market integration of groundnut prices in some important markets of Punjab for the year 1962-63 to 1967-68 and 1972-73 by calculating correlation coefficients. The authors found higher variation in groundnut prices during earlier period (1962-63 and 1967-68) than during the later period (1972-73). Their analysis yielded higher 'r' between Khanna and Malerkotta (0.872) and lower 'r' between Khanna and Sangrus Ludhiana and Mathura markets (0.67). The study further reported that during later period *i.e.,* 1972-73, the value of 'r' was higher than the earlier two in all markets.

Bhat (1980) studied movement of paddy and groundnut prices in the selected market of Karnataka. He employed zero order correlation coefficient analysis for analysing market integration. Further, he suggested a strong integration of markets in price formation indicating the influence of price in one market over the prices in other markets. The 'r' value were higher in the cases of bigger markets compared to smaller markets indicating the influence of traders participation in determining the degree of market integration.

Bhide *et al.* (1981) studied the structural changes in the arecanut market and Mangalore, using data on the size distribution of firms and coefficients of inequality (Gini coefficients) for the period from 1965-66 to 1972-73. Further, they projected the distribution of firms in different size categories by using regression analysis. The analysis suggested an increasing degree of competitiveness in the market structure characterized by a more equal distribution of shares in the market transactions.

Ejiga and Robinson (1981) analysed the market integration interms of storage cost of cowpea in Nigeria and showed that on an average, the stock had to be held for about eight months to secure maximum gains. Significantly, there was high degree of variability from year to year in both prices and arrivals. Suggesting that a farmers or a traders could not be assured of profit from storage every year.

Mundinamani (1985) analysed the market concentrations by commission agents in the selected market of groundnut in Dharwad district. The author found that the top commission agents controlled about two thirds of the total quantity of groundnut handled in Hubli market and one third in Gadag market, indicated a high degree of concentration in purchase in Hubli market compared to Gadag market.

Singhal (1986) studied five primary and one terminal markets in Uttar Pradesh to analyse spatially and temporally, the rape-seed mustard price structure using correlation coefficients technique for spatial analysis. He found that almost every year there were periods of attack 6 to 8 weeks at a strength when the terminal market (Kanpur) price was considerably in excel of the primary market price (after taking transport costs *etc.* into account. It was concluded that while the primary and terminal markets were spatially markets were spatially disintegrated.

Ali (1988) made an attempt to study three regulated market in Sharanpur district (UP) and concluded that these markets were competitive based on the non-significant correlation between weighted average price and number of buyers and sellers, no restriction of entry and traders and awareness of price by all functionaries.

Bhatta and Bhat (1988) analysed the extent of price relationship for arecanut between selected markets of Sirsi and Mangalore using the correlation coefficient method. The results revealed that Mangalore market was more efficient than Sirsi market. The commercial nature of the crop and its varied market behaviour was clear from the fact that there was a direct relationship between supply and price.

Indira (1988) estimate the extent of price relationship for coffee between three pool sale centres- Bangalore, Coimbatore and Vijayawada. The results revealed that Bangalore prices have shown positive relationship with both Coimbatore and Vijayawada prices. Coimbatore and Vijayawada prices have also shown positive relationship with each other. However, there was relatively lower influence of Bangalore prices on Coimbatore prices than on Vijayawada prices.

Prabhakar (1988) studied the market integration of silk cocoon markets of Ramanagaram and Vijayapura in Karnataka. The association between the two markets was studied using the bivariate correlation analysis. The correlation coefficient was found to be 0.947 and was highly significant at one per cent level of significance, indicating that the two markets were highly correlated.

Dinakar (1990) assessed the extent of price integration between the markets by using coefficient of variation technique. He noticed a poor integration between the markets and secondary markets was demonstrated by significant difference in the coefficient of variation of prices.

Arya (1991) analysed the spatial integration of four markets in Gujarat using Zero order price series correlation analysis. She noticed significant and high correlations in the price movements between the markets and concluded that the markets under consideration were integrated interms of price movements.

Gemtessa (1991) analysed the integration of Ethiopian coffee prices with world prices using the correlation coefficient. The correlation coefficient of the monthly average prices secured at domestic and world markets for 12 months lag were calculated. The bivariate correlation coefficient between the two market prices of coffee revealed that they moved together in the same direction. The lagged cross-correlations of domestic prices and world prices of coffee also revealed that they moved together in the same direction. The lagged cross-correlations of domestic prices and world prices of coffee for the period of 1979-80 to 1987-88 indicated that the world prices of coffee had a stronger influence on the domestic prices, than that of domestic price influence on world prices of coffee.

Brahmaprakash and Srivastava (1994) conducted a study on pattern of marketing arrivals and price of grain in Uttar Pradesh. They concluded that the coefficient of correlation between monthly arrivals and average monthly wholesale market prices for different years of the period. The market arrivals and prices were negatively correlated.

Mamatha (1995) used the co-integration analysis for examining the market integration of selected species of India and New York prices. The results indicated that the coefficients were found to be negative and significantly different from zero in case of Indian and New York prices of pepper, chillies, turmeric and ginger confirming the stationary of the series. It also indicated that both the Indian and New York price series for selected spices had the same order to integration.

Kerur (1996) had dealt with temporal integration of markets using coefficient of variation and spatial integration using zero order correlation of sunflower prices.

Hudson (1998) analysed the changes in the price behaviour in US catfish industry. Using monthly catfish price data, a co-integration analysis of subsets of prices showed that price behaviour has changed through time with catfish prices becoming integrated as the

number of processors has increased. The results may have implications for the examination of market price behaviour in developing or emerging markets.

Sharma *et al.* (1998) studied annual prices of milk, butter and ghee in six markets (Delhi, Kanpur, Bombay, Patna, Colcutta and Madras) were studied. The price correlation coefficient between the markets ranged from 0.9529 to 0.9991 for ghee indicating that prices of milk, ghee and butter in different markets are highly correlated. This implies that there is a high degree of inter market integration for milk and milk products and that prices of milk products cannot be determined in isolation in a single market as they are influenced by price variation in other markets. This is more products can be determined in isolation in a single market as they are influenced by price variation in other markets. This is more true in the case of products such as butter and ghee that have a long shelf life and are easily transportable.

Thorsen (1998) studied the spatial integration in Nordic timber market. The degree of spatial integration was tested through a co-integration analysis and a complete identification of the statistical models for long-run. When the results were interpreted in terms of factor price equalization and efficient commodity arbitrages, the Nordic timber markets were found to be strongly integrated.

Bassolet and Lutz (1999) analysed the integration of cereal markets in Burkina Faso which were liberalized in 1992. At the same time a market information service (SIM) was created to collect and disseminate weekly cereal prices of regional markets by radio. A comparison of results of the whole period under study (1990-1995) with the results of the period after SIM (1992-1995) showed that the impact of the diffusion of prices on market integration is moderate.

Samarajeeva and Gunatilake (1999) studied the demand function for coconut using co-integration analysis. The study made use of 20 years Sri Lankan time series data (1978-1997) to estimate the demand function for coconut oil incorporating own price, three substitute prices and income. The results of Dickey fuller and augmented Dickey fuller tests revealed that the quantity consumed and prices of palm oil are integrated to the order zero while prices of coconut oil and soya oil and income are integrated to the order one.

Zanias (1999) analysed the seasonality and spatial integration in agricultural (product) markets especially the soft wheat market of five European Union member states (France, Italy, Belgium, Germany and UK). Co-integration analysis was made use of by incorporating the seasonal components of the agricultural price series in the testing procedure. The results showed that some of the markets turn out to be integrated while in some cases, a unified market cananot be assumed. These results differ in some cases from those obtained by co-integration tests which ignore seasonal unit roots.

Balappa Shivaraya (2000) used zero order correlation matrix to study the potato and onion markets in North Karnataka. He observed a strong integration among all the selected markets both in onion and potato except Bijapur in onion. In case of potato, the correlation coefficient between wholesale prices of selected markets was found to be higher than 0.93 indicating greater integration among Belgaum, Dharwad and Hubli markets.

Mahesh (2000) studied the relationship between domestic (Calcutta) and international (London) market price series of tea using the co-integration analysis. The results revealed that the tendency of the price series of both domestic and international market for tea move in-unison in the long-run confirming the law of one price (LOP).

Patil (2000) examined the extent of market integration and the relationship between the pattern of market arrivals and the prices of rape-seed and mustard, in selected markets of Mensana district, North Gujarat, India. Time series data on wholesale prices for the period 1975-76 to 1991-92 were obtained. The spatially located primary as well as secondary wholesale markets in Mensana were found to be integrated interms of movement of prices. There exists normal conspicuous seasonality in prices and arrivals of rape-seed and mustard. Year-wise and market-wise analysis revealed that market arrivals were high on post-harvest months when prices were low and low arrivals were observed in subsequent months when prices were high.

Jayesh (2001) studied market integration for spices using correlation coefficient. The zero order correlation matrix of prices showed a strong integration among the selected markets of Kerala, Karnataka and Tamil Nadu for both pepper and cardamom.

Balappa Shivaraya (2002) has made on attempt to examine the extent of price integration of onion and potato in the selected markets of North Karnataka, comprising Belgaum, Bijapur, Dharwad, Gulbarga, Raichur and Hubli. Zero-order correlation matrix between average wholesale price of onion clearly indicated the integration among the selected markets, except Bijapur with other markets. However, the magnitude of integration was found to be higher between Belgaum and Raichur (0.9447) between Hubli and Raichur (0.9439), between Belgaum and Hubli (0.9253), Raichur and Gulbarga (0.8669) and Belgaum and Gulbarga (0.8393).

2.3 PRICES AND ARRIVALS OF POTATO

George and Govindan (1975) studied the behaviour of monthly wholesale prices and the pattern of arrival of potatoes in Ahmedabad (Gujarat) market, during 1966/67 to 1973/74 using harmonic analysis. The findings confirm the existence of seasonal cycles both in prices and market arrivals of potatoes. The behaviour of wholesale prices indicated the existence of a three-year cycle. However, the market arrival pattern did not indicate the presence of a similar long-term cycle. The price elasticities associated with the very short-term, seasonal and long-term cycles were 0.518, 0.720 and 0.246, respectively.

Jain and Kaul (1980) analysed the seasonal fluctuations in the potato market and the existence of cycles and worked out their periodicity, using time series data relating to arrivals and prices collected from four major potato markets in the Punjab, India. In the case of two markets (Ludhiana and Pathankot) the data related to the years 1961/62 to 1975/76 while in the case of Jallandar and Hoshiarpur markets, the data related to the years 1963/64 to 1975/76. A multiplicative model of time series was used to analyse the trend, seasonal and cyclical variations in prices and arrivals of potatoes. The analysis of all the objectives showed the instability of price. There is an upward trend in prices but with the large fluctuations in a year. Analysis of cyclical variations confirms the fluctuations in prices as it gave three-year cycle period in potato prices.

Kalyankar and Rajmane (1987) studied the arrivals and prices of potato in Jalna (Maharashtra) market for 1973-82 showed that March was the peak month for arrivals while minimum arrivals were recorded in November. Seasonal price indices showed that the increase in the off season price compared with the immediate post-harvest price was around 30 per cent. The producer's share in consumer's rupee was 65.71 per cent *i.e.,* Rs. 110.40 to Rs. 167.99 per quintal paid by the consumer, the remaining 34.29 per cent being spread over different marketing agencies. The study emphasized the need to stabilize prices during peak harvesting periods by providing cold storage facilities in the producing centres and establishing wholesale and retail markets in the potato producing area to minimize the marketing costs of potatoes.

Kainth and Mehra (1988) examined the trends and seasonal fluctuations in arrivals and prices of potatoes in Amritsar district, Punjab, together with the price spread of potatoes. The study covers the period 1980-81 to 987-88. Seasonal variations may be primarily due to seasonal production, poor cold storage facilities and lack of retention power of the potato growers. Price variations play a pre-dominant role in creating uncertainty in the income levels of potato growers. The main reason for the variation in prices was the pattern of market arrivals. Producers received only about 59 per cent of the consumer price.

Kainth and Mehra (1988a) while studying seasonality pattern of market arrivals and prices of potatoes in Amritsar (Punjab) found that marketing season began with the arrivals of fresh potatoes in the month of December and ended in the month of March (peak season). From April to May as well as November months formed the mid season. However, lean period started from June and ended in October month. Potato prices were much higher (Rs. 137.58/q) in the lean season as compared to peak season (Rs. 74.60/q). The regression analysis indicated that there was significant negative ($r = -0.8595$) relationship between arrivals and prices as expected.

Parthasarathy *et al.* (1988) analysed price behaviour of vegetables in Hyderabad markets from 1980 to 1987 and found that an arrivals in general did not declined the prices. Further, price variations were not uniform magnitude in the same month in different year, in case of both tomato and brinjal. The regression analysis of prices over a period of seven years showed a slight upward movement in prices.

Sangwan (1989) examined seasonal variation in potato price in important markets of the country. He found that the level of seasonal variation in the prices of potato was considerably less in Delhi market than Kanpur, Farrukhabad, Meerut and Patna markets. It was largely due to lower harvest price in producing area than consuming centre like Delhi. All the five markets did not show similar trend over the entire period *i.e.,* 1963 to 1985. The direction of trend changes was largely in keeping with respect to trends in production of potato and establishment of cold storage.

Mundinamani *et al.* (1991) used monthly time series data on market arrivals and prices of groundnuts for the period 1960-61 to1983-84 collected from the regulated markets of Gadag and Hubli to estimate indices, trend equations and coefficients of variation. The pattern of market arrivals of groundnut indicates a seasonal character. The prices of groundnuts were found to be a function of market arrivals only in the short-run. The seasonal pattern of market arrivals and the resulting short-run instability in groundnut prices could be eliminated by using a package of measures. In the long-run, prices are influenced not only by market arrivals but also by other factors such as the general rise in prices and the steady rise in demand for groundnut products.

Selvaraj and Krishnamoorthy (1991) examined the pattern of price behaviour, the existence of market channels, nature of price spread and the relationship between market arrivals and price of potato based on data collected from a sample of 10 commission agents, 10 wholesalers and 10 retailers in Nilgiris districts of Tamil Nadu. The role of co-operatives in marketing is investigated using the case of the Nilgiris co-operative marketing society (NCMS) at Mettupalayam market centre. Two important channels for potato marketing were found : channel-I (producer-NCMS-wholesaler-retailer-consumer) and channel-II (producer-mandies-wholesaler-retailer-consumer). It was observed that channel-I is efficient. The price behaviour analysis showed wide annual and seasonal fluctuation in prices.

Singh *et al.* (1993) concluded that stable prices play an important role in determining farm income, in particular for perishable products such as potatoes, where farmers cannot retain produce. The seasonal nature of agricultural production results in price fluctuations. This paper analyses trends in arrivals and prices of potatoes; examines the seasonal patterns of arrivals and potato prices and suggests measures to help minimize price fluctuations. The study was undertaken in Jalandhar district of Punjab state during 1975-76 to 1989-90. The results indicate a rising trend. During the post-harvest period, the indices of prices remained high and fluctuated widely. These fluctuations may be attributed to the seasonal and perishable nature of the crops. The government needs to take some initiatives such as announcing some support price programmes for potatoes, purchasing the produce at the support price directly from the producers, increasing cold storage facilities in the state, increasing the retention power of the producers by providing adequate credit facilities and establishing more potato processing units in the potato growing areas, thus providing employment to the rural community.

Sharma and Sharma (1996) made an attempt to study the variation in wholesale prices of selected vegetables in India. Coefficient of variation in monthly wholesale prices of potato, tomato and onion were 30, 36 and 42 per cent, respectively in Calcutta. However, price variation in Delhi and Calcutta were more than that in Mumbai and Chennai in the case of potato as against high price variation in Mumbai for onion and Calcutta for tomato. Potato prices were less variable relative to onion and tomato prices. The wholesale prices were low during February-March in potato and tomato whereas onion prices were low in February–March.

Keith *et al.* (1997) examined seasonal potato price indices for two major wholesale potato markets of Delhi and Kolkata. It was cleared that potato prices typically double between the end of harvest in March and the onset of summer in July and August. The most rapid increase in potato prices occurs in April and May. There was a slight dip in price in the

Delhi market in mid summer which may reflect the arrival of a summer crop. Prices then continue to rise until peaking in September or October when existing stocks are lowest and just prior to the arrivals on the market of early potatoes in months of November and December.

Mipramavar and Gummagolamath (1998) studied seasonal indices of arrivals and prices of potato in regulated markets of Northern Karnataka. They revealed that the arrivals were maximum in the month of November in both Belgaum and Dharwad, the markets indicating glut during harvesting season. This situation prevailed mainly due to lack of storage facilities in the area. The seasonal index of arrivals and prices revealed that the seasonal fluctuations in arrivals of potato were more than that of price in Belgaum market. From the above reviews, it is clear that the market arrivals were higher in the months of March and April, and price also had shown decrease at peak period, whereas, price was higher from September to December in the lean period. The arrivals had shown increasing trend from 1989 to 1999 in Belgaum market because of increase in the production of potato. The seasonal fluctuations were more in both price and arrivals due to lack of storage facility and lack of market information.

Ravikumar *et al.* (2001) concluded that in general, arrivals showed mixed trend, whereas, prices showed an increasing trend for the selected commodities in Anakapalle regulated market of Andhra Pradesh. There exists an inverse relationship between seasonal indices of arrivals and prices of selected commodities. Therefore, the policy implication lies in encouraging the farmers dispose their produce at the opportune time to get good remunerative prices. It requires providing finance to farmers and better storage facilities either at village level or at market level so as to spread the arrivals reasonably in the lean months of the year.

Shivaraya and Hugar (2002) inferred that the prices of onion and potato increased as there is increase in arrivals in Belgaum, Hubli, Raichur and Gulbarga markets. However, reverse trend was observed in other markets. The correlation coefficient between arrivals and prices of onion showed negative association with storage cost in Dharwad, Bijapur and Raichur markets and potato in Dharwad market. This clearly indicated that the prices of onion and potato were mainly influenced by their arrivals in these markets in accordance with the law of demand and supply. The substantial quantity of arrivals during post-harvest months of the year led to decline in prices. The development of warehousing facilities and provision of credit to the farmers against warehouse receipts would go a long way in reducing the variation in arrivals and prices. This also calls for dissemination of market information relating to arrivals, prices *etc.* by the respective Agricultural Produce Market Committees.

2.4 BOX-JENKINS MODEL

A class of ARIMA (Auto Regression Integrated Moving Average) model is called Box-Jenkins model. Box and Jenkins popularized it during late sixties. The application of these models for predicting prices of agricultural commodities is very few. Some studies, which have used this modular, reviewed below.

Kirby (1966) employed three different time series methods *viz.,* moving averages, exponential smoothing and regression method. It reveals that interms of month-to-month forecasting accuracy, exponential smoothing method did best, with smoothing averages and exponential smoothing giving similar results when the forecasting horizon was increased by six months. The regression method to long-term forecasts of one year or more.

Reid (1969, 1971) studied comparison of univariate techniques on economic time series used a quadratic cost function various criteria were taken for comparison *viz.,* number of observations available, whether the data were seasonal, whether one was trying to predict long or short lead times and so on. He concluded that when more than 50 observations were available, Box-Jenkins method gave the best “one step a head” forecast to most time series (though not for all series)

Lijung and Box (1978) proposed an alternate test to the Box-Pierce Q statistic, on the grounds that the values of the Q statistic gets inflated for large values of n. Their modified test was;

$$Qr = n(n+2)^{n} (n-k)^{-1} r^{2}_{k}$$

Where,

Qr : Follows a χ^2 (n-q-p) distribution

r_k : Sample auto correlation at time log k

k = Number of lags

q = moving average term

p = Autoregressive term

2.4.1 Price forecasting model

Chatfield and Protharo (1973) observed that the Box-Jenkins procedures was not suitable for sale forecasts with a multiplicative seasonal component in this analysis, monthly data on sales of a company was used. The adequacy of the model was tested using Box-Pierce test.

Govindan (1974) used Box-Jenkins model to analyse wholesale price indices of rice, wheat, jowar and grain. The short-term forecasts were found to give good results while the same was not true of long-term forecasts. Janus quotients of the forecasts showed that the model gave good results.

Newbold and Granger (1974) compared the forecast performance of the Box-Jenkins, Holt-winters and step-wise regression models. The study indicated that each method had its own advantage over the others. It was opined that the Box-Jenkins gave better forecasts in the short-run, but the method required time and skill to compute the results indicated that for time series with less than 30 observations step-wise regression was better, for data between 30 to 50 observations. A combination of Holt-winters and step-wise regression was found suitable for series of 50 and above the Box-Jenkins performed well for data with strong seasonal and long fluctuations the Holt-winters model was suggested.

Protharo and Wallis (1976) examined the extent to which variations in a series could be explained first by a dynamic econometric model and than by a ARIMA model. Econometric model clearly indicated that they provided a closer estimate and behaviour of the series during the sample periods.

Chatfield (1977) observed that the Box Jenkins approach being a valuable addition in the forecasts tool bag, which have deeper understanding of time series behaviour. Eventhough, it was found to be more expensive yet the accuracy justified the cost.

Makridakis and Hibbon (1979) observed that accuracy of forecasts are negatively associated with the error term. Several tests to arrive at the accuracy of forecasts like Mean Square Error (MSE). Theil's 'U' coefficient and Mean Absolute Percentage Error (MAPE) were suggested.

Chengappa (1980) applied the Box-Jenkins model to forecast pool sale and export auction prices of coffee. Monthly data were used and due to the distinct seasonal variation in prices, the ARIMA seasonal model was applied. The pool sale price forecasts were found to be accurate when compared to forecasts of export prices. This was attributed to possible lack of stationary to the data. Hence, the adoption of differencing procedure or a transformation to make the data stationary was found necessary for a better estimate of export prices.

Achoth (1985a) analysed the supply, price and trade of Indian tea by fitting ARIMA models to data on prices and production. The moving average models were found to be most suitable. Among the price series particular months price was not related to the price of the immediate previous month but significantly related to the price of the same month in previous year. However, the production in a particular month was related both to production of the previous month as well as to the production of the same month in previous years. The forecasts yielded reasonably good results as judged from the tests of their efficiency. The

forecasts of prices were superior when compared to the forecasts of quantities, which was attributed to the highly structured pattern of price behaviour.

Achoth (1985b) fitted the seasonal ARIMA model to price data of tea at Calcutta and Cochin auctions to production data of Northern and Southern regions of the country and quantity of tea exports and their prices. He identified that the moving average model was most suitable. The forecasts from these models yielded reasonably good ex-post and ex-ante forecasts judging from the test of their efficiency. By for the forecast of prices were superior to the forecasts of quantities which may be due to the predictable pattern of price behaviour. Further, some of the models fitted to the quantity series did reveal a certain degree of inadequacy which was not considered serious probably because certain cyclic pattern may not have been captured by the model.

Devaiah *et al.* (1988) attempted forecasting the prices of cocoons at Ramanagaram market by using ARIMA models. The forecasts was made for 13 months from April 1987 to April 1988. The forecasted values were observed to be close to the actual prices.

Lanciotti (1990) presented a paper that analyses time series data of monthly prices for a group of dairy products with the aim of obtaining reliable forecasts. The method of analysis employed is ARIMA as put forward by Box-Jenkins. The time series data covers both wholesale and retail prices for butter. Gorgonzola, Provolone, Grana Padano and Pasmigiano Reggiano. To estimate the reliability of the forecasts obtained, a comparison is made with those resulting from naïve models do not require any estimates. Indicators on the accuracy of the forecasts show that except for Grana Padana, Le ARIMA forecasts are better.

Yin-Runsheng and Min-Rs (1999) used for timber price forecasts were conducted with univariate Auto Regression Integrated Moving Average (ARIMA) models employing the standard Box-Jenkins modeling strategy using quarterly price series Timber Mart South, results showed that most of the selected pipe pulpwood and saw timber markets in six southern US states can be evaluated using ARIMA models, and that short-term forecasts, especially those of one lead forecasts, are fairly accurate. It is suggested that forecasting future prices could aid timber producers and consumers alike in timing harvests reducing uncertainty and enhancing efficiency.

Mastny (2001) used ARIMA models, also called Box and Jenkins, models after their developers, is a group of models allowing the analysis of time series with various features. The article demonstrates the possible usage of the Box-Jenkins methodology for the analysis of time series for agricultural commodities. The paper contains a basic mathematical explanation of ARIMA models together with a practical illustration of a price development forecast for a selected agricultural commodity.

III. METHODOLOGY

This chapter presents the methodology employed in the study. It also deals with the selecting of the markets, sources and nature of data and the analytical techniques, which are used in the analysis. This chapter has the following headings.

3.1 Selection of the markets

3.2 Database

3.3 Analytical techniques

3.1 SELECTION OF THE MARKETS

Potato was the crop selected for the study. As per the Karnataka State Agricultural Marketing Board (KSAMB), the major markets for potato in Karnataka were Bangalore, Belgaum, Chikkaballapur, Hassan, Hubli, Kolar and Mysore. Out of these seven markets, five markets were selected for the study based on the volume of arrivals. They are Bangalore, Belguam, Hassan, Hubli and Kolar. The total arrivals potato ding 1992-93 was 25, 39, 112 quintals in the state, out of which the above selected five markets accounted for about 98 per cent (*i.e.,* 24, 86, 607 quintals).

3.2 DATABASE

Data for the study were obtained from secondary sources. Time series data on the monthly arrivals and prices of potato required for the study were collected from the Karnataka State Agricultural Marketing Board (KSAMB), Bangalore. This board receives monthly arrivals and prices data from the respective Agricultural Produce Market Committees (APMCs) of various markets throughout the state. Both, the board as well as APMCs maintain data on daily, monthly and yearly arrivals and prices of the regulated agricultural commodities.

The data on arrivals refer to the total arrivals during the month in quintals in a market place. The data on prices used refer to the modal price in a month. Modal price is considered to be superior to the monthly average price as it represents the major proportion of the commodity marketed during the month in a particular market.

The data on monthly total arrivals and modal prices were collected for the period of 1996-97 to 2003-04 (8 years) April-March for the selected markets.

3.3 ANALYTICAL TECHNIQUES

In this section, a brief description of statistical tools employed was presented.

Time series analysis employed for studying the long-term, short-term and other periodic fluctuations in price and arrivals of potato for each market

3.3.1 Relationship between price and arrivals

Box-Jenkins model for forecasting of price and arrivals was used. This is a methodological investigation (suitability of the model).

3.3.2 Analysis of time series

Database for time series analysis was the data on price and arrival in chronological order. Such a data is usually conceived of as being generated by certain regulated base causative sources such as long-time forces, cyclical forces usually with a periodicity of longer duration than a year, annual fluctuation associated with season of a year and many other sources of fluctuations producing random effects. These are described as detailed below.

The graph of such a time series data gives a rough idea about the nature of fluctuations in the value of the variable with time. The fluctuations have the combined effect of various causes such as the ones mentioned above which sometimes induce sharp rise and fall. Segregating these various types of fluctuations in the time series is known as analysis of time series.

The important basic components of time series are i) secular trend (T_t) ii) seasonal variation/periodic movements (S_t) iii) cyclical movements (C_t) and iv) irregular variations (I_t).

Secular trend (T_t) : Over a long period of time, time series is very likely to show a tendency to increase or decrease over time. The factors responsible for such changes in time series are the growth of population change in the taste of people, technological advances in the field *etc.*

There are different types of trends, some of them are linear and some are non-linear in their form. For shorter period of time, in most of the situations the straight line provides the best description of trend and for longer period of time, the non-linear form generally provides a good description of the trend. Often, it may be possible to describe such movements a structured mathematical model. In the absence of such a definite format, approximately a polynomial or a free hand could describe the movements.

Periodic movement (seasonal variation) (S_t) : The variation with in a year is called as seasonal variation. The main causes of seasonal variations are customs, climates *etc.* Such seasonal components can be analysed through harmonic analysis.

Cyclical movements (C_t) : Cyclical movements are fluctuations which differ from periodic movements (cyclical movements) have longer duration than a year and have periodically of several years as in business cycles.

Irregular variations (I_t) : Here the effects could be completely unpredictable, changing in a random manner. A given observation is affected by episodic and accidental factors. These are also known as causal series and are affected by the unknown causes. These unknown causes act in an unpredictable manner.

3.3.3 Time series model

For analysis of time series data, a model is essential. Generally two broad approaches are resorted too. One is a multiplicative model and the other is an additive model. There could be other approaches too resulting in a hybrid model of these two. In this present study multiplicative model has been employed, since many of agriculture data admit such a model as a more appropriate one.

Let the original observation at the time point to be denoted by Y_t and the four components *viz.,* Trend, seasonal, cyclical and irregular variations by T_t, S_t, C_t and I_t, respectively, for a time period t (where, t = 1, 2, 3…).

Then the multiplicative model can be expressed as;

$Y_t = T_t \times S_t \times C_t \times I_t, \qquad t = 0, 1, 2\ldots$

3.3.4 Estimation of seasonal indices of monthly data

The multiplicative model permits the estimation of each of the four components.

As a first step, to estimate the seasonal index a 12 months centered moving averages was calculated as follows.

$$M_1 =$$

$$M_2 = \frac{Y_1 + 2Y_2 + 2Y_3 + \ldots\ldots\ldots\ldots\ldots\ldots + 2Y_{12} + Y_{13}}{12}$$

$$M_3 = \frac{Y_2 + 2Y_3 + 2Y_4 + \ldots\ldots\ldots\ldots\ldots\ldots + 2Y_{13} + Y_{14}}{12}$$

$$M_3 = \frac{Y_3 + 2Y_4 + 2Y_5 + \ldots\ldots\ldots\ldots\ldots\ldots + 2Y_{14} + Y_{15}}{12}$$

etc., which is a sequential manner for each points of time t.

In this fashion a 12 month centered moving average removes a large part of fluctuation due to seasonal effects so that what remains is mainly attributable to other sources

viz., long-term effects T_t and cyclical effect C_t; the irregular variation (I_t) due to random causes is also minimized as process of smoothing out effect. Thus, this affords a means of not only estimating trend cycle effect but also estimating seasonal components.

In the next step of computing the seasonal index, the original series is divided by the centered moving average. This gives the first estimate of seasonal components (S_t).

$$S_t = \frac{Y_t}{(TC)_t}$$

$$S_I = \frac{T_t \,.\, C_t \,.\, S_t \,.\, I_t}{T_t \,.\, C_t}$$

It is always expressed in terms of percentages (column 4 of Table 3.1). In this process, we do not have moving average for first six and last six months. These seasonal components are next arranged month-wise for each year (Table 3.2).

The last row in the Table 3.2 give estimates of seasonal index for the 12 months, adjusted for their total to 1200 or averaged to 100.

The last row of Table 3.2 gives the first estimates of seasonal variations. In order to obtain a better estimate *i.e.,* stabilized seasonal indices we need to employ an interactive process as under.

The original observation (Y_t) is divided by corresponding (S_t) value and then obtain the residual $(TCI)_t$ corresponding to time point t.

$$(TCI)_t = = \frac{Y_t}{S_t} \qquad \frac{(TCSI)_t}{S_t}$$

The residual series $(TCI)_t$ thus obtained is subjected to the same process of determining 12 month centered averages as done earlier to obtain better estimates for trend cycle effect *viz.,* $(TC)_t$. These revised estimates are next employed as above to generate a revised set of seasonal indices by dividing each observation (Y_t) by the corresponding $(TC)_t$ value. This will lead to revise estimates of seasonal indices (S_t) as second interactive ones. This interactive process is separately employed until stabilized seasonal indices are obtained *i.e.,* two successive seasonal indices do not differ by more than five per cent i.e.

$$\frac{S_{i+j} - S_i}{S_i}$$

$$(TCI)_t = \times 100 \leq 5 \quad i=j=1, 2, \ldots 12 \qquad (3.4)$$

3.3.5 Estimation of cyclical indices

The most commonly used method for estimating cyclical movement of time series is the Residual method by eliminating the seasonal variation and trend. This is accomplished by dividing (Y_t) by corresponding (S_t) for time t.

Symbolically, = T. C. I. and

$$\frac{T.\,C.\,I}{T} = C.\,I.$$

$$\frac{T.\,C.\,S.\,I}{S}$$

Table 3.1: Computation of centered 12 months moving average

Year/month	Observations (Y)	Centered 12 months moving average	Per cent 12 months moving average
1996			
July	Y_1	-	-
August	Y_2	-	-
September	Y_3	-	-
October	Y_4	-	-
November	Y_5	-	-
December	Y_6	-	-
1997			
January	Y_7	M_1	S_1
February	Y_8	M_2	S_2
March	Y_9	M_3	S_3
April	Y_{10}	M_4	S_4
May	Y_{11}	M_5	S_5
June	Y_{12}	M_6	S_6
July	Y_{13}	M_7	S_7
August	Y_{14}	M_8	S_8
September	Y_{15}	M_9	S_9
1998			
January	Y_{16}	M_{10}	S_{10}
*	*	*	*
*	*	*	*
2003			
*	Y	M	S

Table 3.2 : Average of percentage centered 12 months moving average and computation of seasonal index for observation

Year	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1996							S	S	S	S	S	S
1997	S	S	S	S	S	S	S	S	S	S	S	S
**	*	*	*	*	*	*	*	*	*	*	*	*
**	*	*	*	*	*	*	*	*	*	*	*	*
2003	S	S	S	S	S	S						
Mean	*	*	*	*	*	*	*	*	*	*	*	1200
Adj seasonal index	*	*	*	*	*	*	*	*	*	*	*	100

Table 3.3: Tabular format of obtaining cyclical component

Months cycle	1	2	3	31	32	60	Total
I	*	*	*……*	C	C……C	C	
II	C	C	C……C	C	C……C	C	
III	C	C	C……C	C	C……C	C	
IV	C	C	C……C	C	C……C	C	
V	C	C	C……C	C	C……C	C	
Mean	-	-	-	-	-	-	
Cyclical index (adjusted)	-	-	-	-	-	-	Row total

These deseasonalized data contain trend, cyclical and irregular components. This trend cycle components are plotted against time for examining cyclical behaviour. If there is any existence of cycle, periodicity of cycle is noted. Again moving average of length equal to periodicity of cycle is computed for eliminating cyclical behaviour.

These moving averages are arranged cycle wise. These are adjusted for cyclical indices, as in the case of seasonal indices. Then trend cycle values (TC) are divided by adjusted components CI (Table 3.2).

The examination of both the graphs of trend cycle component as well as trend component will give a clear idea of the presence of cycle. If there is similarity in these two graphs, it is an indication of non-existence of the cycle. However, the non-similarity in the two graphs is an indication of the presence of the cycle. If ultimately a cycle is reflected, then the cyclical effect is removed from T-C components. If no cycle is detected, then the trend cycle values are treated as pure trend values. The Friedman's two-way analysis of variances was employed to know the significant differences among months within a cycle and also between cycles. A significant difference indicates the presence of changing cyclical behaviour and non-significant difference indicates the consistency of cyclical pattern.

3.3.6 Analysis of long-term movements

The residuals ($T_t = Y_t/S_tC_t$) after eliminating seasonal effects and cyclical effects (if any) from original observations (Y_t) are used to determine the trend. If there is no cyclical pattern, then trend cycle components are treated as trend values.

When definite mathematical model cannot be identified to fit to trend data, the orthogonal polynomials are used to determine the long term behaviour. These polynomials are fitted by the principles of least squares. The polynomials tried are shown below.

1^{st} degree (straight line) $= Y_t = a + bx + e$

2^{nd} degree polynomial $= Y_t = a + bx + cx^2 + e$

3^{rd} degree [polynomial $= Y_t = a + bx + cx^2 + dx^3 + e$

4^{th} degree polynomial $= Y_t = a + bx + cx^2 + dx^3 + ex^4 + e$

5^{th} degree polynomial $= Y_t = a + bx + cx^2 + dx^3 + ex^4 + fx^5 + e$

6^{th} degree polynomial $= Y_t = a + bx + cx^2 + dx^3 + ex^4 + fx^5 + gx^{6+} e$

Where,

Y_t = Trend values at time t

e = Disturbance term

a, b, c, d, f and g are the coefficients to be estimated.

The suitable model for data is judged based on R^2 (coefficient of determination) value, after adjustment for loss in df is made.

3.3.7 Relationship between two markets

Sometimes, it is of interest to know, to what extent price variation of one market is reflected in the price prevalence in the other market and vice-versa. These in a way measure the market integration for some commodity.

The most convenient and simple method for measuring the relationship between two markets is conventionally through computation of correlation coefficient between unadjusted series of two markets. However, while correlating price series of two markets, of a given period, it is necessary to adjust for trend, otherwise there will be a biased measure of market integration, because price contains trend effects also. Therefore, price series adjusted for trend is recommended as a better measure.

A significant correlation implies that the markets are well integrated *i.e.,* markets are mutually dependent on price.

3.3.8 Relationship between prices and arrivals

A correlation coefficients (r) between arrivals and prices for a given market is also computed. This is a method which confirms an assumption of the inverse relationship between price and arrivals.

3.4 BOX-JENKINS MODELS

The Box-Jenkins procedure is concerned with fitting a mixed Auto regressive Integrated Moving Average (ARIMA) model to a given set of data. The main objectives in fitting this ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. These methods have also been useful in many types of situation which involve the building of models for discrete time series and dynamic systems. But, this method was not good for lead times or for seasonal series with a large random component (Granger and Newbold, 1970).

Originally ARIMA models have been studied extensively by George Box and Gwilym Jenkins (1968) and their names have frequently been used synonymously with general ARIMA process applied to time series analysis, forecasting and control. However, the optimal forecast of future values of a time-series are determined by the stochastic model for that series. A stochastic process is either stationary or non-stationary. The first thing to note is that most time series are non-stationary and the ARIMA model most time series are non-stationary and the ARIMA model refer only to a stationary time series. Therefore, it is necessary to have a national distinction between the original non-stationary time series and its stationary counterpart.

3.4.1 Stationarity and non-stationarity

The term stationarity meaning that the process generating the data is in equilibrium around a constant value and that the variance around the mean remains constant over time. The data must be roughly horizontal along time axis.

If mean changes over time (with some trend cycle pattern) and variance is not reasonably constant then series is non-stationary in both mean and variance.

If a time series is not stationary, then it can be made more nearly stationary by taking the first difference of the series. Conversely a stationary process may be summed or integrated to give a non-stationary process.

Let X_t be a random variable and x_t (where t=1, 2……n) be the observations on X_t with density function f (x_t). If the observation are independent, then

$$f(X_1, X_2 \ldots\ldots..X_n) = f_1(x_1)\, f_2(x_2) \ldots.. f_n(x_n)$$

This implies that joint distribution is independent of historical time.

The assumption of stationarity reduces the number of parameters in the joint probability density function of a random variable x_t in the series.

Since the ARIMA model refer only to a stationary time series, the first stage of Box-Jenkins model is reducing non-stationary series x_t to a stationary series Y_t by taking first differences as follows

$$\begin{aligned} Y_t &= \nabla X_t \qquad (3.1)\\ &= X_t - X_{t-1}\\ &= X_t - BX_t\\ &= (1-B)X_t \end{aligned}$$

Where,

B = Backward shift operator

The backward shift operator is convenient for describing the process of differencing. To define B, such that

$$B_i\, x_t = x_{t-i} \qquad i = 1, 2, \ldots$$

Suppose the first difference of the series doesn't become stationary then second order differencing is done as follows;

$$\begin{aligned} Y_t &= \nabla\,(\nabla\, X_t) \qquad (3.2)\\ &= \nabla\,(X_t - X_{t-1})\\ &= (X_t - X_{t-1}) - (X_{t-1} - X_{t-2})\\ &= X_t - 2X_{t-1} + X_{t-2}\\ &= X_t - 2BX_t + B^2X_t\\ &= (1 - 2B + B^2)\, X_t\\ &= (1 - B)^2\, X_t \qquad (3.3) \end{aligned}$$

In general, if it takes a d^{th} order difference to achieve stationarity we will write

d^{th} order difference $= (1\text{-}B)^d\, X_t$

The general ARIMA (o, d, o) model will be

$$= (1 - B)^2\, X_t = e_t \qquad (3.4)$$

Where e_t is error term distributed normally with

$E(e_t) = 0$, $V(e_t) = e_t^{\,2}$ and

$Cov(e_i, e_j) = \theta$ for all t. $(i \neq j)$.

In order to test the stationarity, compute the auto-correlation functions (ACF) of difference series (Y_t) upto 24 lags. If the ACF for first and higher differences (after 2-3 lags) drop abruptly to zero then it indicates the series is stationary.

3.4.2 Stationary time series model

3.4.2.1 Auto Regressive process (p, o, o)

If the observation Y_t depends on previous observation and error term e_t is called auto regressive process (AR process)

$$\begin{aligned} Y_t &= \mu + \varnothing_1 Y_{t-1} + \varnothing_2 Y_{t-2} + \ldots\ldots\ldots + \varnothing_p Y_{t-p} + e_t \qquad (3.5)\\ &= \varnothing_p\,(B)\,(Y_t - \mu) + e_t \end{aligned}$$

Note the term μ in equation (3.5) is not quite the same as the "Mean" of the Y series. Rather, the development is as follows:

$$\begin{aligned} (Y_t - \mu) &= \phi_p\,(Y_t - \mu) + e_t\\ &= \phi_1\,(Y_{t-1} - \mu) + \phi_2\,(Y_{t-2} - \mu) + \ldots\ldots\ldots \phi_p\,(Y_{t-p} - \mu) + e_t\\ &= (\phi_1\, Y_{t-1} - \phi_1\mu) + (\phi_2\, Y_{t-2} - \phi_2\mu) + \ldots\ldots\ldots (\phi_p\, Y_{t-p} - \phi\mu) + e_t\\ Y_t &= (\mu - \phi_1\mu - \ldots\ldots\ldots - \phi\mu) + \phi_1 Y_{t-1} + \ldots\ldots\ldots + \phi_p Y_{t-p} + e_t\\ &= \mu_1 + \phi_1 Y_{t-1} + \ldots\ldots\ldots + \phi_p Y_{t-p} + e_t \end{aligned}$$

and the values of auto regressive coefficient restricted to lie between – 1 and + 1.

3.4.2.2 Moving Average Process (o, o, q)

If the observation Y_t depends on the error term e_t and also on one or more previous error terms (e_t 's) then we have Moving Average (MA) process.

$$Y_t = \mu_{1+} e_t - \theta_1 e_t\, t_{-1} \theta_2 e_{t-2} - \ldots\ldots \theta_p e_t\text{-}q$$

Where,

$\theta_i \rightarrow$ i^{th} moving average parameter

$i \rightarrow$ 1, 2, …. q

$q \rightarrow$ order moving average

The values of the coefficient are restricted to lies between –1 to +1.

3.4.2.3 Mixtures : ARIMA Process

If the non-stationarity is added to a mixed ARMA process, then the general ARIMA (p, d, q) is implied. Here the word integrated is confusing to many and refers to the differencing of the data series.

$$(1 - B)^d (1 - \phi_p B^p) Y_t = u + (1 - \phi_p B^q) e_t \ldots\ldots\ldots \qquad (3.9)$$

The main stages in setting up a box-Jenkins forecasting model are as follows :

1. Identification
2. Estimating the parameters
3. Diagnostic checking and
4. Modification

3.4.2.3.1 Identification of models

A good starting point for time series analysis is a graphical plot of the data. It helps to identify the presence of trends.

Before estimating the parameter (p,q) of model, the data are not examined to decide about the model which best explains the data. This is done by examining the sample ACF (Autocorrelation function) and PACF (Partial Autocorrelation function) of differenced series Y_t. Usually ACF and PACF are calculated upto maximum of 24 lags (k).

The sample auto correlations for k time lags can be found and denoted by rk as follows.

$$P_k (Y_t) = r_k (Y_t)$$

$$= \frac{e_k (Y_t)}{e_0 (Y_t)}$$

Where,

$$C_k (Y_t) = \frac{1}{n} \sum_{t=1}^{n} (Y_t - \bar{Y})(Y_{t+k} - \bar{Y})$$

k = 0,1,2…16

t = 1, 2, …n-k

$\bar{Y} = \frac{1}{n} \sum_{t=1}^{n} Y_t$

n = Length of time period

Both ACF and PACF are used as the aid in the identification of appropriate models. There are several ways of determining the order type of process, but still there was not exact procedure for identifying the model.

3.4.2.3.2 Estimation of parameters

After tentatively identifying the suitable model, next step is to obtain least sequence estimates of the parameters such that the error sum of squares is minimum.

$$S(\theta, \varnothing) = = \Sigma e_t^2 (\theta, \varnothing)$$

$$t=1 \qquad (3.13)$$

Where,

$$n$$

t = 1, 2, 3…n.

There are fundamentally two ways of getting estimates for such parameters:

a) Trail and error : Examine many different values and choose set of values that minimizes the sum of squares of residual

b) Interative method : Choose a preliminary estimate and let a computer program refine the estimate interatively

The latter method is used in our analysis for estimating the parameters.

3.4.2.3.3 Diagnostic checking

After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the model is adequate.

Examining ACF and PACF of residuals may show up an adequacy or inadequacy of the model. If it shows random residuals, then it indicates that the tentatively identified model was adequate. When an inadequacy is detected, the checks should give an indication of how the model need be modified, after which further fitting and checking takes place.

One of the procedures for diagnostic checking mentioned by Box-Jenkins is called over fitting *i.e.,* using more parameters are necessary. But the main difficulty in the correct identification is not getting enough clues from the ACF because of inappropriate level of differencing. The residuals of ACF and PACF considered random when all their ACF were within the limits.

$$\pm 1.96 \qquad (3.14)$$

We also used Box and Pierce (1970) 'Q' statistic for whether the auto correlations for these residuals are significantly different from zero. It can be computed as follows.

$$Q = n \sum_{k=1} r_k^2 \qquad (3.15)$$

Where,

$$m\sqrt{\frac{1}{(n-12)}}$$

m = Maximum lag considered

n = N - D

N = Total number of observations

r_k = ACF for lag k

D = Differencing

Where, Q is distributed approximately as a Chi-square statistic with (m-p-q) degree of freedom.

The minimum Akike Information Coefficient (AIC) criteria is used to determine both the differencing order (d, D) required to attain stationarity and the appropriate number of Auto Regressive (AR) and Moving Average (MA) parameters it can be computed as follows;

$$AIC_{(p+q)} = N\,\sigma^2 + 2\,(p + q) \qquad (3.16)$$

Where,

σ^2 = Estimated MSE.

N = Number of observations

(p + q) = Number of parameters to be estimated

This diagnostic checking helps us to identify the differences in the model, so that the model could be subjected to modification, if need be.

3.4.2.3.4 Forecasting

After satisfying about the adequacy of the fitted model, it can be used for forecasting. Forecasts based on the model.

$$(1-\varnothing B) = (1-\phi B)\, e_t \qquad (3.17)$$

were computed for upto 24 months (m) ahead. The above model (3.17) gives the forecasting equation as

$$Y_t = \varnothing Y_{t-1} + e_t - \theta e_{t-1} \qquad (3.18)$$

Given data upto time 't' the optional forecast of Y (also called Ex-Ante forecast) model at the t is the conditional expectation of Y_{t+1}.

It follows, in particular, that

$$e_t = Y_t - Y_{t-1} \qquad (3.19)$$

"The errors e_t in (3.19) are in fact the forecast errors for unit lead time. That for an optimal forecast these 'one step ahead' forecast errors ought to from an uncorrelated series is otherwise obvious". Suppose, if these forecast errors were autocorrelated; then it would be possible to forecast the next forecast error in which case it could not be optimal.

The required expectations are easily found because

$$E(Y_{t+m}) = Y_t(m), \qquad E(e_{t+m}) = 0, \qquad (3.20)$$

Where,

m = 1,2,3, … 19

$$E(Y_{t-m}) = Y_{t-m}, \; E(e_{t-m}) \quad = a_{t-m} = Y_{t-m} - Y_{t-m-1} \qquad (3.21)$$

Where, m = 0,1,2,……..16

For instance, to determine the three month ahead (1-3) forecast for series Y_t (use equation (3.18).

$Y_{t+1} = Y_{t+3}$

$= \varnothing Y_{t+2} + \phi Y_{t-9} - \varnothing\phi Y_{t-10} + e_{t+13} - \theta e_{t-2} - (H)\, e_{t-9} + \theta(H) e_{t-10}$

taking conditional expectations at time t,

$Y_t(1) = Y_t(3)$

$= 0\; Y_{t(2)}{}^{+} 0 - 0(\,0\,)$

Because, $E(e_{t+1}) = 0$, $E(e_{t-1}) = Y_{t-1} - Y_{t-1} = e_{t-1}$

i.e., $Y_t(3) = 0 Y_t(2)$ ^

The forecast $Y_t(2)$ can be obtained in a similar way in terms of $Y_t(1)$ from E (Y_{t+2}). Similarly Y_t (1) can be obtained from E (Y_{t+1}).

In practice it is very easy to compute the forecast Y_t (1), Y_t (2), Y_t (3) *etc.*, recursively using the forecast function (3.18).

E(Yt+1) = E(0Yt+1-1 + Q_{t+1}-0 $e_{t+1-1)}$ - θ e_{t+1-1} - (H) e_{t+1-12} + θ(H)e_{t+1-13} and using (3.20) and (3.21).

However, using these methods, Ex-post forecasts can also be calculated for comparing with the value actually realized.

The accuracy of forecasts for both Ex-ante and Ex-post were tested using the following tests (Markidakis and Hibbon, 1979).

1) Mean square error (MSE); the formula for computing MSE is

$$MSE = \frac{1}{n} \sum_{t=1}^{n} (X_t - \hat{X}_t)^2$$

Where,

X_t = Actual values

$\hat{X}_t$ = Predicted values

2) Mean average percentage error (MAPE) : The formula for this is

$$MAPE = \frac{1}{n} \sum_{t=1}^{n} \frac{|X_t - \hat{X}_t|}{X_t} \times 100$$

X_t = Actual values

$\hat{X}_t$ = Predicted values

3.5 CO-INTEGRATION TEST

Spatial price relationship have been widely used to indicate overall market performance. The usual definition is that integrated markets are those where prices are determined interdependently. This has generally been assumed to mean that the price changes in one market will be fully transmitted to the other markets. Co-integration test was developed by Engle and Granger (1987) to show the integration between different markets.

In short, if markets are efficient, then prices in different markets must be co-integrated. To examine the price relation between two markets the following basic relationship is commonly used to test for the existence of market integration.

$$Pit = \alpha_0 + \alpha_1 P_{jt} + \varepsilon_t \qquad (3.22)$$

Where, Pi = Price series of a specific commodity in i^{th} market

P_j = Price series of a specific commodity in j^{th} market

ε = is the residual term assumed to be distributed identically and independently

. α= represent domestic transportation costs, processing costs, sales taxes etc.

The test for market integration is straight forward if Pi and Pj are stationary variables. Often, however economic variables are non-stationary in which case the conventional tests are biased towards rejecting the null hypothesis. Thus, before proceeding to further analysis, it is important to check for stationarity of variables (Granger and New Bold, 1977).

Stationary series is defined as one whose parameters that describe the series (namely mean, variance and autocorrelation) are independent of time or rather exhibits

constant mean and variance and have autocorrelation that are invariant through time. Once the non-stationarity status of the variables are obtained, the next step is to test for the presence of co-integration relationships between the variables.

Dickey-Fuller (1979) test (DF test) can be used to determine the stationarity of variable. The test is based on the t-statistic of □1 given by following equation.

$$P_t = \square_0 + \square_1 P_{t-1} + \text{---} \square \text{---} Pt_{-1} + \square_t \qquad (3.23)$$

Where $P_t = P_t - P_{t-1}$, the test statistic is simply the t-statistic, however, under the null hypothesis it is not distributed as student-t, but this ratio can be compare with critical values tabulated in Fuller (1976). In estimation of the equation, the null hypothesis is $H_0 : P_1$ is I(1) which is rejected [in favour of I (0)] if $\square_1$ is found to be negative and statistically significant. The above test can also be carried out for first difference of the variables. That is, we estimate the following regression equation.

$$^2P_t = \square_0 + \square_1 P_{t-1} + \text{--} \square_k \ 2P_{t-k} + \square_t \qquad (3.24)$$

Where the null hypothesis is $H_0 : P_t$ is I(2), which is rejected [in favour of I(1) if $\square_1$ is found to be negative and significant. In general, a series Pt is said to be integrated of order d, if the series achieves stationarity after differencing d time, denoted $P_t \sim I(d)$. Consequently, if P_t is stationary after differencing once then we may denote $P_t \sim I(1)$ and $Pt \sim I(0)$. However, in most applied work the procedure is terminated after the first or second differences. As a matter of fact, Nelson and Plosser (1982) have indicated that most macro economic variables are I(1) process, that is, the variables achieved stationarity after differencing once.

Having established that the variables are non-stationary in level, we may then test for co-integration. Only variables that are of the same order of co-integration may constitute a potential co-integration relationship. The definition of co-integration used here that of Engle-Granger (1978a, b) and is defined as follows.

Consider a pair of variables P_i and P_j, each of which is integrated of order d. their linear combination, that is,

$$\square_t = P_{it} - \square P_{jt} \qquad (3.25)$$

will generally be I(d). However, if there is a constant □, such that □ is I(d-b), where b>0, then Pi and Pj are said to be co-integrated of order d, b and the vector (1, d) is called the co-integrating regression. The relation $P_i = \square P_j$ may be considered as long run or equilibrium relation (Engle and Granger, 1987a, b) and □is the deviation from the long run equilibrium. When Pi and Pj are co-integrated, the long run relationship, $P_j \square P_i = 0$ will tend to be reestablished after a stochastic shock.

Before proceedings to test for market integration using the approach of co-integrated analysis, we need to determine the nature of integration of the variables. According to Granger (1986), a model specified by equation (3.26) does not make sense P_i and P_j are of the same order of integration. Thus, a necessary condition for P_i and P_j to be co-integrated is that they must be integrated of the same order. Testing whether the variables are co-integrated is merely another unit root test on the residual in equation (3.25). The test involved regressing the first difference of the residual series on residual lagged level and lagged dependent variables is as follows.

$$\square_t = \square_1 \square_{t-1} + \square \ \square_{t-k} + \square_t$$

(3.26)

Again the test statistic is the t-statistic of $\square_1$. The critical values are tabulated in Fuller (1976). The null hypothesis is H0 : P_i and P_j are not co-integrated. The null hypothesis is rejected if estimated $\square_1$ is negative and found to be significantly different from zero.

Co-integration between the prices of two markets was evaluated by regressing the prices of one market with that of the prices in other market. The residues were examined for the order of integration.

IV. RESULTS

The data collected on arrivals and prices of potato for five markets from the Karnataka State Agricultural Marketing Board (KSAMB) are subjected to statistical analysis using techniques outlined in the previous chapter. The results of such analysis are reported in this chapter under four heads.

4.1 Behaviour of arrivals and prices of potato

4.2 Association between arrivals and prices of potato

4.3 Co-integration

4.4 Box-Jenkins model

First the place and pattern of arrivals in terms of seasonality and trend path are presented. This is followed by similar presentation for price data. Next, the results pertaining to the relationship between the markets. An attempt is made to compare different markets regarding the extent of integration in respect of price of the commodity. Lastly, Box-Jenkins model is preferred to the multiplicative time series model for forecasting purpose. It was used for forecasting of arrivals and prices.

4.1 BEHAVIOUR OF ARRIVALS AND PRICES OF POTATO

4.1.1 Monthly seasonal indices of potato arrivals in Bangalore market

The pattern of variation in arrivals within a year is revealed by seasonal indices were computed for each month. The final estimated stabilized monthly seasonal indices are shown in Table 4.1. It indicates that there are three peak arrivals that is during April (188.3), October (142.7) and March (123.0) the lowest arrivals that is during January (60.2). The data was subjected to the seasonal analysis as described in the previous chapter, to determine the final stabilized seasonal indices.

Seasonality in arrivals movements indicated that the season starts from August and it is peak in October, but from March to April, October and November there is moderate seasonal arrivals was seen. While the lowest arrivals were seen in the month of January. The two way ANOVA is applied to seasonal indices, which indicates that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is a significant difference among the years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.1.2 Secular trend in monthly arrivals of potato in Bangalore market

In order to determine the nature of trend movement in the arrivals of potato in Bangalore market. The data was adequately fitted to 6^{th} degree polynomial. The trend equation was in the form of

$$Y_t = -3E\text{-}05t^6 + 0.0113t^5 - 1.5488t^4 + 101.49t^3 - 3210.7t^2 + 4305t^1 \quad -4435.6$$

$$R^2 = 57.72$$

Where,

Yt = Predicted value of trend at time t

t = Month t = 0, 1, 2, …

It can be seen from above equation the arrivals of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.1.

Table 4.1 : Monthly seasonal indices of potato arrivals in Bangalore market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	241.1	127.7	118.8	59.7	61.5	72.5	681.4
1997-98	72.3	94.8	166.3	139.1	130.0	53.5	64.6	52.1	147.3	76.9	97.0	355.7	1449.5
1998-99	101.7	65.9	8.5	69.0	69.5	62.0	125.0	130.0	47.7	53.3	119.9	94.9	947.5
1999-00	80.3	84.7	91.7	108.6	82.3	107.0	218.0	85.0	64.0	66.5	73.0	94.2	1155.3
2000-01	149.8	95.9	83.3	93.3	57.5	65.5	137.9	116.4	112.7	60.5	73.7	84.9	1131.4
2001-02	307.0	84.7	58.0	6.7	61.2	94.3	151.9	215.3	104.8	47.5	91.4	94.2	1317.1
2002-03	99.9	129.8	85.7	91.3	73.0	83.3	60.8	64.3	66.8	57.0	70.2	64.5	946.4
2003-04	507.1	60.3	55.6	58.6	66.3	50.4	-	-	-	-	-	-	-
Total	1318.1	616.2	549.1	566.7	539.7	516.0	999.2	790.8	662.0	421.3	586.8	860.9	7628.6
SI	188.3	88.0	78.4	81.0	77.1	73.7	142.7	113.0	94.6	60.2	83.8	123.0	1200.0

SI = Seasonal Index

Months : 3.275
Years : 4.927

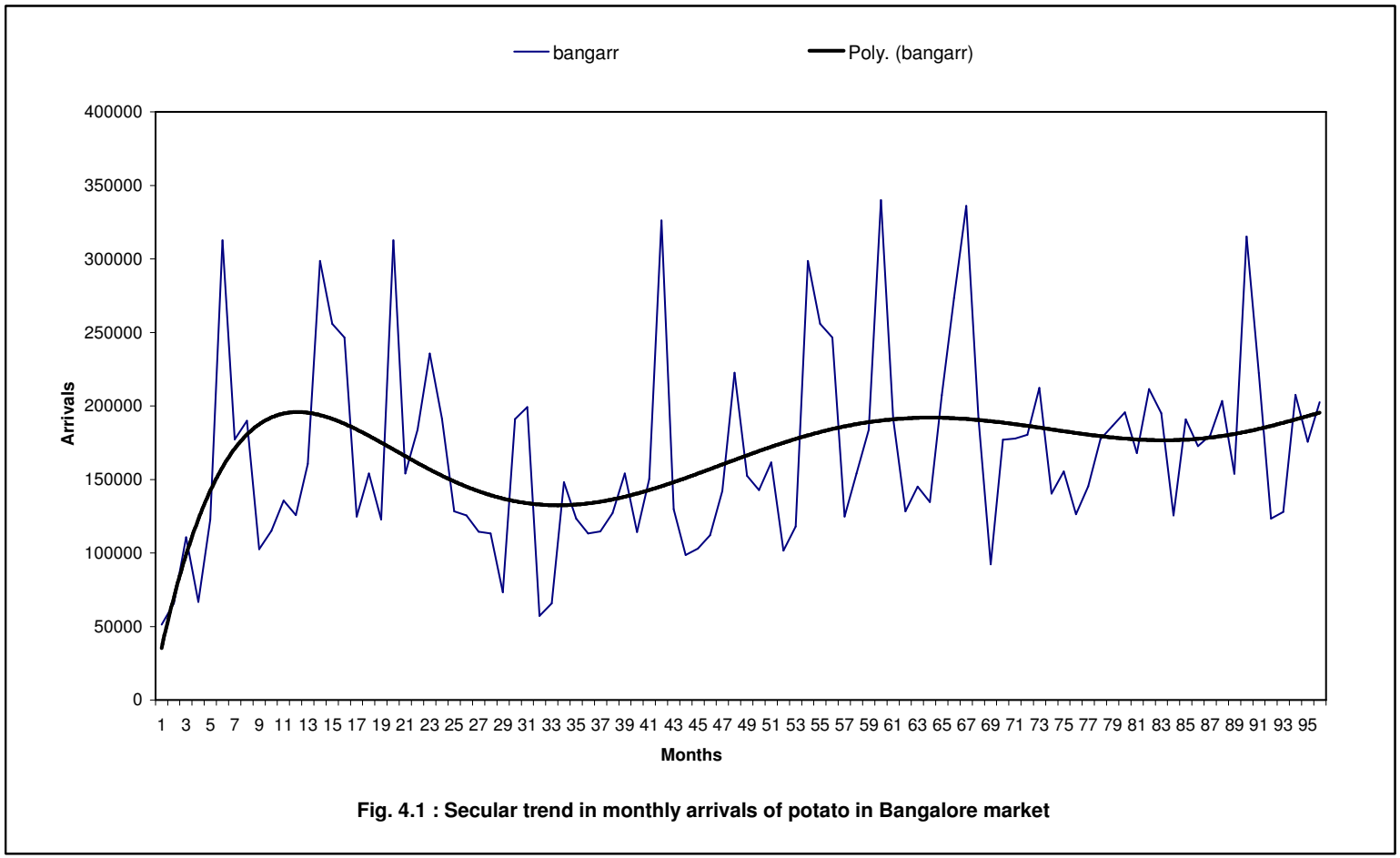


Fig. 4.1 : Secular trend in monthly arrivals of potato in Bangalore market

Fig. 4.1: Secular trend in monthly arrivals of potato in Bangalore market

4.1.2 Monthly seasonal indices of potato prices in Bangalore market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.2. The prices were high during the month of August (127.7), July (116.7) and December (118.6) and lowest during March (73.1) and April (73.4).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.2.1 Secular trend in monthly prices of potato in Bangalore market

In order to determine the nature of trend movement in the prices of potato in Bangalore market, the data was adequately fitted to 6^{th} degree polynomial. The trend equation was in the form of

$$y_t = 3E\text{-}07t^6 - 0.0001t^5 + 0.0121t^4 - 0.6542t^3 + 16.694t^2 \quad -172.99t + 6.64$$

$$R^2 = 31.71$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.2.

4.1.3 Monthly seasonal indices of potato arrivals in Kolar market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.3. The prices were high during the month of April (207.8), March (177.9) and May (169.9) and lowest arrivals during October (48.9) and December (46.3).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F = 1.9153 with 11 and 77 d.f) and there is non-significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.3.1 Secular trend in monthly arrivals of potato in Kolar market

In order to determine the nature of trend movement in the arrivals of potato in Kolar market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$y_t = 2E\text{-}06t^6 - 0.0005t^5 + 0.0713t^4 - 4.4555t^3 + 134.37t^2 - 1661.3x \quad + 8454.9$$

$$R^2 = 57.23$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the arrivals of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.3.

4.1.4 Monthly seasonal indices of potato prices in Kolar market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.4. This was subjected to two way ANOVA as in the case of arrivals. The prices were high during the month of November (130.1), December (177.8) and August (177.6) and lowest during April (65.6) and March (73.0).

Table 4.2 : Monthly seasonal indices of potato prices in Bangalore market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	59.7	80.9	102.7	101.3	120.3	105.7	570.6
1997-98	81.0	104.0	92.9	88.2	95.0	105.5	120.0	105.1	107.7	64.4	63.9	63.4	1091.2
1998-99	68.3	88.9	120.4	127.4	115.9	130.0	109.1	112.0	147.8	127.7	111.0	85.3	1343.7
1999-00	63.4	72.7	89.6	82.9	108.3	89.0	47.9	127.7	130.9	139.9	90.0	68.9	1111.1
2000-01	78.0	92.9	105.4	128.2	164.6	126.1	93.6	125.0	77.4	110.0	52.6	55.6	1209.3
2001-02	66.8	85.9	161.6	148.6	132.3	65.1	58.6	117.9	142.2	118.1	78.7	69.7	1245.5
2002-03	74.7	96.7	107.6	114.8	146.4	97.9	105.4	122.5	121.9	83.9	75.7	63.2	1210.7
2003-04	81.4	89.7	94.6	126.4	131.4	100.5	-	-	-	-	-	-	-
Total	513.6	630.8	772.1	816.6	893.9	714.1	594.4	791.2	830.5	745.2	592.1	511.7	7782.1
SI	73.4	90.1	110.3	116.7	127.7	102.0	84.9	113.0	118.6	106.5	84.6	73.1	1200.9

SI = Seasonal Index

Months : 2.972
Years : 3.254

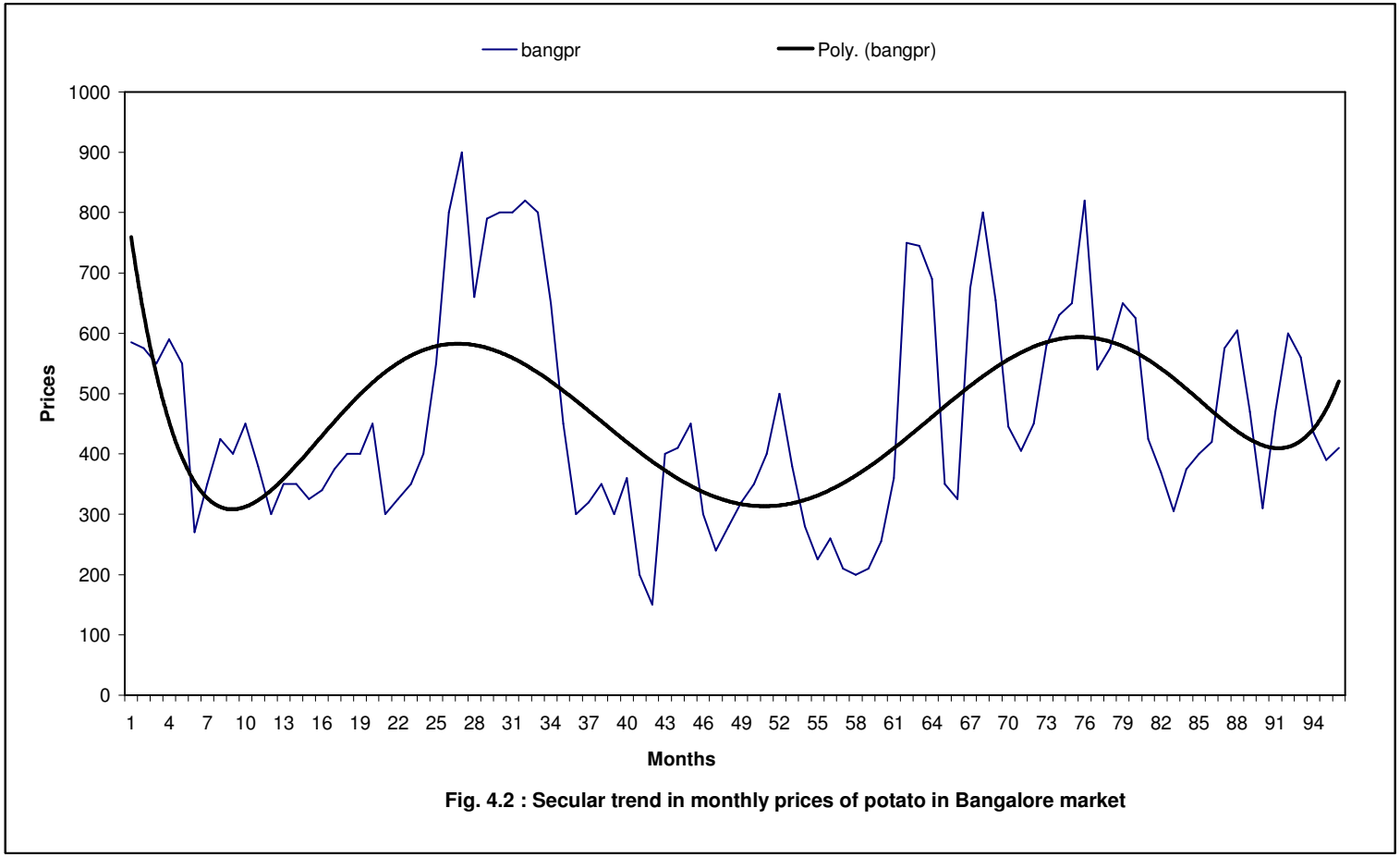


Fig. 4.2 : Secular trend in monthly prices of potato in Bangalore market

Fig. 4.2 : Secular trend in monthly prices of potato in Bangalore market

Table 4.3 : Monthly seasonal indices of potato arrivals in Kolar market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	61.4	43.5	57.3	54.2	42.3	57.7	316.4
1997-98	183.0	175.4	60.5	55.3	147.8	47.3	66.0	82.6	48.4	129.0	112.7	80.8	1188.8
1998-99	145.2	125.4	85.0	103.8	80.7	79.4	21.1	18.7	46.6	39.6	51.4	264.9	1061.8
1999-00	389.6	113.3	122.9	62.9	60.8	23.0	43.6	10.0	21.0	22.9	215.1	255.2	1340.2
2000-01	250.5	112.8	72.6	26.4	64.6	64.7	84.8	93.2	62.1	131.7	256.1	64.3	1283.7
2001-02	73.6	193.6	54.5	28.9	68.0	75.7	43.9	81.1	71.6	54.9	123.0	362.6	1231.4
2002-03	170.5	138.0	107.8	43.2	25.3	21.7	21.7	18.7	17.2	17.2	215.1	160.0	956.4
2003-04	242.4	330.5	143.8	98.6	99.9	106.6	-	-	-	-	-	-	-
Total	1454.7	1189.0	647.0	419.0	547.2	418.3	342.5	347.9	324.1	449.5	1015.8	1245.4	
SI	207.8	169.9	92.4	59.9	78.2	59.8	48.9	49.7	46.3	64.2	145.1	177.9	1200.1

SI = Seasonal Index

Months : 2.735
Years : 1.5279 NS

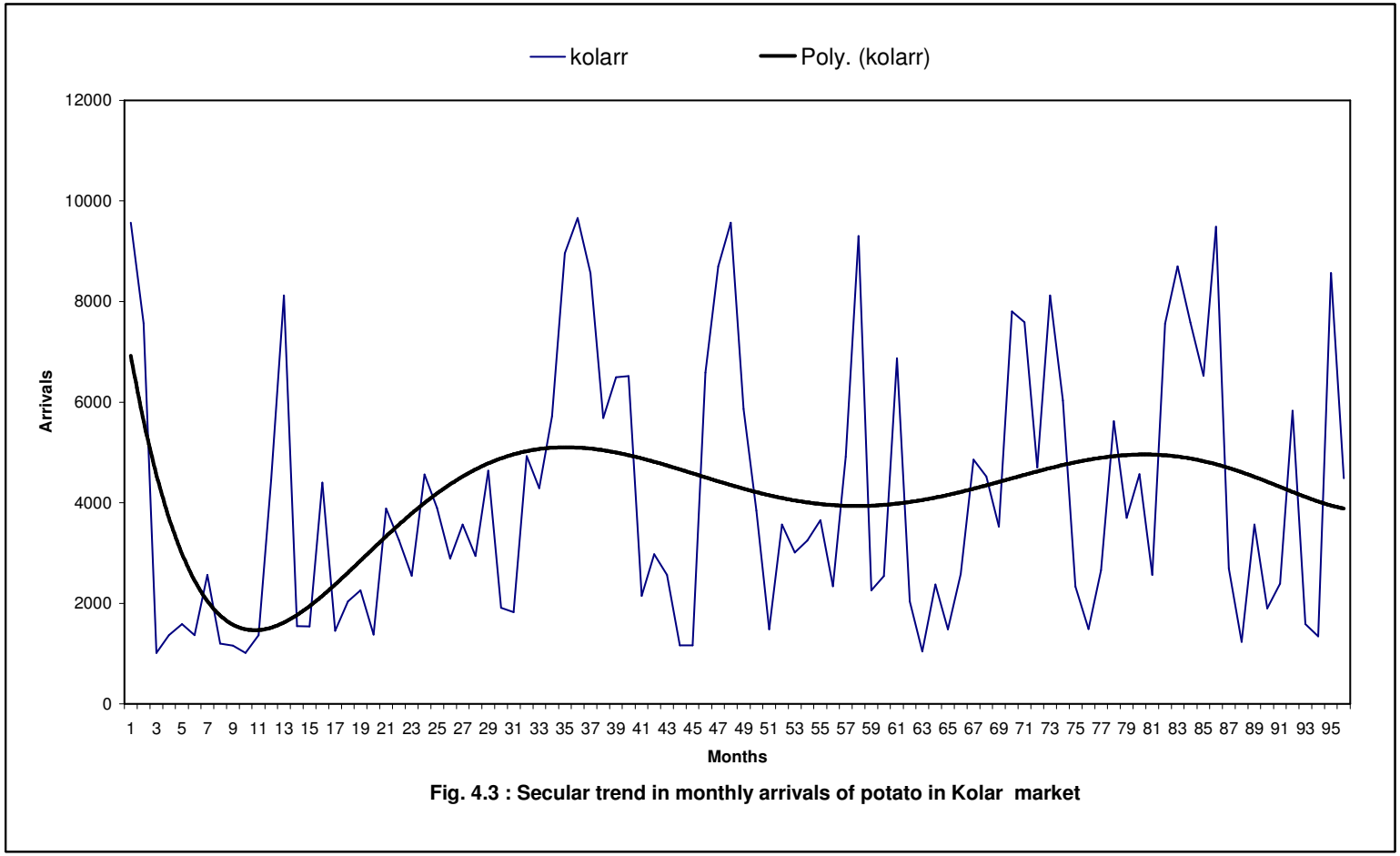


Fig. 4.3 : Secular trend in monthly arrivals of potato in Kolar market

Fig. 4.3. Secular trend in monthly arrivals of potato in Kolar market

Table 4.4 : Monthly seasonal indices of potato prices in Kolar market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	75.2	84.0	88.1	102.7	103.9	50.6	504.6
1997-98	67.2	85.3	87.8	98.6	149.5	110.4	56.0	190.5	58.1	54.4	63.7	47.4	1069.1
1998-99	76.4	126.3	107.5	88.0	109.8	101.7	94.7	132.8	208.7	181.0	97.0	44.9	1368.7
1999-00	57.1	48.6	65.1	75.7	82.9	81.4	164.0	161.4	132.2	116.9	75.5	73.9	1134.8
2000-01	64.9	80.5	97.2	132.7	101.0	115.4	99.8	123.9	95.4	106.7	72.0	104.7	1194.0
2001-02	68.6	102.9	129.7	123.1	121.0	121.0	80.9	91.8	135.4	130.9	86.9	64.8	1257.0
2002-03	58.3	81.1	99.8	71.6	131.7	132.7	128.1	126.0	106.6	106.7	82.6	125.0	1250.2
2003-04	66.9	92.6	106.9	131.3	127.1	95.4	-	-	-	-	-	-	620.2
Total	459.4	617.4	694.0	721.0	823.0	758.1	698.7	910.4	824.5	799.3	581.5	511.3	-
SI	65.6	88.2	99.1	103.0	117.6	108.3	99.8	130.1	117.8	114.2	83.1	73.0	1199.8

SI = Seasonal Index

Months : 2.9276
Years : 1.9625

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is non-significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.4.1 Secular trend in monthly prices of potato in Kolar market

In order to determine the nature of trend movement in the prices of potato in Kolar market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$y_t = 2E\text{-}07t^6 - 5E\text{-}05t^5 + 0.0064t^4 - 0.3727t^3 + 10.258t^2 - 113.03t + 680.99$$

$$R^2 = 46.82$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.4.

4.1.5 Monthly seasonal indices of potato arrivals in Hassan market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.5. This was subjected to two way ANOVA as in the case of prices. The arrivals were high during the months of November (208.5), October (176.9) and June (165.2) and lowest arrivals during April (43.4) and May (47.4).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.5.1 Secular trend in monthly arrivals of potato in Hassan market

In order to determine the nature of trend movement in the arrivals of potato in Hasan market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$y_x = -1E\text{-}06t^6 + 0.0004t^5 - 0.0496t^4 + 2.5106t^3 - 55.043t^2 + 431.46t + 3471.1$$

$$R^2 = 57.23$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.5.

4.1.6 Monthly seasonal indices of potato prices in Hassan market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.6. This was subjected to two way ANOVA as in the case of arrivals. The prices were high during the months of July (116.5), August (116.3) and June (108.2) and lowest prices during April (79.4).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

Table 4.5 : Monthly seasonal indices of potato arrivals in Hassan market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	35.4	23.3	76.0	33.1	52.0	101.4	321.2
1997-98	111.4	156.2	172.5	74.8	99.6	71.0	74.1	136.4	194.3	30.8	129.9	50.1	1301.1
1998-99	73.1	49.1	191.7	112.7	155.3	96.8	75.6	113.1	37.6	97.0	97.0	62.2	1161.3
1999-00	14.5	15.1	490.8	250.0	47.0	39.8	154.1	74.1	32.2	85.0	62.7	25.5	1290.8
2000-01	10.6	15.5	29.0	185.7	49.3	52.6	396.2	280.4	95.4	106.7	98.0	104.7	1423.9
2001-02	44.4	21.0	135.5	224.6	22.5	22.4	190.8	387.2	136.7	26.6	24.6	28.3	1264.6
2002-03	14.2	36.3	85.0	54.0	35.0	32.7	311.9	445.3	165.6	89.8	56.0	78.0	1403.8
2003-04	35.6	38.3	51.9	32.8	39.0	32.5	-	-	-	-	-	-	230.1
Total	303.8	331.5	1156.4	934.6	447.7	347.7	1238.1	1459.8	737.8	468.9	520.2	450.1	-
SI	43.4	47.4	165.2	133.5	64.0	49.7	176.9	208.5	105.4	67.0	74.3	64.3	1199.5

SI = Seasonal Index

Months : 2.3914
Years : 7.1276

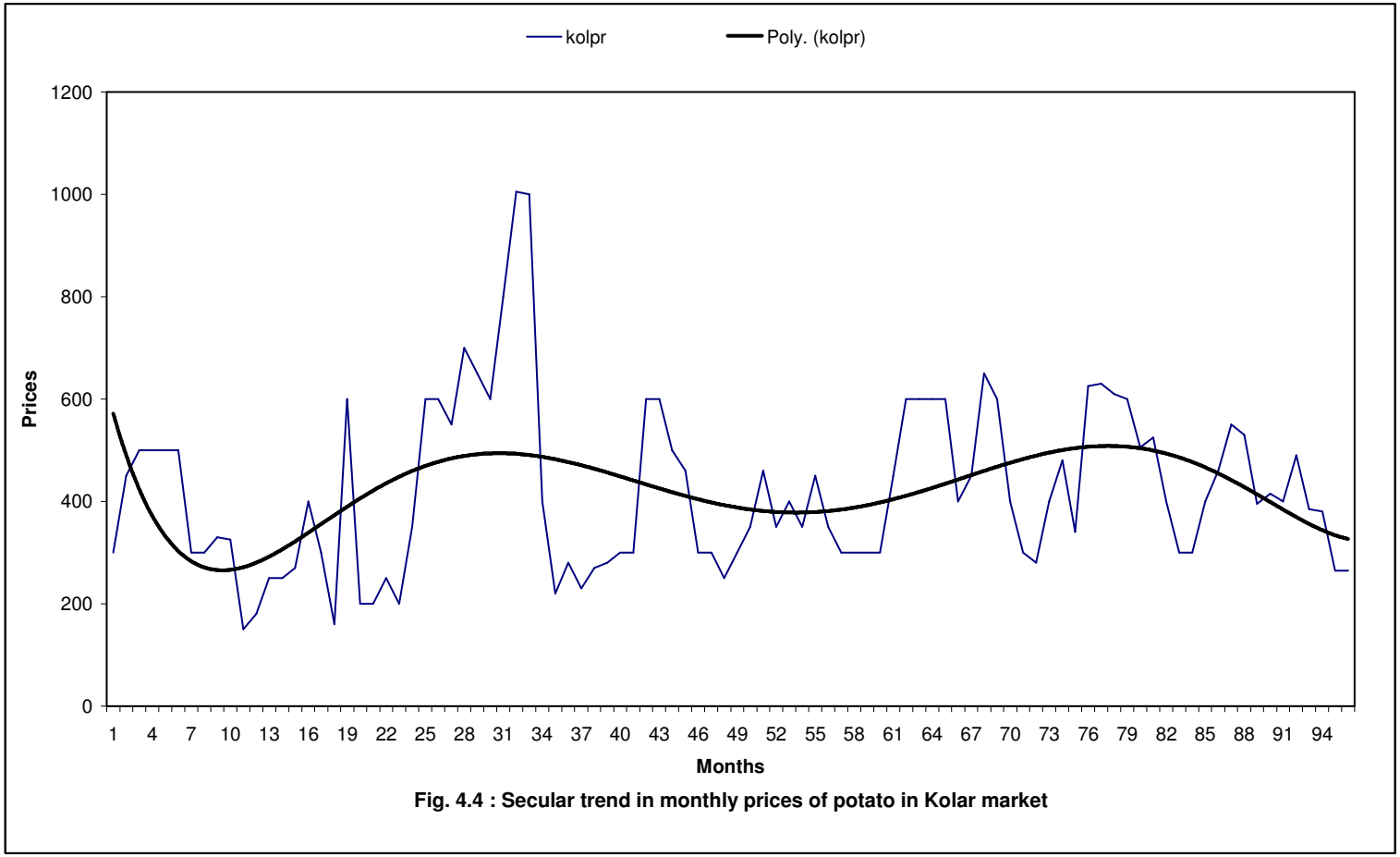


Fig. 4.4 : Secular trend in monthly prices of potato in Kolar market

Fig. 4.4 : Secular trend in monthly prices of potato in kolar market

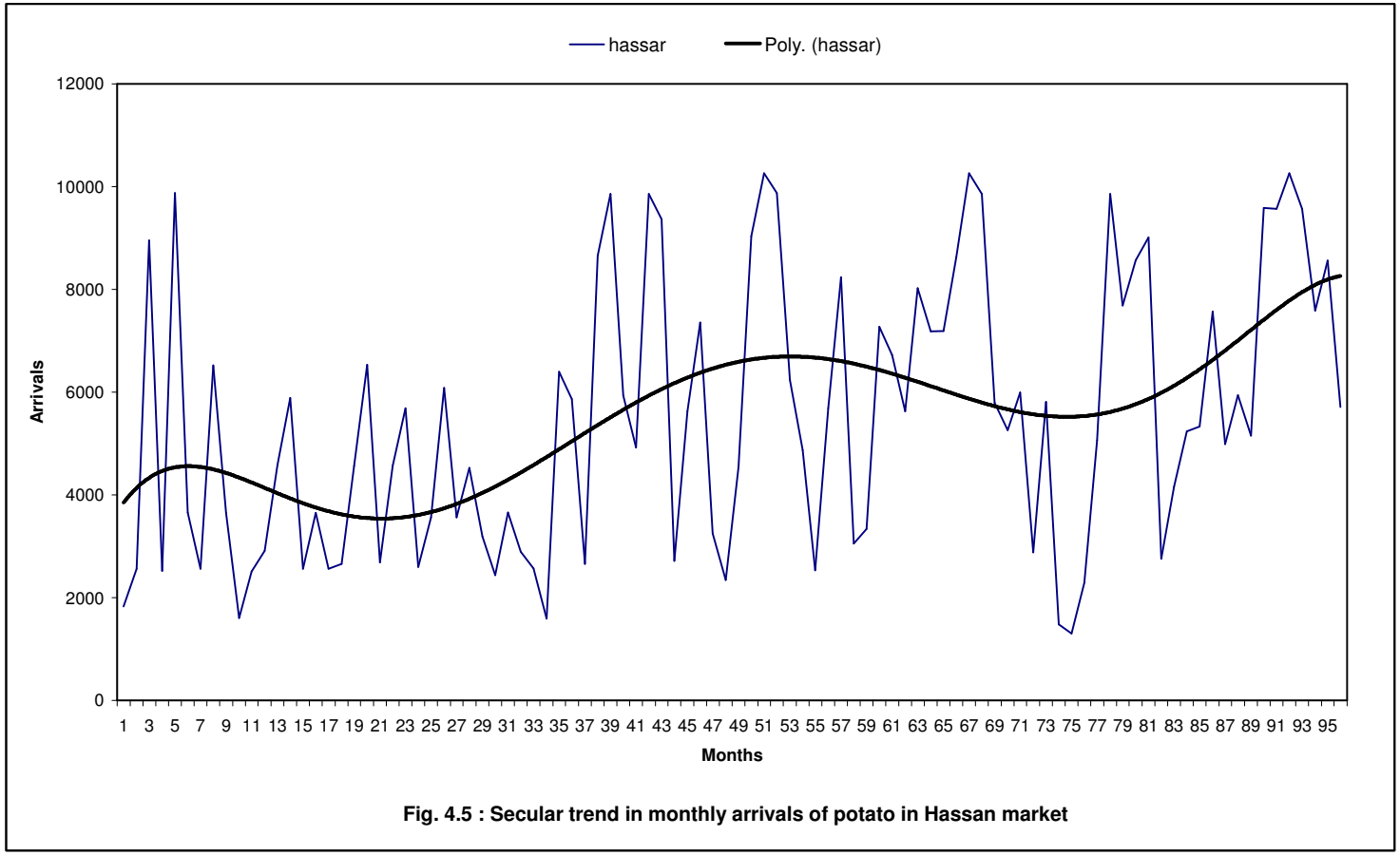


Fig. 4.5 : Secular trend in monthly arrivals of potato in Hassan market

Fig. 4.5 : Secular trend in monthly arrivals of potato in Hassan market

Table 4.6 : Monthly seasonal indices of potato prices in Hassan market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	77.9	83.7	71.7	127.7	145.0	91.3	597.3
1997-98	89.8	107.7	89.8	81.7	121.7	98.6	117.4	89.4	102.4	70.6	103.5	84.5	1157.2
1998-99	83.5	91.1	104.9	104.7	80.0	93.6	99.1	130.9	129.7	118.9	96.4	109.6	1242.5
1999-00	64.6	87.7	110.1	107.5	96.5	75.1	136.2	123.8	75.1	99.6	98.8	76.8	1151.7
2000-01	88.8	106.8	114.7	132.4	126.3	127.7	81.3	74.6	67.6	66.2	65.4	64.6	1116.6
2001-02	81.6	116.8	126.1	146.3	142.5	90.9	58.9	94.0	104.5	130.9	123.5	65.5	1281.5
2002-03	66.8	72.0	101.8	120.6	124.3	109.7	118.6	108.8	106.0	108.5	87.0	79.5	1203.6
2003-04	81.1	99.5	109.7	122.4	122.4	114.0	-	-	-	-	-	-	649.2
Total	556.1	681.6	757.2	815.7	813.8	709.5	689.3	705.4	657.1	722.5	719.5	571.9	-
SI	79.4	97.4	108.2	116.5	116.3	101.4	98.5	100.8	93.9	103.2	102.8	81.7	1199.9

SI = Seasonal Index

Months : 2.1527
Years : 4.9552

4.1.6.1 Secular trend in monthly prices of potato in Hasan market

In order to determine the nature of trend movement in the prices of potato in Hasan market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$y_t = 1E\text{-}07t^6 - 3E\text{-}05t^5 + 0.0037t^4 - 0.1966t^3 + 4.9805t^2 - 52.859t + 550.59$$

$$R^2 = 62.15$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.6.

4.1.7 Monthly seasonal indices of potato arrivals in Belgaum market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.7. This was subjected to two way ANOVA as in the case of prices. The arrivals were high during the months of November (219.7) and December (173.36) and lowest arrivals during March (56.9) and September (57.1).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.6.1 Secular trend in monthly arrivals of potato in Belgaum market

In order to determine the nature of trend movement in the arrivals of potato in Belgaum market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$y_t = 3E\text{-}06t^6 - 0.0008t^5 + 0.0746t^4 - 3.2307t^3 + 66.911t^2 - 612.98t + 18577$$

$$R^2 = 48.32$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.7.

4.1.8 Monthly seasonal indices of potato prices in Belgaum market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.8. This was subjected to two way ANOVA as in the case of arrivals. The prices were high during the months of November (118.8) and September (117.9) and lowest prices during April (81.2), May (87.1) and March (87.7).

Two way ANOVA is applied to seasonal indices, indicating that there is non-significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

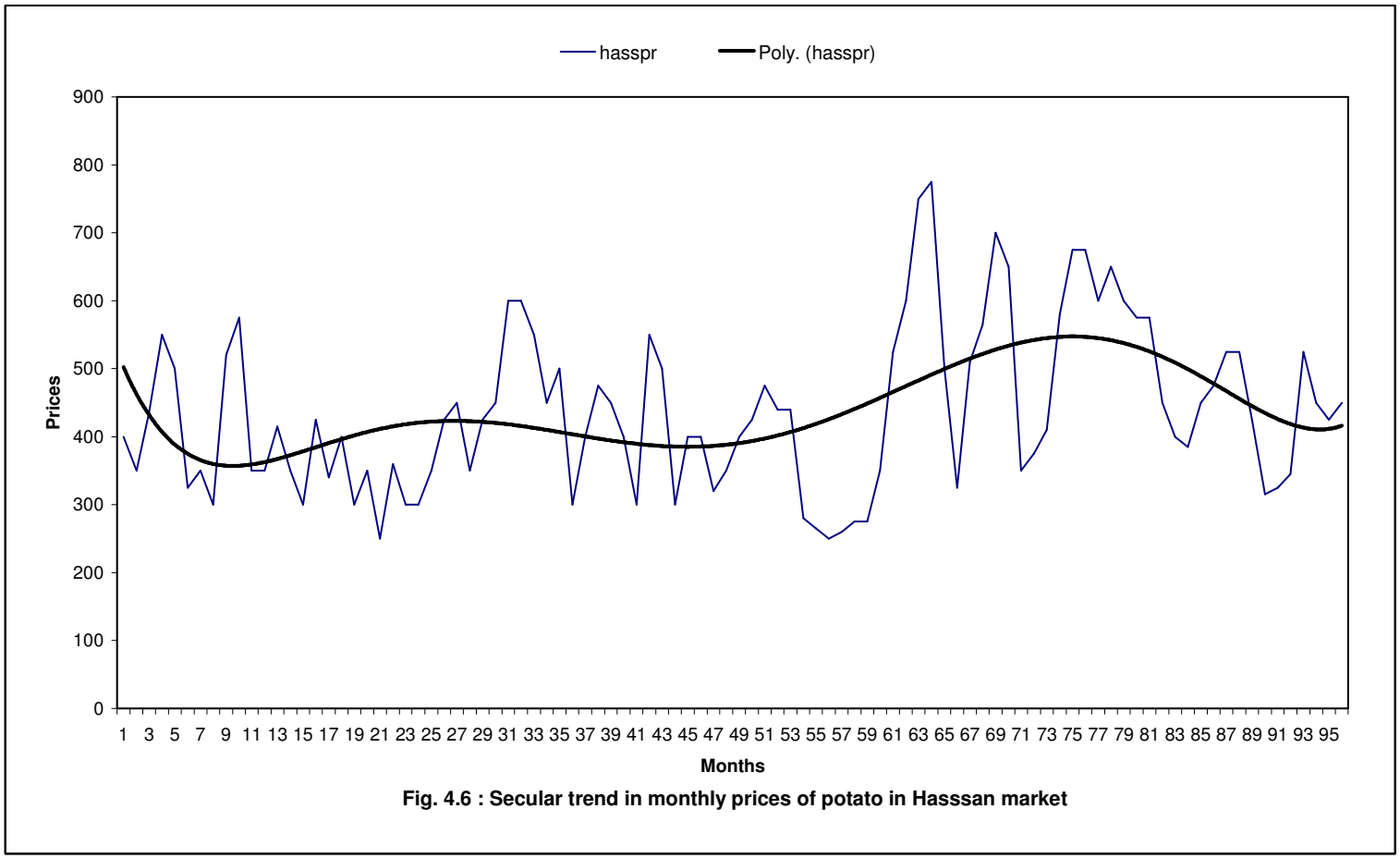


Fig. 4.6 : Secular trend in monthly prices of potato in Hasssan market

Fig. 4.6 : Secular trend in monthly prices of potato in Hassan market

Table 4.7 : Monthly seasonal indices of potato arrivals in Belgaum market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	227.4	58.8	67.6	59.5	82.8	66.3	562.4
1997-98	119.9	156.8	124.4	118.6	85.0	93.2	116.5	52.5	85.0	216.8	73.6	78.6	1320.8
1998-99	97.7	164.4	65.3	58.6	85.0	44.3	88.6	264.6	182.1	49.0	136.4	56.7	1292.7
1999-00	77.4	80.8	94.5	70.6	72.5	64.6	127.5	61.2	276.7	150.0	37.4	30.0	1143.2
2000-01	89.7	141.3	81.2	53.4	50.0	50.3	62.6	223.6	248.7	136.9	59.3	52.1	1249.0
2001-02	96.1	90.8	65.8	41.5	54.7	10.3	38.0	486.9	172.8	52.5	44.0	46.0	1199.4
2002-03	73.9	75.9	73.6	38.2	38.6	37.7	177.2	390.7	180.1	74.6	53.8	68.8	1283.2
2003-04	4.6	65.7	78.0	52.2	50.5	99.0	-	-	-	-	-	-	350.1
Total	559.2	775.8	582.7	433.2	436.4	399.4	837.8	1538.2	1213.1	739.3	487.3	398.5	-
SI	79.9	110.8	83.2	61.9	62.3	57.1	119.7	219.7	173.3	105.6	69.6	56.9	1200.1

SI = Seasonal Index

Months : 3.2626
Years : 6.4312

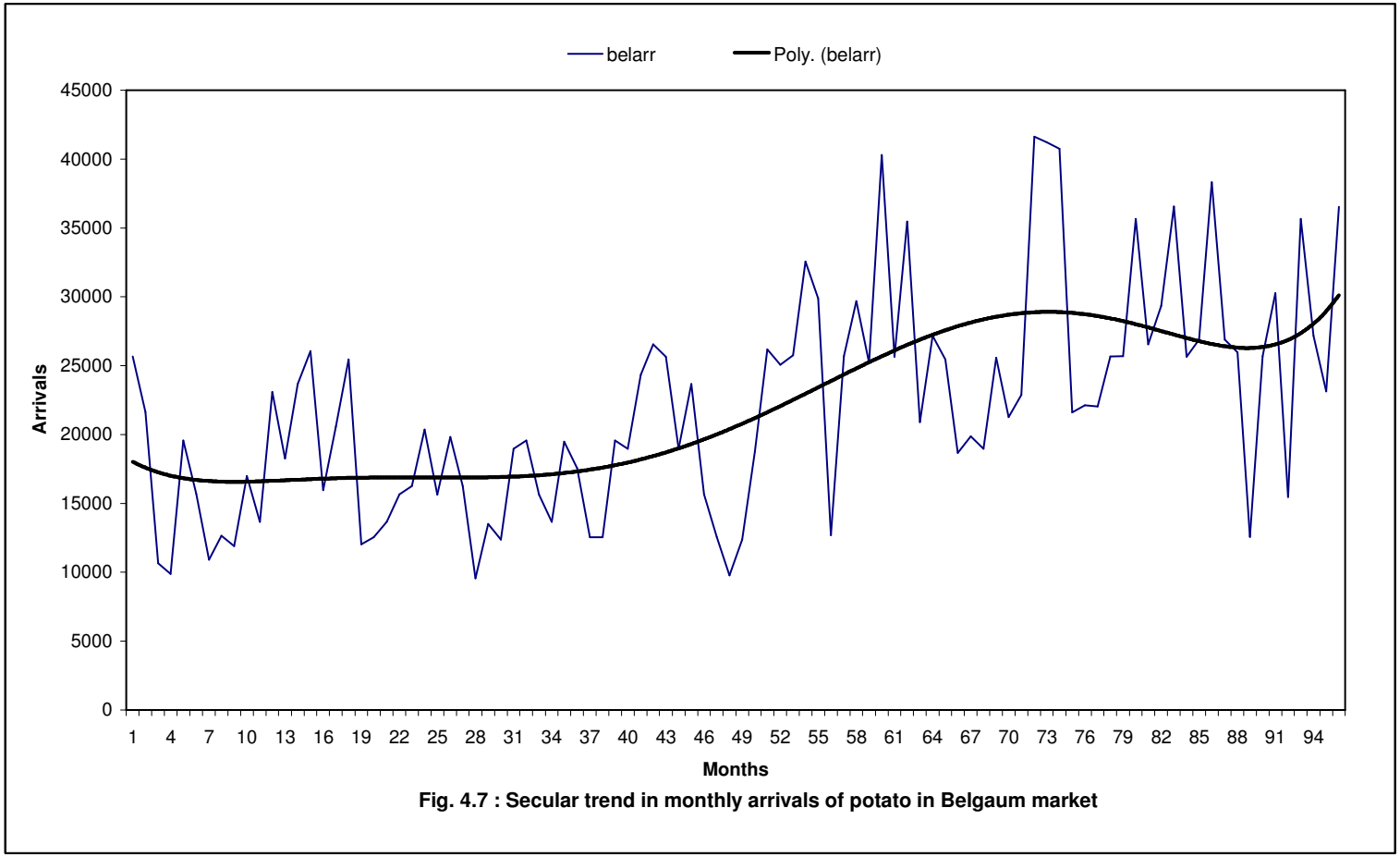


Fig. 4.7 : Secular trend in monthly arrivals of potato in Belgaum market

Table 4.8: Monthly seasonal indices of potato prices in Belgaum market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	131.6	135.0	75.1	90.6	138.0	82.9	653.2
1997-98	101.3	82.3	94.9	93.8	107.7	98.1	105.4	113.6	69.8	61.9	84.3	104.1	1117.1
1998-99	92.3	82.8	111.8	74.1	61.9	139.5	121.1	169.9	162.5	97.4	101.9	64.2	1279.3
1999-00	56.0	106.3	87.1	92.1	107.4	112.2	78.7	111.8	100.4	87.9	126.6	115.8	1182.3
2000-01	70.4	90.6	92.6	107.5	115.4	113.2	97.1	111.0	79.4	67.3	65.6	89.7	1099.8
2001-02	74.0	70.2	105.2	146.3	149.4	99.2	81.0	86.0	109.4	153.4	78.8	72.7	1225.6
2002-03	80.5	95.5	88.7	101.8	117.6	134.4	126.7	104.5	108.0	88.7	78.6	84.8	1209.8
2003-04	94.0	82.3	95.5	129.4	107.6	128.8	-	-	-	-	-	-	637.5
Total	568.6	609.8	675.9	745.0	766.8	825.4	741.6	831.8	704.6	647.2	673.9	614.1	-
SI	81.2	87.1	96.6	106.4	109.5	117.9	105.9	118.8	100.7	92.5	96.3	87.7	1200.7

SI = Seasonal Index

Months : 1.5275 NS
Years : 4.001

4.1.8.1 Secular trend in monthly prices of potato in Belgaum market

In order to determine the nature of trend movement in the prices of potato in Belgaum market, the data was adequately fitted to 6th degree polynomial equation. The trend equation was in the form of

$y_t = 3E\text{-}07t^6 - 0.0001t^5 + 0.012t^4 - 0.6603t^3 + 17.217t^2 - 183.14t + 960.09$

$R^2 = 58.62$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an oscillation trend in prices over years. The graph of the trend in arrivals over years is shown in Fig. 4.8.

4.1.9 Monthly seasonal indices of potato arrivals in Hubli market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.9. This was subjected to two way ANOVA as in the case of prices. The arrivals were high during the months of December (175.4) and January (162.8) and lowest arrivals during April (68.0)

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

4.1.9.1 Secular trend in monthly arrivals of potato in Hubli market

In order to determine the nature of trend movement in the arrivals of potato in Hubli market, the data was adequately fitted to 6th degree polynomial equation. The trend equation was in the form of

$Y_t = -6E\text{-}06t^6 + 0.0019t^5 - 0.2186t^4 + 11.71t^3 - 299.23t^2 + 3310.2t + 1657.6$

$R^2 = 58.67$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an increasing trend in arrivals over years. The graph of the trend in arrivals over years is shown in Fig. 4.9.

4.1.10 Monthly seasonal indices of potato prices in Hubli market

The pattern of variation in price within a year is revealed by seasonal indices, computed for each month. The final estimated stabilized seasonal indices are presented in Table 4.10. This was subjected to two way ANOVA as in the case of arrivals. The prices were high during the months of September (112.8), August (111.8) and July (111.5) and lowest prices during March (83.5) and February (85.2).

Two way ANOVA is applied to seasonal indices, indicating that there is significant difference among months (F=1.9153 with 11 and 77 d.f) and there is significant difference among years (F = 2.131 with 7 and 77 d.f) at 5 per cent level of significance.

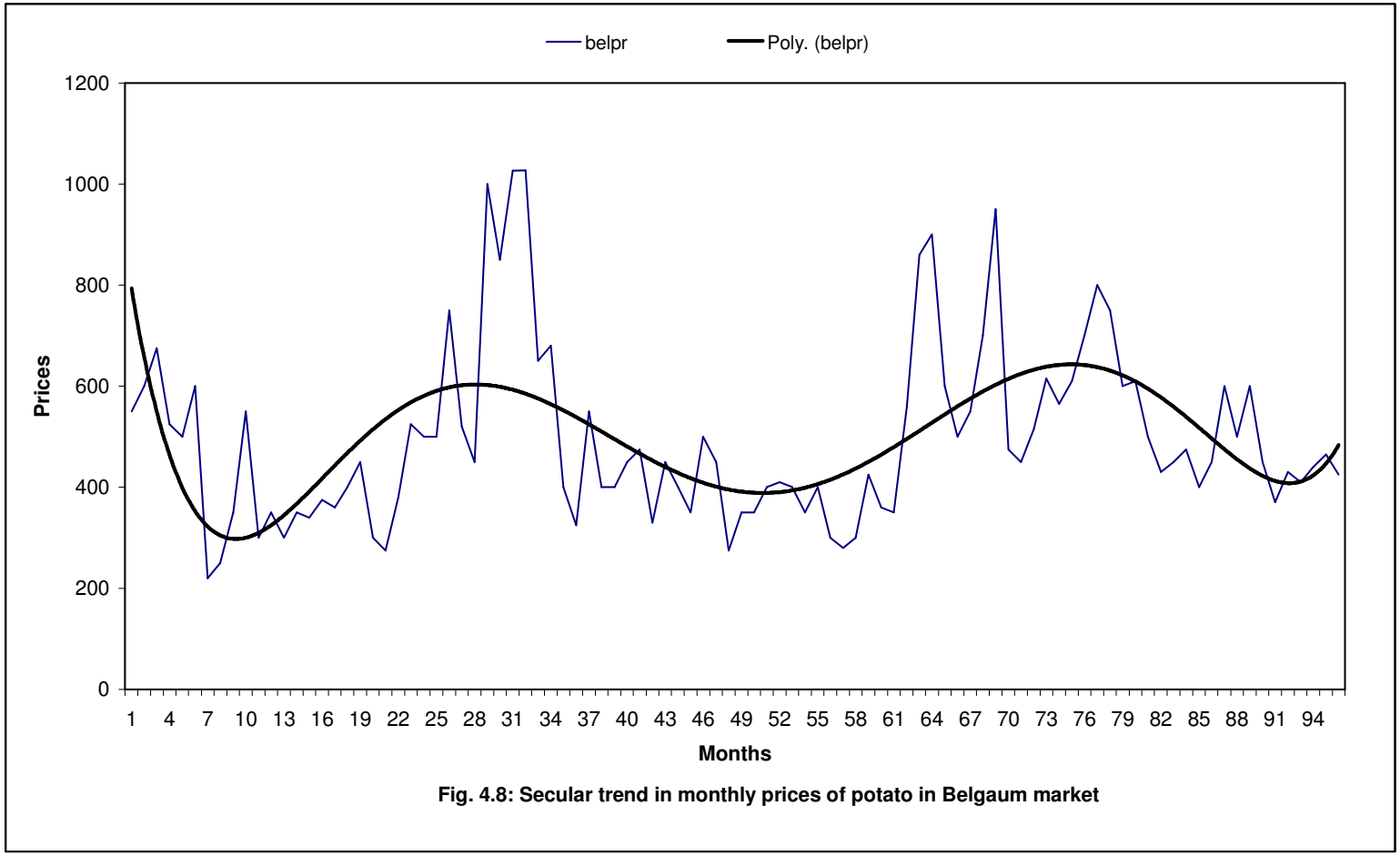


Fig. 4.8: Secular trend in monthly prices of potato in Belgaum market

Fig. 4.8 : Secular trend in monthly prices of potato in Belgaum market

Table 4.9 : Monthly seasonal indices of potato arrivals in Hubli market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	38.2	63.6	119.1	81.6	37.3	73.1	412.9
1997-98	43.3	178.0	158.0	159.8	34.9	25.6	13.9	26.2	335.4	300.5	132.1	94.4	1502.0
1998-99	45.1	16.2	22.6	38.9	31.7	139.8	260.1	100.8	207.6	130.0	82.1	73.5	1148.4
1999-00	87.1	37.0	56.2	84.8	95.8	31.2	75.4	89.7	151.0	231.8	99.0	97.3	1136.3
2000-01	78.3	81.8	107.7	108.6	108.1	71.6	125.4	76.5	155.1	143.9	104.6	75.0	1236.7
2001-02	73.7	98.89	108.8	84.5	77.5	78.3	79.0	148.4	134.7	171.1	110.9	59.7	1126.5
2002-03	69.2	92.2	91.2	89.9	92.6	126.7	102.8	120.8	125.2	80.9	104.2	80.1	1175.9
2003-04	79.2	66.9	66.6	94.2	155.1	118.3	-	-	-	-	-	-	580.3
Total	475.9	472.1	611.1	660.7	595.8	591.4	694.8	626.0	1228.1	1139.8	670.1	553.3	-
SI	68.0	78.7	87.3	94.4	85.1	84.5	99.3	89.4	175.4	162.8	95.7	79.0	1199.7

SI = Seasonal Index

Months : 2.5627
Years : 3.5247

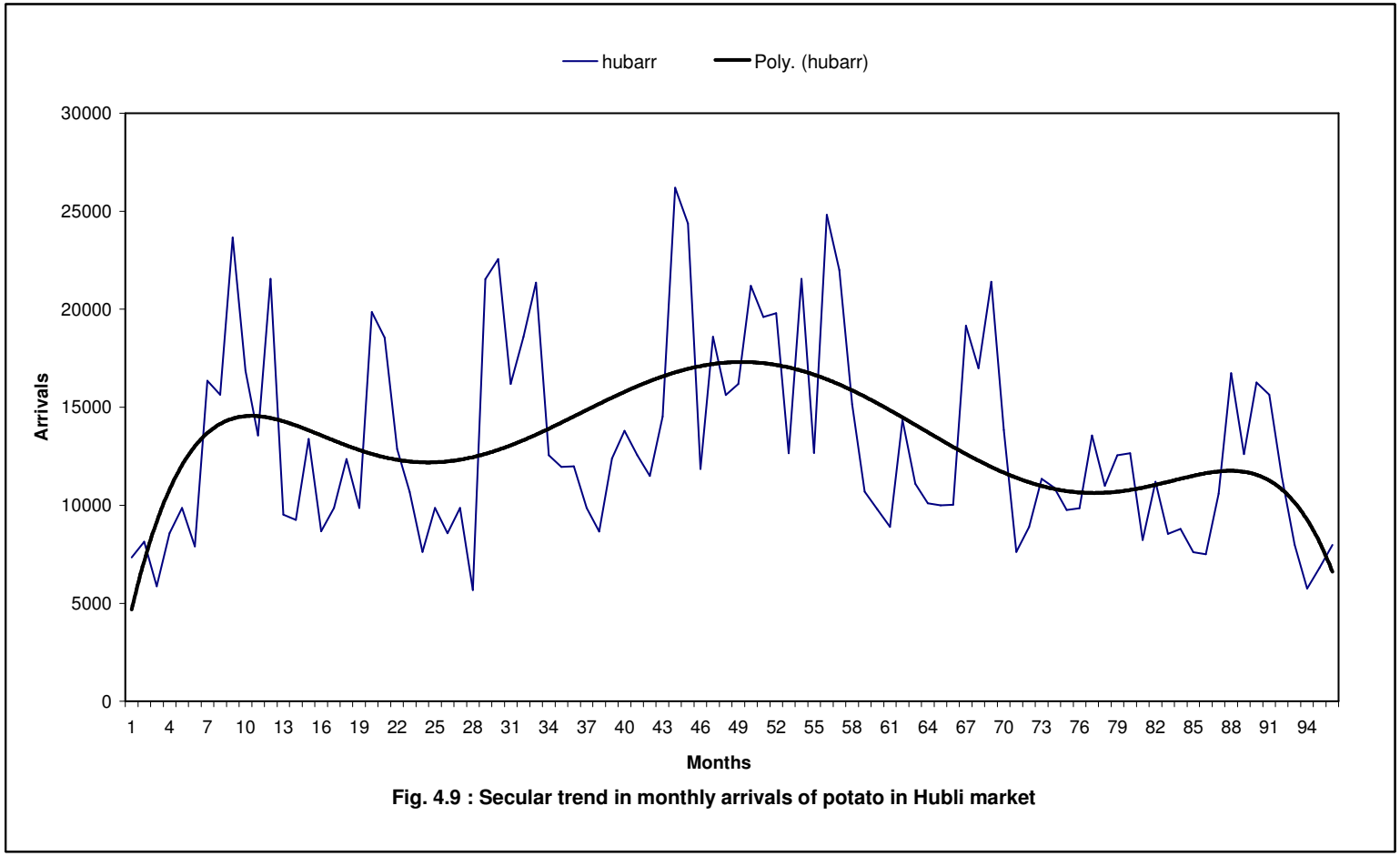


Fig. 4.9 : Secular trend in monthly arrivals of potato in Hubli market

Fig. 4.9 : Secular trend in monthly arrivals of potato in Hubli market

Table 4.10 : Monthly seasonal indices of potato prices in Hubli market

Months / Years	April	May	June	July	August	Sept	October	Nov.	Dec.	January	February	March	Total
1996-97	-	-	-	-	-	-	102.7	83.1	94.9	93.3	112.0	113.9	599.9
1997-98	92.5	109.7	94.5	107.7	91.0	102.1	108.3	80.5	62.3	63.2	61.9	104.9	1078.8
1998-99	123.5	130.4	95.9	69.0	123.0	81.5	86.3	187.5	196.7	116.1	86.4	75.9	1372.3
1999-00	68.3	76.1	117.0	107.1	109.6	139.8	76.9	90.9	85.3	75.9	99.0	86.3	1132.0
2000-01	99.6	98.8	115.7	132.4	122.1	126.0	99.5	109.1	56.3	52.6	49.1	41.4	1102.6
2001-02	89.7	98.89	139.1	138.7	127.1	121.8	74.1	98.1	108.5	109.6	103.3	83.0	1192.9
2002-03	83.2	83.2	91.5	113.2	98.6	120.3	125.4	105.3	116.4	120.4	85.0	79.3	1221.9
2003-04	85.6	98.2	95.5	112.7	111.1	97.8	-	-	-	-	-	-	600.8
Total	642.5	596.4	749.2	780.7	782.6	789.4	673.2	754.4	720.5	631.0	596.7	584.8	-
SI	91.8	99.4	107.0	111.5	111.8	112.8	96.2	107.8	102.9	90.1	85.2	83.5	1200.1

SI = Seasonal Index

Months : 2.2613
Years : 5.4427

4.1.10.1 Secular trend in monthly prices of potato in Hubli market

In order to determine the nature of trend movement in the prices of potato in Hubli market, the data was adequately fitted to 6^{th} degree polynomial equation. The trend equation was in the form of

$$Y_t = 2E\text{-}07t^6 - 7E\text{-}05t^5 + 0.0077t^4 - 0.4217t^3 + 11.29t^2 - 133.35t + 906.87$$

$$R^2 = 50.42$$

Where,

Yt = Predicted value of trend at time t

t = Months t = 0, 1, 2, …

It can be seen from above equation the prices of potato, displayed an decreasing trend in initial years and after increasing trend over years. The graph of the trend in arrivals over years is shown in Fig. 4.10.

4.1.2 Cyclical variation in arrivals and prices of potato

The cyclical variation in arrivals and prices of potato are presented from Fig. 4.11 to 4.20 and Table from 4.11 to 4.20. It could be seen from the figures that there was no cycle in any selected markets.

4.2 ASSOCIATION BETWEEN ARRIVALS AND PRICES OF POTATO

4.2.1 Zero order correlation coefficients for monthly arrivals and prices of potato in selected markets

The correlation coefficient between arrivals and prices of potato in selected markets during the study period were presented in Table 4.21. The correlation coefficient was worked out to know the degree of association between arrivals and prices the table indicates that there is a significant difference between the arrivals and prices of potato except in Bangalore market. From this we note that the monthly arrivals have negative and significant correlation coefficients indicating that both the increasing arrivals and potato decrease the prices of that commodity. But in Bangalore market, the correlation coefficient is negative and non-significant difference between the arrivals and prices.

4.2.2 Correlation between market arrivals and prices of potato in selected markets

The correlation analysis of the average monthly arrivals and prices of potato in selected markets presented in Table 4.21. The table reveal that all the selected markets, there is a significant negative correlation coefficient was observe except in Bangalore market. This revealed that the price and arrivals were moving in the opposite direction in the long run. An increase in one resulted in the decrease of other correspondingly.

The correlation between arrivals and prices of potato in Bangalore market indicated as negative and non-significant relationship between arrivals and prices of potato at 5 per cent level of significance. It indicates that the price and arrivals were moving slightly opposite direction in the long run. This may be due to farmers sold their potato immediately after harvest for lack of storage facilities.

4.3 CO-INTEGRATION

Spatial market integration refers to a situation in which prices of a commodity in separated markets move together and price singals and information are transmitted smoothly across the markets, hence, spatial market performance may be evaluated in terms of the relationship between the prices of spatially separated markets and spatial behaviour in the markets may be used as a measure of overall market performance.

The present study empirically evaluates spatial integration of the time selected potato markets. The market integration was assessed by employing co-integration technique. In the

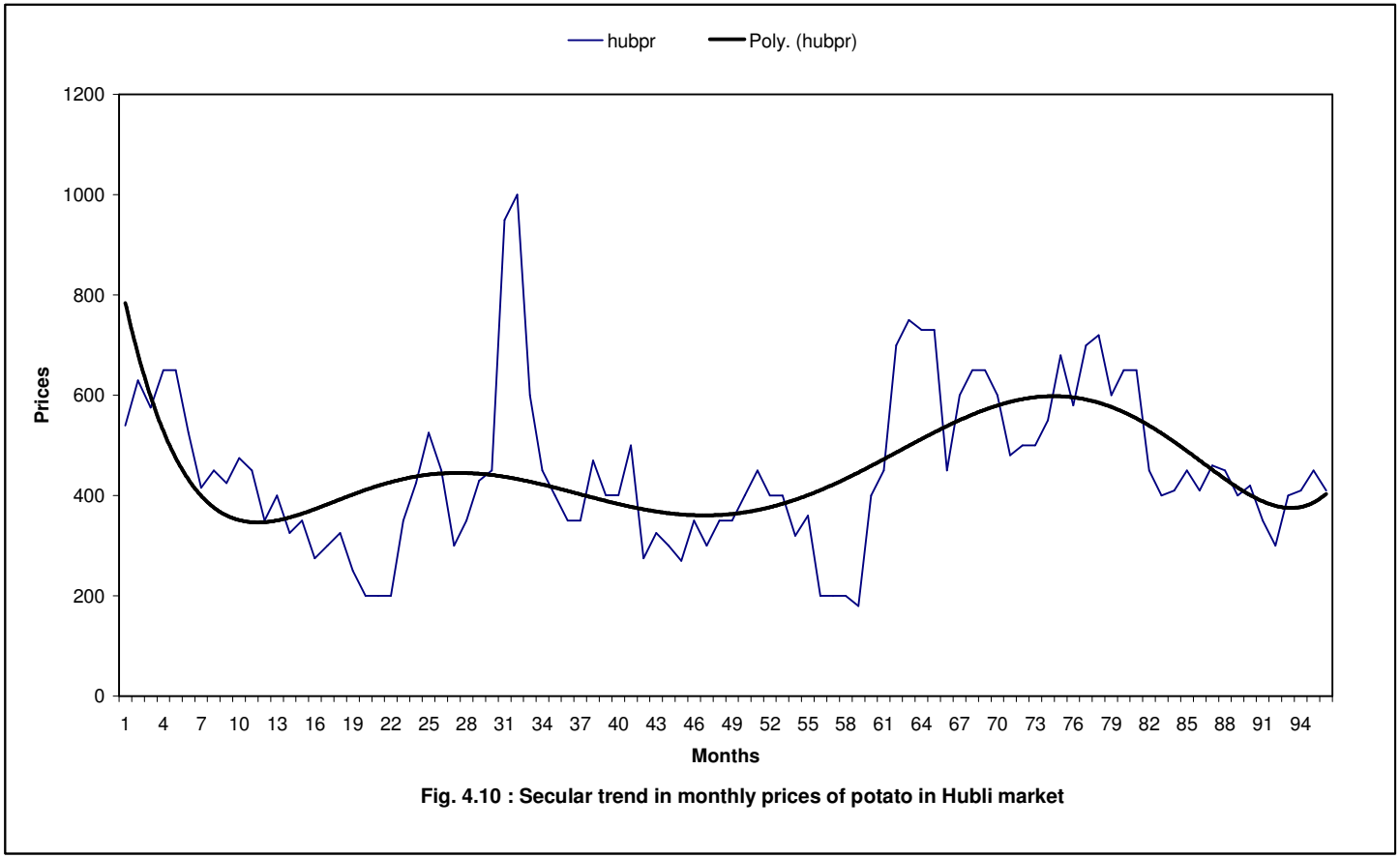


Fig. 4.10 : Secular trend in monthly prices of potato in Hubli market

Fig. 4.10 : Secular trend in monthly prices of potato in Hubli market

Table 4.11: Cyclic indices of Potato arrivals in Banglore market

Months		Months		Months		Months	
1	1.37	26	0.52	51	0.57	76	0.72
2	1.37	27	0.55	52	0.75	77	0.65
3	0.64	28	1.20	53	0.88	78	5.26
4	0.67	29	1.00	54	3.04	79	0.61
5	0.73	30	0.87	55	0.89	80	0.55
6	0.67	31	0.81	56	0.57	81	0.58
7	0.92	32	0.94	57	0.07	82	0.66
8	1.76	33	1.11	58	0.62	83	0.50
9	1.42	34	0.81	59	0.94	84	1.03
10	1.34	35	1.08	60	1.24	85	0.47
11	0.66	36	2.32	61	2.17		
12	0.66	37	0.87	62	1.05		
13	0.51	38	0.65	63	0.51		
14	1.33	39	0.67	64	0.91		
15	0.73	40	0.73	65	0.92		
16	0.92	41	0.93	66	0.96		
17	3.48	42	1.48	67	1.18		
18	1.03	43	1.03	68	0.86		
19	0.68	44	0.90	69	0.95		
20	0.08	45	0.94	70	0.74		
21	0.66	46	0.59	71	0.84		
22	0.68	47	0.67	72	1.02		
23	0.45	48	1.66	73	0.64		
24	1.61	49	1.18	74	0.67		
25	1.78	50	1.12	75	0.57		

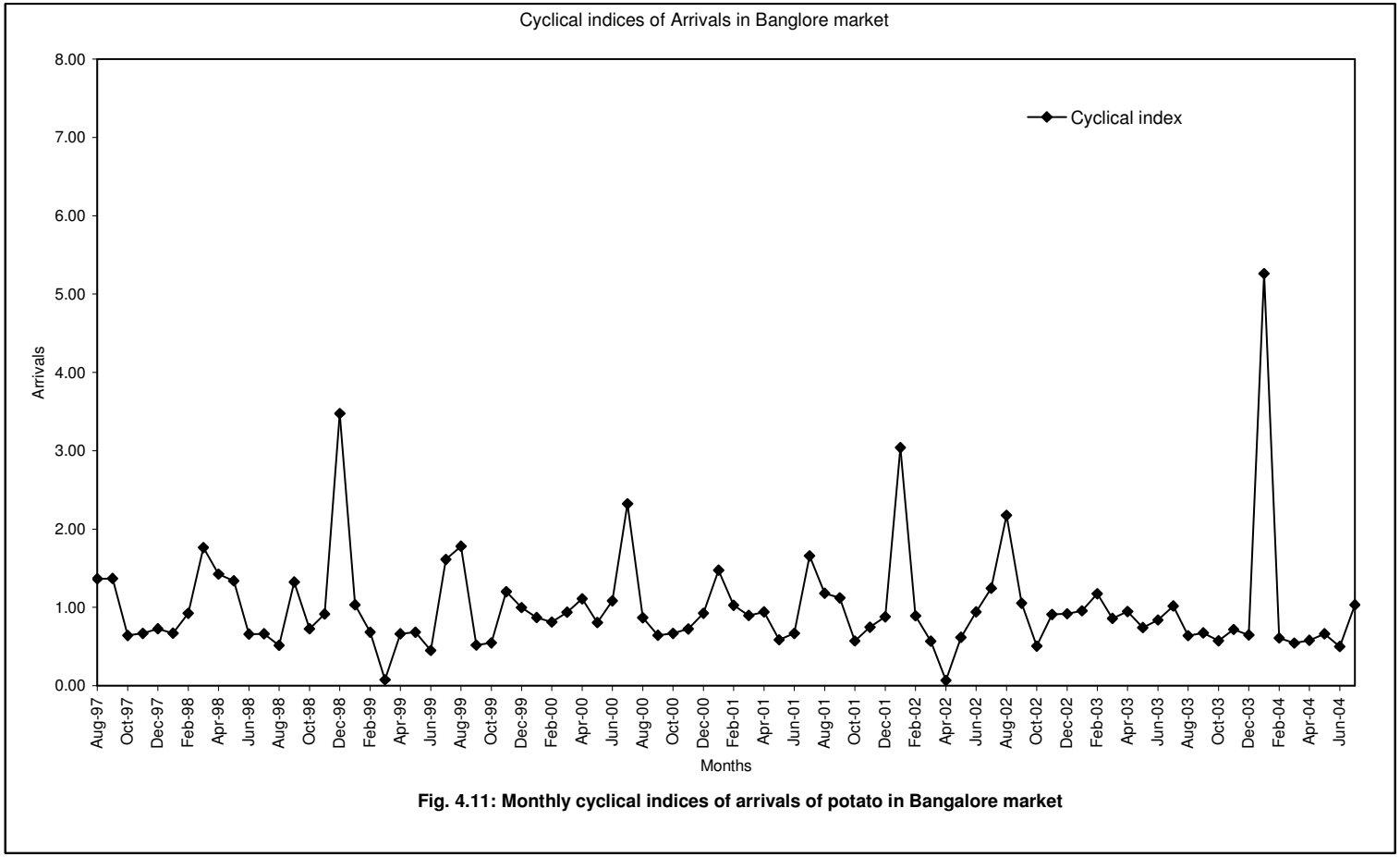


Fig. 4.11: Monthly cyclical indices of arrivals of potato in Bangalore market

Fig. 4.11 : Monthly cyclical indices of arrivals of potato in Bangalore market

Table 4.12: Cyclic indices of Potato prices in Banglore market

Months		Months		Months		Months	
1	0.60	26	1.12	51	0.77	76	0.84
2	0.81	27	1.48	52	0.58	77	0.76
3	1.03	28	1.28	53	0.53	78	0.63
4	1.01	29	1.11	54	0.56	79	0.81
5	1.20	30	0.85	55	0.67	80	0.90
6	1.06	31	0.63	56	0.86	81	0.95
7	0.81	32	0.73	57	1.62	82	1.26
8	0.93	33	0.90	58	1.49	83	1.31
9	0.93	34	0.83	59	1.32	84	1.01
10	0.88	35	1.08	60	0.65	85	0.66
11	0.95	36	0.63	61	0.59		
12	1.06	37	0.48	62	1.18		
13	1.10	38	1.28	63	1.42		
14	1.05	39	1.31	64	1.18		
15	1.08	40	1.40	65	0.79		
16	0.64	41	0.90	66	0.70		
17	0.64	42	0.69	67	0.75		
18	0.63	43	0.78	68	0.97		
19	0.68	44	0.93	69	1.08		
20	0.89	45	1.05	70	1.15		
21	1.20	46	1.28	71	1.46		
22	1.27	47	1.65	72	0.98		
23	1.16	48	1.26	73	1.05		
24	1.21	49	0.94	74	1.23		
25	1.09	50	0.74	75	1.22		

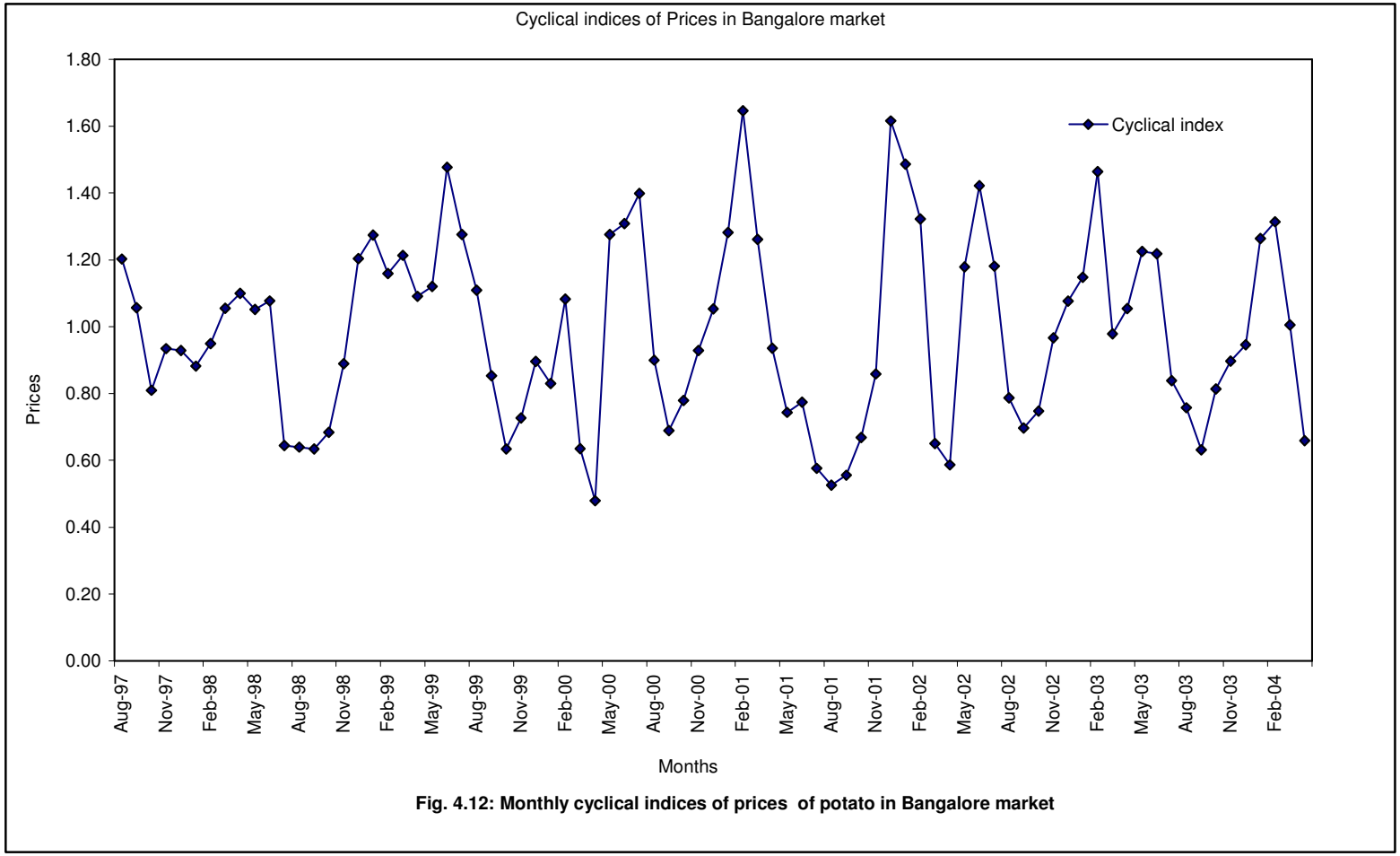


Fig. 4.12: Monthly cyclical indices of prices of potato in Bangalore market

Fig. 4.12 : Monthly cyclical indices of prices of potato in Bangalore market

Table 4.13: Cyclic indices of Potato arrivals in Kolar market

Months		Months		Months		Months	
1	0.61	26	0.19	51	0.62	76	0.17
2	0.44	27	0.47	52	1.32	77	2.15
3	0.57	28	0.40	53	2.56	78	1.60
4	0.54	29	0.51	54	0.64	79	2.42
5	0.42	30	2.65	55	0.74	80	3.31
6	0.58	31	3.90	56	1.94	81	1.44
7	1.83	32	1.13	57	0.55	82	0.08
8	3.19	33	1.23	58	0.29	83	0.10
9	0.60	34	0.63	59	0.68	84	0.17
10	0.55	35	0.61	60	0.28	85	0.20
11	1.48	36	0.23	61	0.44		
12	0.47	37	0.44	62	0.81		
13	0.66	38	0.10	63	0.72		
14	0.83	39	0.21	64	0.55		
15	0.48	40	0.23	65	1.23		
16	1.29	41	2.15	66	3.63		
17	1.13	42	2.55	67	1.70		
18	0.81	43	2.51	68	1.38		
19	1.45	44	1.13	69	1.08		
20	1.25	45	0.73	70	0.43		
21	0.85	46	0.26	71	0.25		
22	1.04	47	0.65	72	0.22		
23	0.81	48	0.65	73	0.22		
24	0.79	49	0.85	74	0.19		
25	0.21	50	0.93	75	0.17		

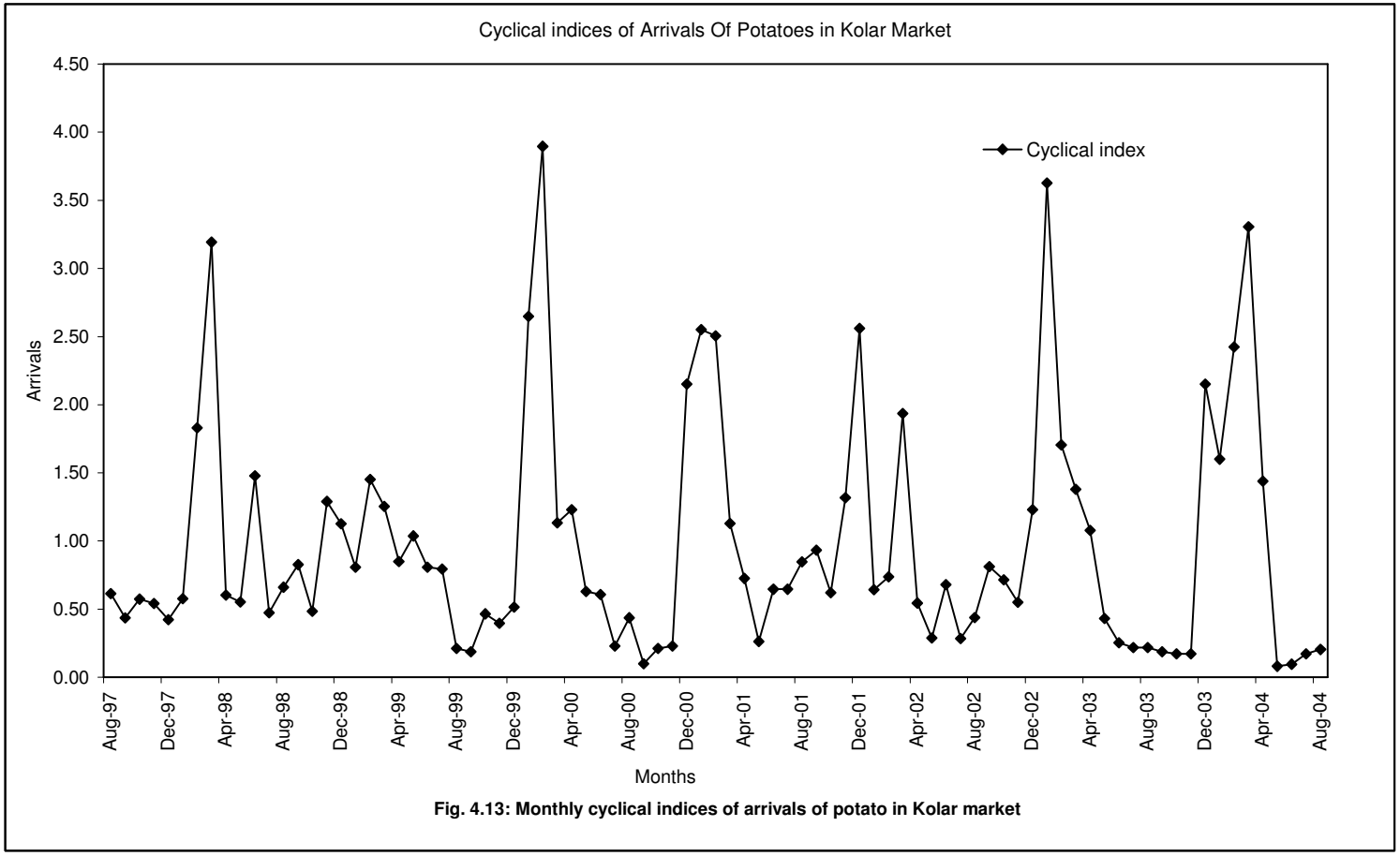


Fig. 4.13: Monthly cyclical indices of arrivals of potato in Kolar market

Fig. 4.13 : Monthly cyclical indices of arrivals of potato in Kolar market

Table 4.14: Cyclic indices of Potato prices in Kolar market

Months		Months		Months		Months	
1	1.38	26	1.33	51	0.91	76	1.07
2	0.84	27	2.09	52	0.76	77	0.83
3	0.88	28	1.81	53	0.72	78	0.65
4	1.03	29	0.77	54	0.69	79	0.67
5	1.04	30	0.45	55	0.69	80	0.93
6	0.51	31	0.57	56	1.03	81	1.07
7	0.67	32	0.49	57	1.30	82	1.31
8	0.85	33	0.65	58	1.23	83	1.27
9	0.88	34	0.76	59	1.21	84	0.95
10	0.99	35	0.83	60	1.21	85	1.01
11	1.50	36	0.81	61	0.81		
12	1.10	37	1.64	62	0.92		
13	0.56	38	1.61	63	1.35		
14	1.90	39	1.32	64	1.31		
15	0.58	40	1.17	65	0.87		
16	0.54	41	0.75	66	0.65		
17	0.64	42	0.74	67	0.58		
18	0.47	43	0.65	68	0.81		
19	0.76	44	0.81	69	1.00		
20	1.26	45	0.97	70	0.72		
21	1.07	46	1.33	71	1.32		
22	0.88	47	1.01	72	1.33		
23	1.10	48	1.15	73	1.28		
24	1.02	49	1.00	74	1.26		
25	0.95	50	1.24	75	1.07		

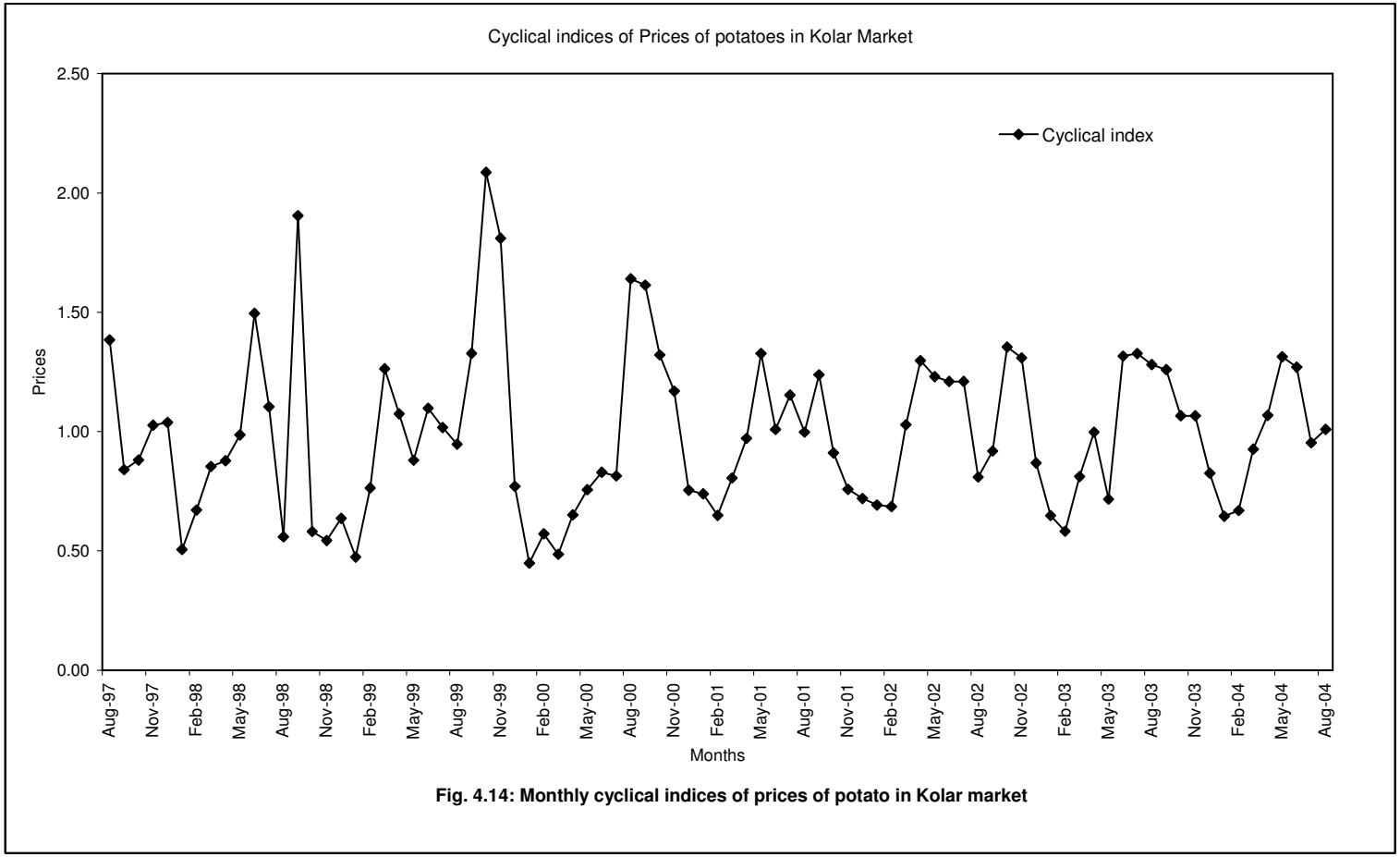


Fig. 4.14: Monthly cyclical indices of prices of potato in Kolar market

Fig. 4.14 : Monthly cylical indices of prices of potato in Kolar market

Table 4.15: Cyclic indices of Potato arrivals in Hassan market

Months		Months		Months		Months	
1	0.35	26	1.13	51	0.69	76	0.90
2	0.23	27	0.38	52	0.59	77	0.16
3	0.22	28	0.09	53	0.08	78	0.25
4	0.33	29	0.16	54	0.09	79	0.36
5	0.52	30	0.62	55	0.44	80	0.38
6	1.01	31	0.15	56	0.21	81	0.52
7	1.11	32	0.15	57	1.36	82	0.33
8	1.56	33	4.91	58	2.25	83	0.39
9	1.73	34	2.60	59	0.23	84	0.32
10	0.75	35	0.47	60	0.22	85	1.53
11	1.00	36	0.40	61	1.91		
12	0.71	37	1.54	62	3.87		
13	0.74	38	0.74	63	1.37		
14	1.36	39	0.32	64	0.27		
15	1.94	40	0.09	65	0.25		
16	0.31	41	0.63	66	0.28		
17	1.30	42	0.25	67	0.14		
18	0.50	43	0.11	68	0.36		
19	0.73	44	0.16	69	0.10		
20	0.49	45	0.29	70	0.08		
21	1.92	46	1.86	71	0.15		
22	1.13	47	0.49	72	0.33		
23	1.55	48	0.53	73	3.12		
24	0.97	49	3.96	74	4.45		
25	0.76	50	2.80	75	1.66		

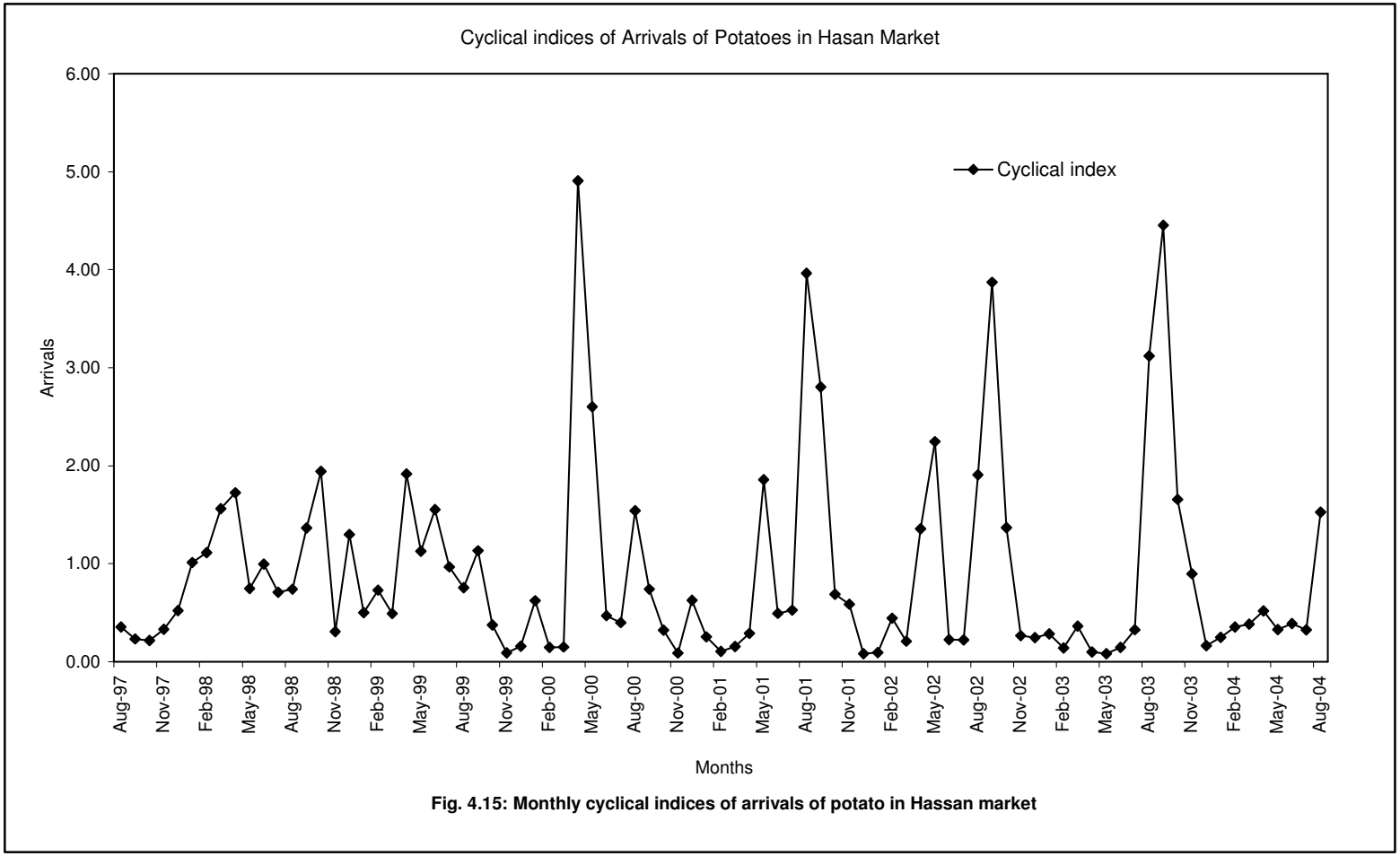


Fig. 4.15: Monthly cyclical indices of arrivals of potato in Hassan market

Fig. 4.15 : Monthly cyclical indices of arrivals of potato in Hassan market

Table 4.16: Cyclic indices of Potato prices in Hassan market

Months		Months		Months		Months	
1	0.78	26	1.31	51	0.68	76	1.08
2	0.84	27	1.30	52	0.66	77	0.87
3	0.72	28	1.19	53	0.65	78	0.80
4	1.28	29	0.96	54	0.65	79	0.81
5	1.45	30	1.10	55	0.82	80	1.00
6	0.91	31	0.65	56	1.17	81	1.10
7	0.90	32	0.88	57	1.26	82	1.22
8	1.08	33	1.10	58	1.46	83	1.22
9	0.90	34	1.07	59	1.43	84	0.99
10	0.82	35	0.96	60	0.91	85	0.72
11	1.22	36	0.75	61	0.59		
12	0.99	37	1.36	62	0.94		
13	1.17	38	1.24	63	1.04		
14	0.89	39	0.75	64	1.31		
15	1.02	40	1.00	65	1.24		
16	0.71	41	0.99	66	0.65		
17	1.03	42	0.77	67	0.67		
18	0.85	43	0.89	68	0.72		
19	0.84	44	1.07	69	1.02		
20	0.91	45	1.15	70	1.21		
21	1.05	46	1.32	71	1.24		
22	1.05	47	1.26	72	1.10		
23	0.80	48	1.28	73	1.19		
24	0.94	49	0.81	74	1.09		
25	0.99	50	0.75	75	1.06		

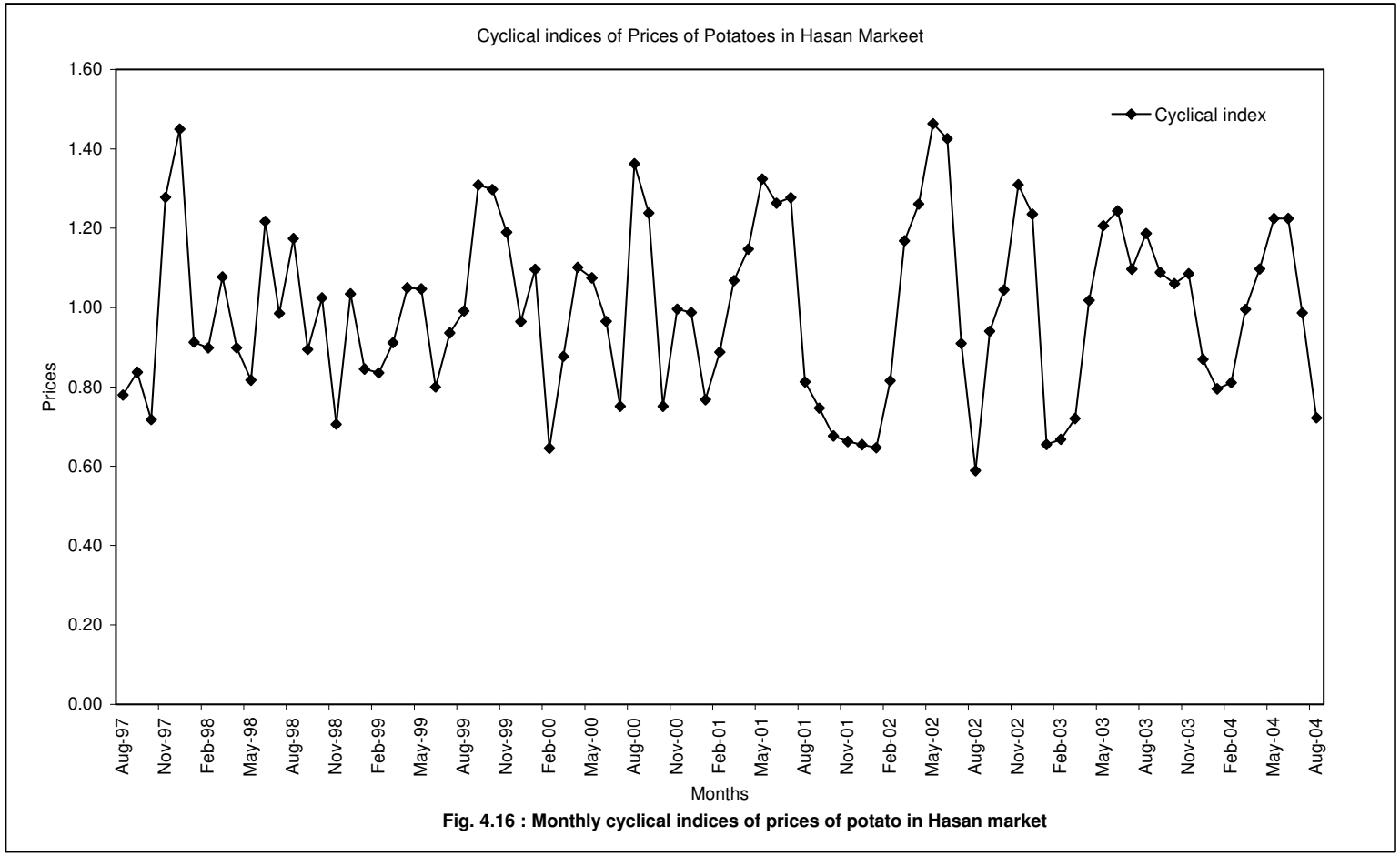


Fig. 4.16 : Monthly cyclical indices of prices of potato in Hasan market

Fig. 4.16 : Monthly cyclical indices of prices of potato in Hassan market

Table 4.17: Cyclic indices of Potato arrivals in Hassan market

Months		Months		Months		Months	
1	0.59	26	1.82	51	1.37	76	0.54
2	0.68	27	0.49	52	0.59	77	0.69
3	0.59	28	1.36	53	0.52	78	0.05
4	0.83	29	0.57	54	0.96	79	0.66
5	0.66	30	0.77	55	0.91	80	0.78
6	1.20	31	0.81	56	0.66	81	0.52
7	1.57	32	0.94	57	0.42	82	0.51
8	1.24	33	0.71	58	0.55	83	0.10
9	1.19	34	0.73	59	0.10	84	1.51
10	0.73	35	0.65	60	0.38	85	1.44
11	0.93	36	1.27	61	4.87		
12	1.17	37	0.61	62	1.73		
13	0.52	38	2.77	63	0.52		
14	0.38	39	1.50	64	0.44		
15	2.17	40	0.37	65	0.46		
16	0.74	41	0.30	66	0.74		
17	0.79	42	0.90	67	0.76		
18	0.98	43	1.41	68	0.74		
19	1.64	44	0.81	69	0.38		
20	0.65	45	0.53	70	0.39		
21	0.59	46	0.50	71	0.38		
22	0.32	47	0.50	72	1.77		
23	0.44	48	0.63	73	3.91		
24	0.89	49	2.24	74	1.80		
25	2.65	50	2.49	75	0.75		

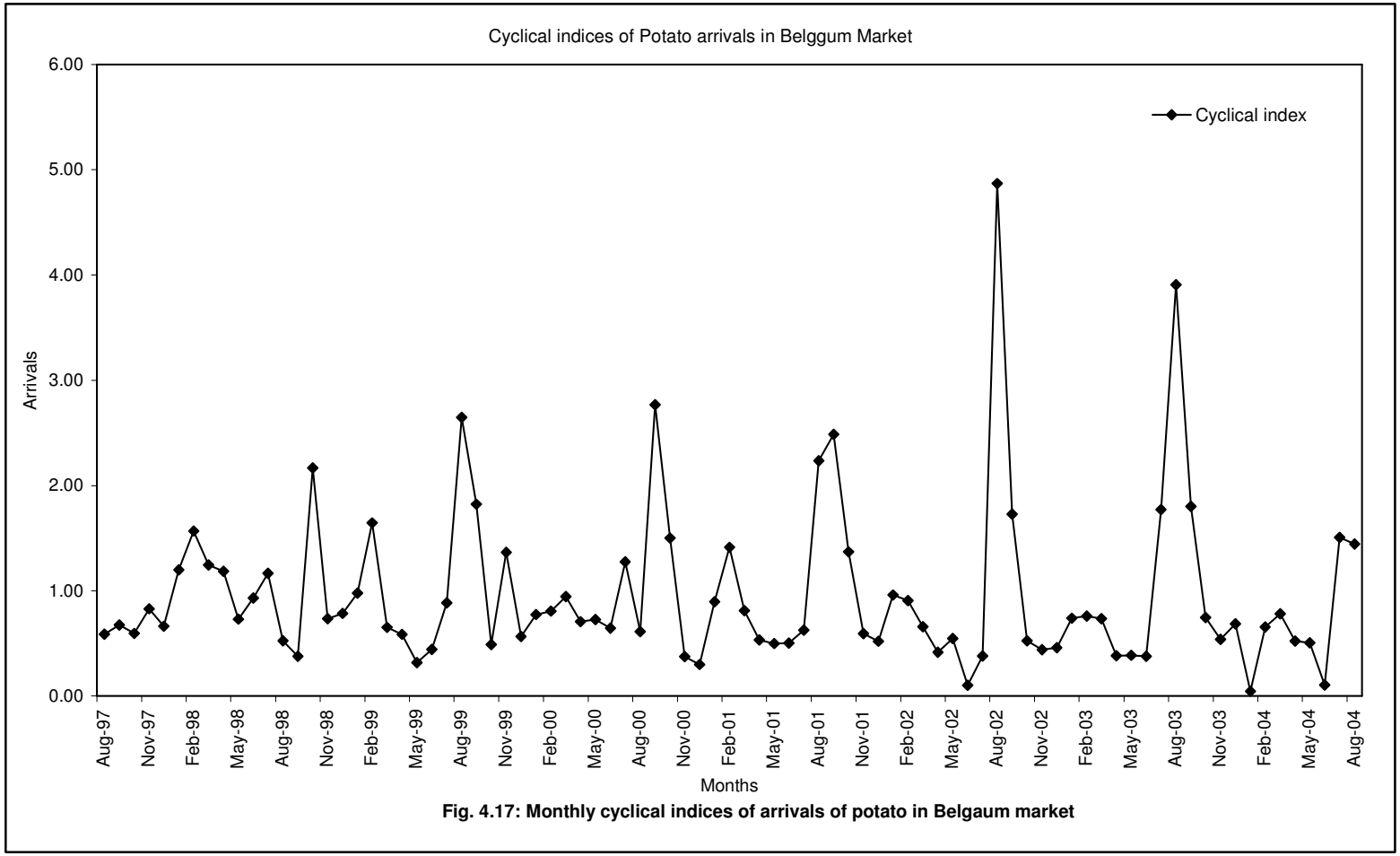


Fig. 4.17: Monthly cyclical indices of arrivals of potato in Belgaum market

Fig. 4.17 : Monthly cyclical indices of arrivals of potato in Belgaum market

Table 4.18: Cyclic indices of Potato prices in Belgaum market

Months		Months		Months		Months	
1	1.32	26	1.70	51	0.79	76	0.89
2	0.51	27	1.62	52	0.67	77	0.79
3	0.60	28	0.97	53	0.66	78	0.85
4	0.91	29	1.02	54	0.90	79	0.94
5	1.47	30	0.64	55	0.74	80	0.82
6	0.83	31	0.56	56	0.70	81	0.95
7	1.01	32	1.06	57	1.05	82	1.29
8	0.82	33	0.87	58	1.46	83	1.08
9	0.95	34	0.92	59	1.49	84	1.29
10	0.94	35	1.07	60	0.99	85	0.97
11	1.08	36	1.12	61	0.81		
12	0.98	37	0.79	62	0.86		
13	1.05	38	1.12	63	1.09		
14	1.14	39	1.00	64	1.53		
15	0.70	40	0.88	65	0.79		
16	0.62	41	1.27	66	0.73		
17	0.84	42	1.16	67	0.80		
18	1.04	43	0.70	68	0.95		
19	0.92	44	0.91	69	0.89		
20	0.83	45	0.93	70	1.02		
21	1.12	46	1.08	71	1.18		
22	0.74	47	1.15	72	1.34		
23	0.62	48	1.13	73	1.27		
24	1.40	49	0.97	74	1.04		
25	1.21	50	1.11	75	1.08		

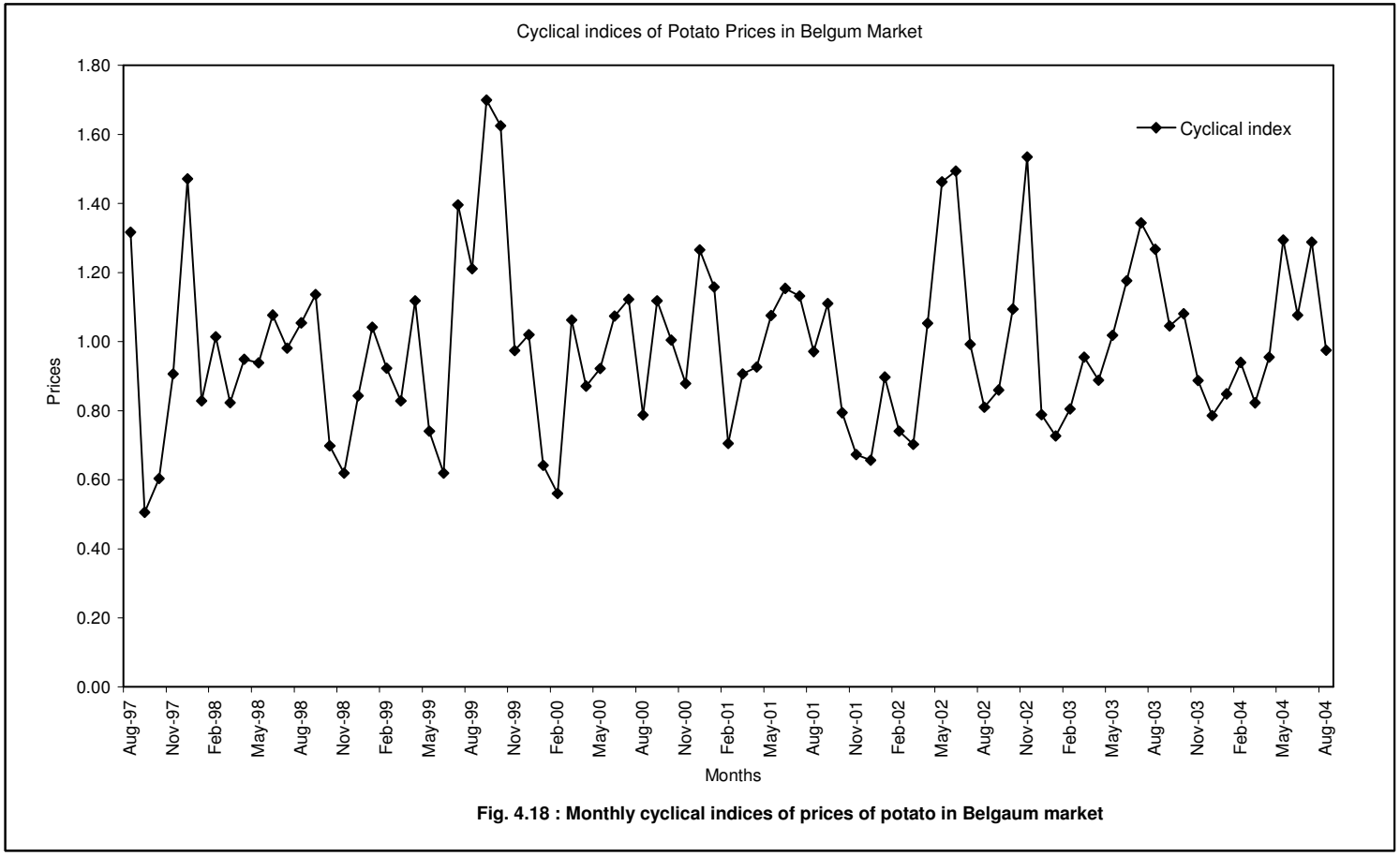


Fig. 4.18 : Monthly cyclical indices of prices of potato in Belgaum market

Fig. 4.18 : Monthly cyclical indices of prices of potato in Belgaum market

Table 4.19: Cyclic indices of Potato arrivals in Hubli market

Months		Months		Months		Months	
1	0.38	26	1.01	51	1.55	76	0.81
2	0.64	27	2.08	52	1.44	77	1.04
3	1.19	28	1.30	53	1.05	78	0.80
4	0.82	29	0.82	54	0.75	79	0.79
5	0.37	30	0.74	55	0.74	80	0.67
6	0.73	31	0.87	56	0.64	81	0.67
7	0.43	32	0.37	57	1.09	82	0.94
8	1.78	33	0.56	58	0.84	83	1.55
9	0.41	34	0.85	59	0.78	84	1.18
10	1.60	35	0.96	60	0.78	85	1.54
11	0.35	36	0.31	61	0.79		
12	0.26	37	0.75	62	1.48		
13	0.14	38	0.90	63	1.35		
14	0.26	39	1.51	64	1.71		
15	3.35	40	2.32	65	1.11		
16	3.00	41	0.64	66	0.60		
17	1.32	42	0.97	67	0.69		
18	0.94	43	0.78	68	0.92		
19	0.45	44	0.82	69	0.91		
20	0.16	45	1.08	70	0.90		
21	0.23	46	1.09	71	0.93		
22	0.39	47	1.08	72	1.27		
23	0.32	48	0.72	73	1.03		
24	1.40	49	1.25	74	1.21		
25	2.60	50	0.76	75	1.25		

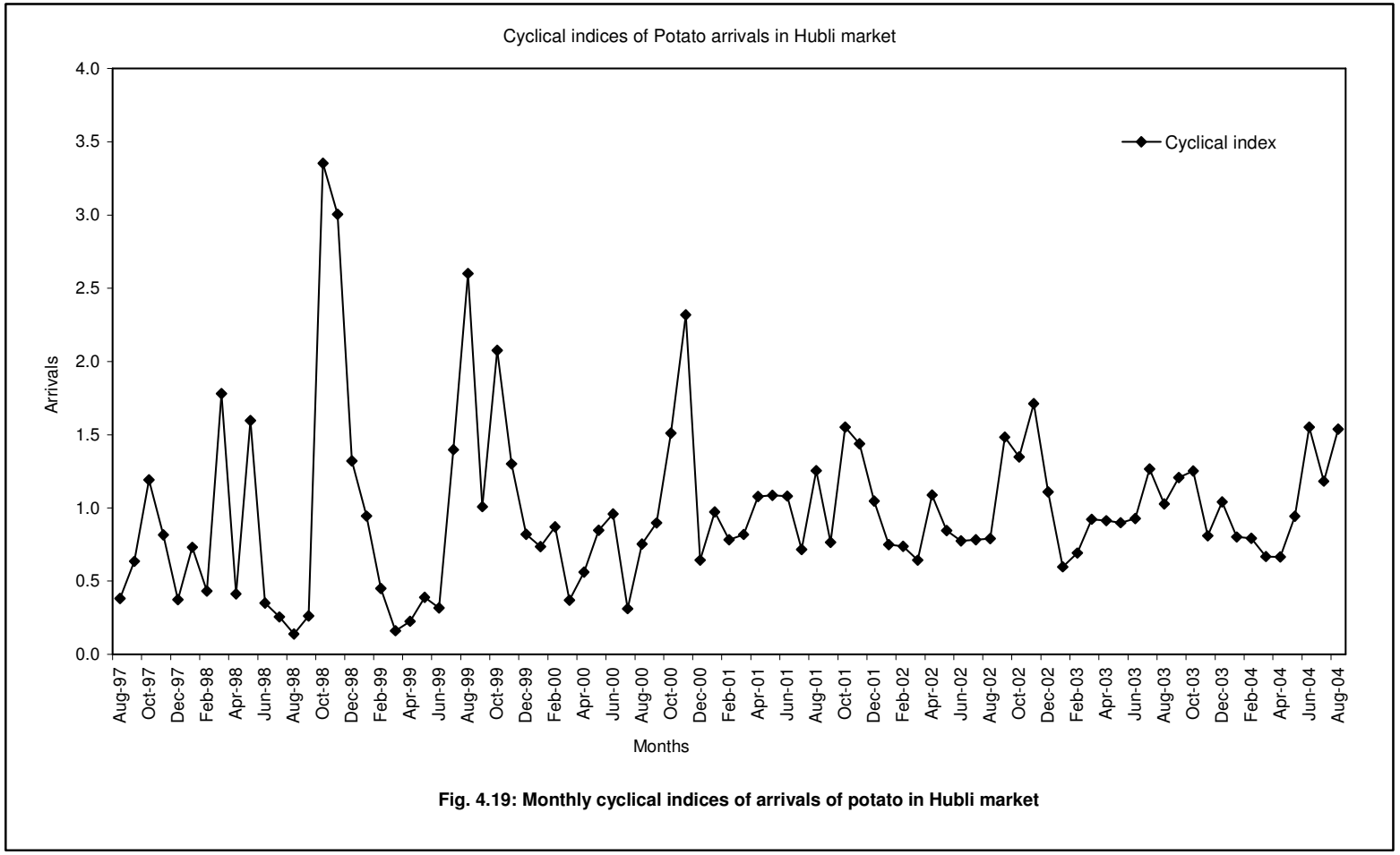


Fig. 4.19: Monthly cyclical indices of arrivals of potato in Hubli market

Fig. 4.19 : Monthly cyclical indices of arrivals of potato in Hubli market

Table 4.20: Cyclic indices of Potato prices in Hubli market

Months		Months		Months		Months	
1	1.03	26	1.88	51	0.56	76	1.20
2	0.83	27	1.97	52	0.53	77	0.85
3	0.95	28	1.16	53	0.49	78	0.79
4	0.93	29	0.86	54	0.41	79	0.86
5	1.12	30	0.76	55	0.90	80	0.98
6	1.14	31	0.68	56	0.97	81	0.96
7	0.93	32	0.76	57	1.39	82	1.13
8	1.10	33	1.17	58	1.39	83	1.11
9	0.95	34	1.07	59	1.27	84	0.98
10	1.08	35	1.10	60	1.22	85	1.03
11	0.91	36	1.40	61	0.74		
12	1.02	37	0.77	62	0.98		
13	1.08	38	0.91	63	1.08		
14	0.81	39	0.85	64	1.10		
15	0.62	40	0.76	65	1.03		
16	0.63	41	0.98	66	0.83		
17	0.62	42	0.86	67	0.83		
18	1.05	43	1.00	68	0.83		
19	1.23	44	0.99	69	0.92		
20	1.30	45	1.16	70	1.13		
21	0.96	46	1.32	71	0.99		
22	0.60	47	1.22	72	1.20		
23	0.67	48	1.26	73	1.25		
24	0.82	49	0.99	74	1.05		
25	0.86	50	1.09	75	1.16		

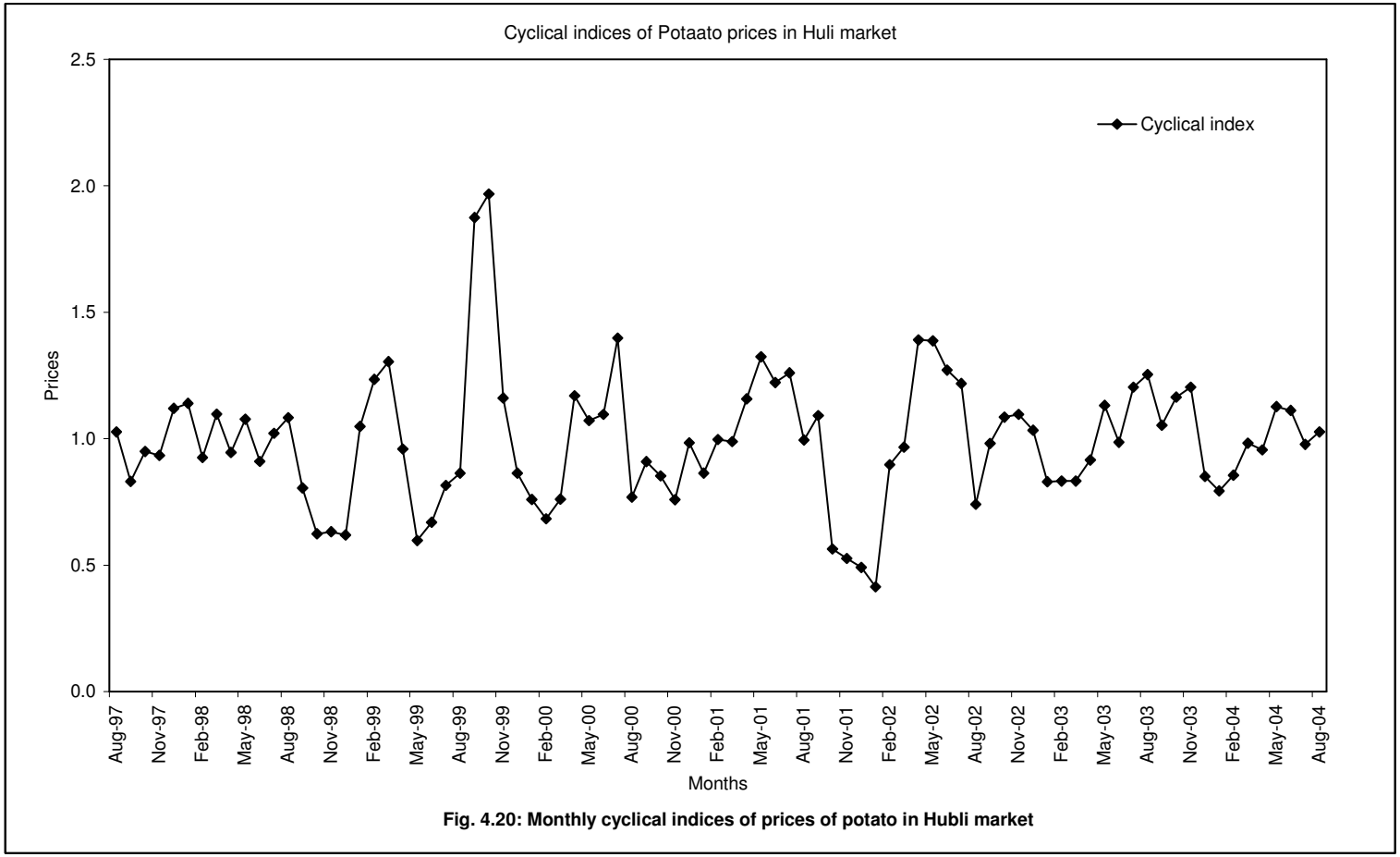


Fig. 4.20: Monthly cyclical indices of prices of potato in Hubli market

Fig. 4.20 : Monthly cyclical indices of prices of potato in Hubli market

Table 4.21: Correlation for monthly arrivals and prices of potato in selected market

Sl. No.	Market	Correlation coefficient	't' value
1.	Bangalore	-0.17NS	1.095
2.	Kolar	-0.37*	3.725
3.	Hassan	-0.58*	7.269
4.	Belgaum	-0.38*	3.825
5.	Hubli	-0.36*	3.302

NS – Non-significant * - Significant at 5%

Table 4.22: Dickey fuller test for stationarity of the price series of potato in selected markets

Sl. No.	Market	Order of integration	ADF value	Assy. critical value @ 10%
1.	Bangalore	0	-2.8781	-2.57
2.	Kolar	0	-2.8802	-2.57
3.	Hassan	0	-2.7714	-2.57
4.	Belgaum	0	-2.6965	-2.57
5.	Hubli	0	-2.7687	-2.57

Table 4.23 : ACF and PACF of monthly arrivals and prices of potato in Bangalore market

Bangalore Arrivals (A)

Lags	ACF	PACF
1	-.257	-0.257
2	-.209	-0.295
3	0.016	-0.152
4	-0.038	-0.172
5	-0.136	-0.290
6	0.062	-0.198
7	0.083	-0.136
8	0.075	-0.009
9	-0.036	-0.035
10	0.012	0.022
11	0.175	0.313
12	-0.338	-0.097
13	-0.043	-0.067
14	0.151	-0.012
15	0.070	0.074
16	-0.125	-0.098

Bangalore prices (B)

Lags	ACF	PACF
1	0.127	0.127
2	-0.038	-0.055
3	-0.148	-0.139
4	-0.076	-0.042
5	0.218	0.232
6	0.071	-0.009
7	-0.250	-0.295
8	-0.069	0.068
9	0.111	0.208
10	-0.047	-0.265
11	0.031	-0.037
12	-0.537	-0.439
13	-0.200	-0.044
14	0.116	0.068
15	0.097	-0.059
16	0.172	0.145

Table 4.24: ACF and PACF of monthly arrivals and prices of potato in Kolar market

Kolar Arrivals (A)

Lags	ACF	PACF
1	-0.339	-0.339
2	-0.295	-0.462
3	0.272	-0.044
4	-0.121	-0.199
5	-0.037	-0.079
6	0.121	-0.024
7	-0.116	-0.094
8	0.049	0.007
9	-0.072	-0.185
10	0.031	-0.038
11	0.199	0.158
12	-0.291	-0.155
13	0.071	0.009
14	0.030	-0.230
15	0.003	0.067
16	0.002	-0.117

Kolar prices (B)

Lags	ACF	PACF
1	-0.145	-0.145
2	-0.266	-0.293
3	0.075	-0.019
4	0.040	-0.030
5	-0.131	-0.125
6	0.026	-0.017
7	0.032	-0.038
8	-0.091	-0.095
9	0.051	0.019
10	0.153	0.120
11	-0.080	-0.007
12	-0.445	-0.451
13	0.209	0.000
14	0.090	-0.110
15	-0.141	-0.092
16	0.045	-0.027

Table 4.25 : ACF and PACF of monthly arrivals and prices of potato in Hassan market

Hassan Arrivals (A)

Lags	ACF	PACF
1	-0.299	-0.299
2	-0.336	-0.467
3	0.219	-0.095
4	0.091	-0.004
5	-0.252	-0.184
6	-0.045	-0.239
7	0.254	-0.017
8	-0.013	0.056
9	-0.307	-0.224
10	0.254	0.030
11	0.177	0.141
12	-0.412	-0.200
13	0.008	-0.178
14	0.238	-0.158
15	-0.035	-0.027
16	-0.164	-0.056

Hassan prices (B)

Lags	ACF	PACF
1	-0.215	-0.215
2	-0.046	-0.097
3	-0.113	-0.153
4	-0.078	-0.157
5	-0.029	-0.123
6	0.045	-0.041
7	-0.013	-0.067
8	0.073	0.023
9	-0.032	-0.027
10	-0.072	-0.094
11	0.296	0.296
12	-0.465	-0.405
13	0.090	-0.050
14	-0.071	-0.144
15	0.107	-0.014
16	0.087	0.037

Table 4.26 : ACF and PACF of monthly arrivals and prices of potato in Belgaum market

Belgaum Arrivals (A)

Lags	ACF	PACF
1	-0.337	-0.337
2	-0.139	-0.284
3	0.137	-0.023
4	-0.156	-0.178
5	0.054	-0.053
6	-0.090	-0.190
7	-0.059	-0.195
8	0.134	-0.060
9	-0.060	-0.088
10	0.127	0.095
11	0.068	0.153
12	-0.328	-0.242
13	0.124	-0.144
14	0.037	-0.083
15	-0.002	0.076
16	-0.104	-0.165

Belgaum prices (B)

Lags	ACF	PACF
1	-0.123	-0.123
2	-0.211	-0.230
3	0.029	-0.034
4	-0.215	-0.284
5	0.218	0.162
6	0.055	-0.017
7	-0.171	-0.081
8	0.109	0.047
9	0.004	0.057
10	0.082	0.122
11	-0.076	-0.122
12	-0.357	-0.314
13	0.060	-0.107
14	0.126	-0.031
15	0.052	-0.001
16	0.011	-0.085

Table 4.27: ACF and PACF of monthly arrivals and prices of potato in Hubli market

Hubli Arrivals (A)

Lags	ACF	PACF
1	-0.477	-0.477
2	0.046	-0.236
3	-0.082	-0.231
4	0.077	-0.100
5	0.060	0.063
6	-0.132	-0.076
7	0.087	0.004
8	-0.061	-0.038
9	-0.072	-0.200
10	0.050	-0.142
11	0.193	0.208
12	-0.384	-0.301
13	0.167	-0.189
14	-0.058	-0.156
15	0.218	0.044
16	-0.225	-0.136

Hubli prices (B)

Lags	ACF	PACF
1	0.134	0.134
2	-0.175	-0.197
3	-0.029	0.027
4	-0.354	-0.412
5	-0.157	-0.038
6	0.056	-0.105
7	0.232	0.264
8	0.167	-0.067
9	-0.038	-0.006
10	0.105	0.133
11	-0.288	-0.282
12	-0.437	-0.261
13	0.119	0.083
14	0.093	-0.015
15	0.032	-0.114
16	0.201	-0.037

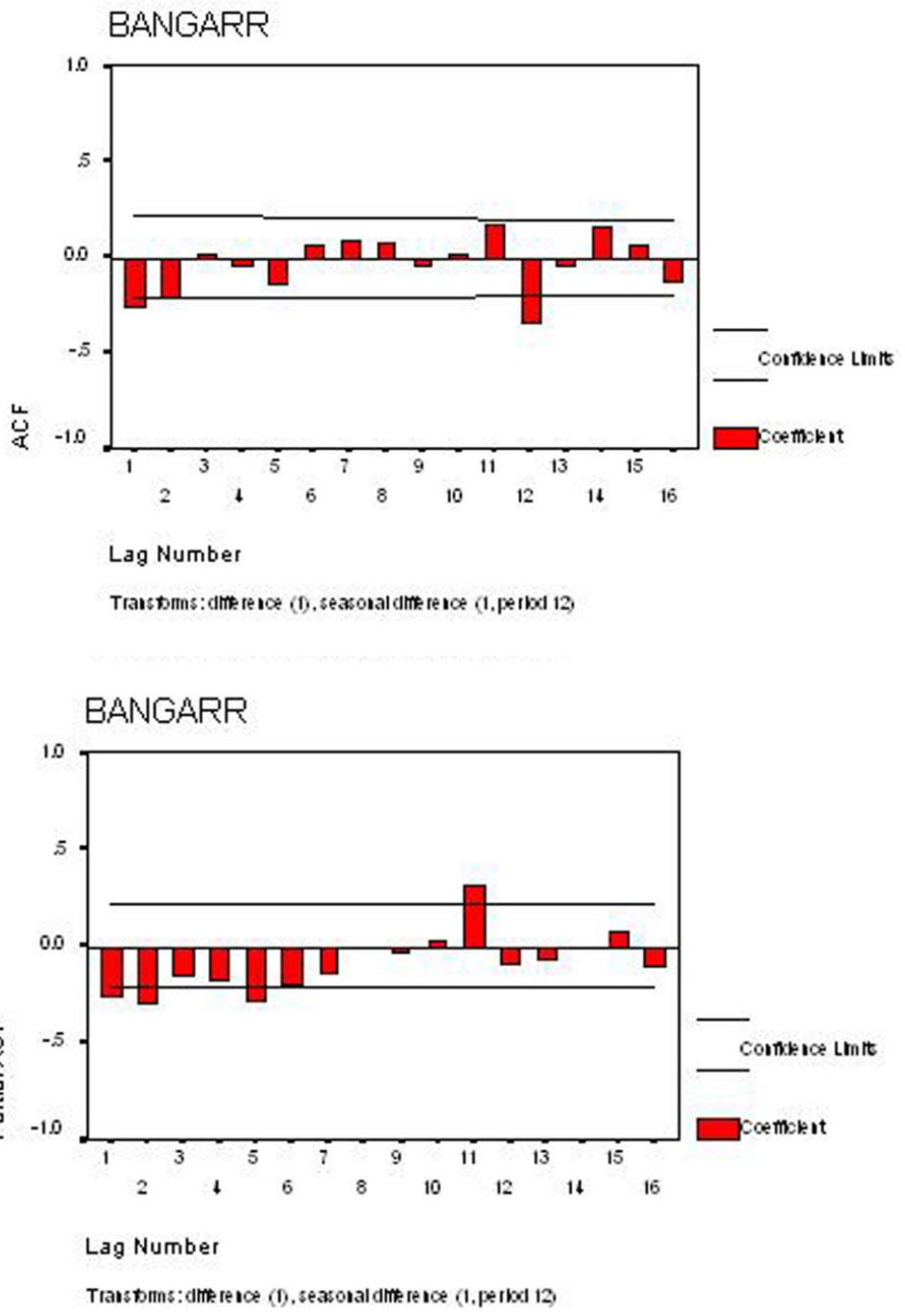
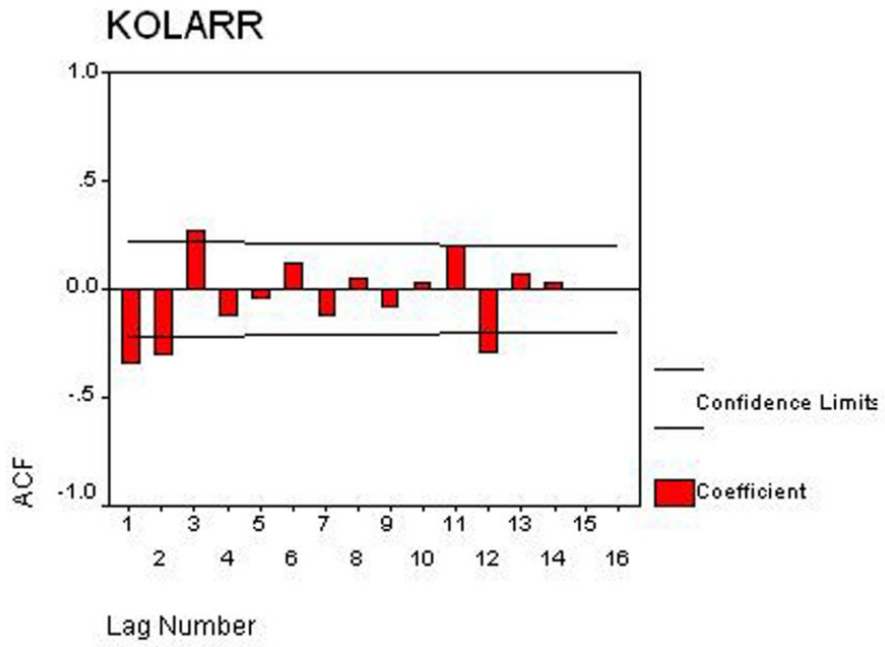


Fig. 4.21 : ACF and PACF of monthly arrivals of potato in Bangalore



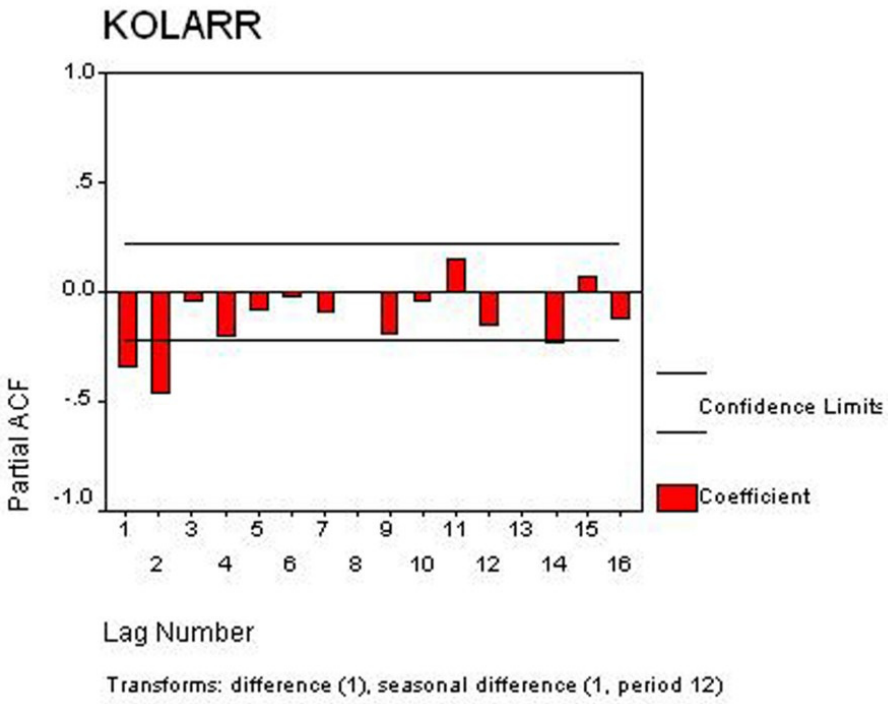


Fig. 4.22 : ACF and PACF of monthly arrivals of potato in Kolar market

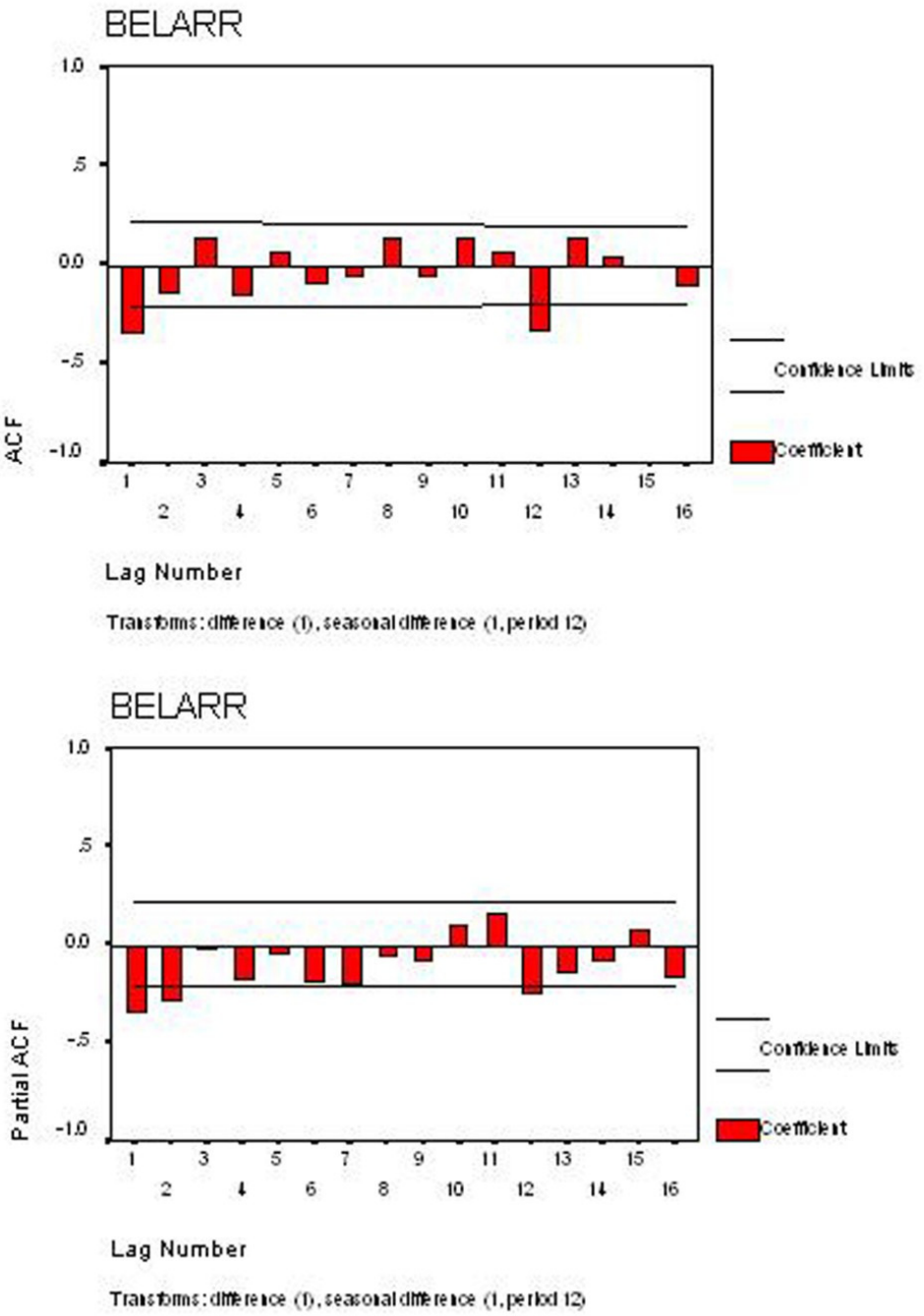
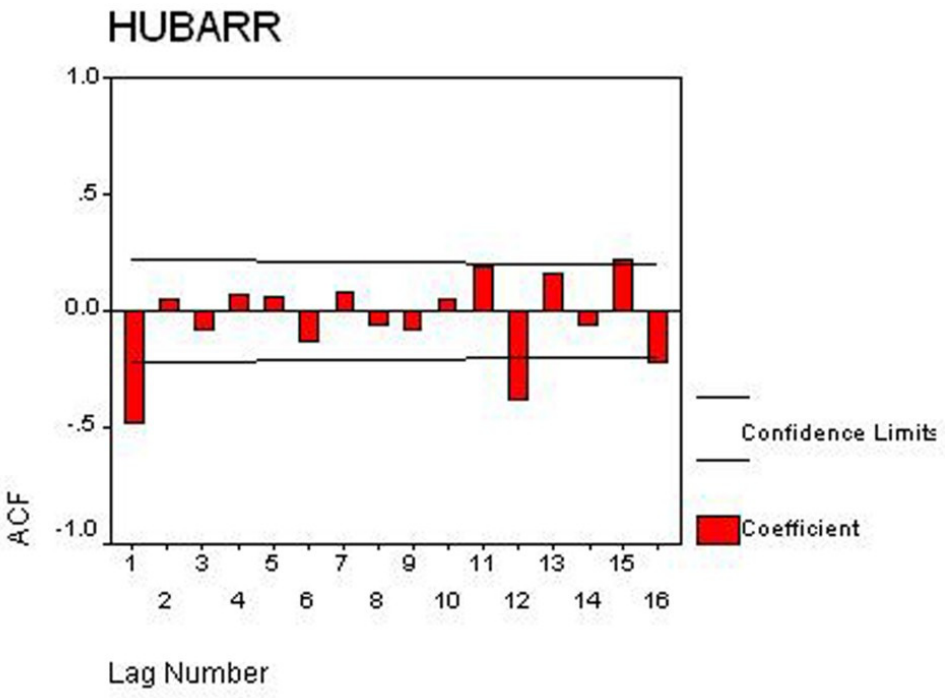


Fig. 4.23 : ACF and PACF of monthly arrivals of potato in Belgaum



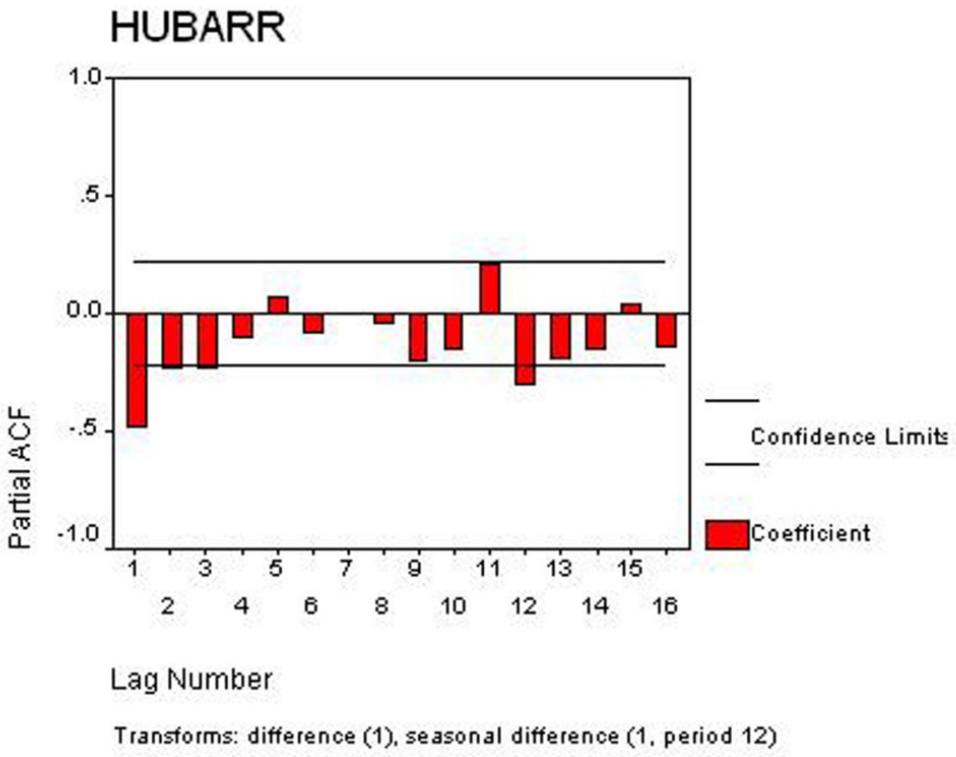


Fig. 4.24 : ACF and PACF of monthly arrivals of potato in Hubli market

present context, co-integration analysis is employed to examine whether the one market is integrated with the other market. This is studied by testing whether the Law of one Price (LOP) holds in these markets.

For co-integration analysis, at first the order of integration of the price series is to be determined. The number of times a series has to be differenced before it comes stationary is itself the order of integration. A series, which has to differenced once to become stationary, has an order of integration one, denoted as I(1). A series, which has been differed twice to become stationary has an order of integration two, denoted as I(2).

It determining the order of integration under study, the Dickey-Fuller test was employed. The Dickey-Fuller test is based on the regression.

$P_t = bP_{t-1} + e$

Here, 'b' will be zero if 'P' follows random walk. It will be negative and significantly different from zero if P_t is stationary.

Dickey-Fuller test for stationarity of the price series of potato of selected markets presented in Table 4.22. It could be seen from the table that the price series of potato in all the selected markets attain stationarity at same orders of differencing. The dickey Fuller values for the differenced series in all the markets found to be negative and significant at same levels of differencing. This indicates that the price series of all the selected markets attains its stationarity at zero order of integration, thus showing the integrated of order I(0). It means the price series for all the markets were stationarity at their original level. Hence, from this conclusion can be drawn that all the selected five markets are co-integrated.

4.4 BOX-JENKINS MODEL

4.4.1 Arrivals of potato in selected markets

4.4.1.1 Identification of the models

The tentative models were first identified based on the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) for the different series Y_t. The computed value of ACF and PACF of different series are shown in Table from 4.23 (A) to 4.27 (A) upto 16 lags. The chart of the ACF and PACF of arrivals of potato over time lag are shown in Fig from 4.21 to 4.24. An examination of the ACF and PACF revealed no seasonality. However, the series was found to be stationary since the co-efficient dropped to zero after the first or second lag. Each individual co-efficient of ACF and PACF are tested for their significance using 't' test. Further, the absence of peak at first values clearly indicate suitability of the choice of non-seasonal difference d=1, to accomplish stationarity series. So based on ACF and PACF, the tentatively identified models are as follows.

(p. d. q)	(p. d. q)
(1 1 0)	(1 1 2)
(0 1 1)	(2 1 2)
(2 1 1)	(3 1 2)

4.4.1.2 Estimation of models

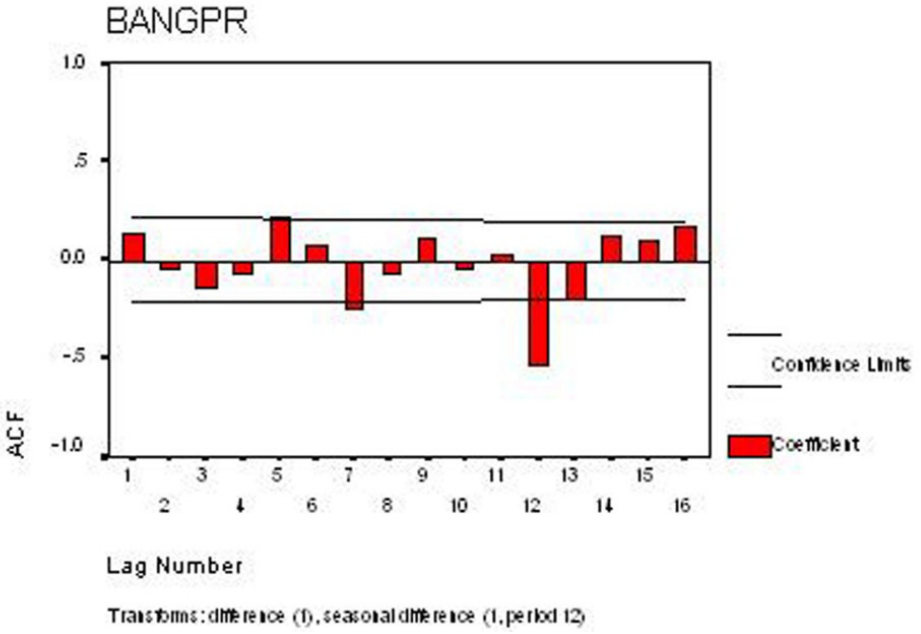
After identifying the models tentatively the next step is to obtain the estimate by the method of least square estimates of the parameters = (0, 0) such that the error sum of squares is to be minimum.

i.e., $S(0, 0) = e_t^2 (0, 0)$

The parameters of the tentatively identified models were estimated by a iterative process and then the residuals of each of the models is to be obtained.

Table 4.28 : Residual analysis of monthly arrival of potato in selected markets

Model	SE	Akike information coefficient
(2 1 2)	425.25	1238.28
(2 1 1)	447.56	1412.56
(1 1 2)	432.27	1295.22



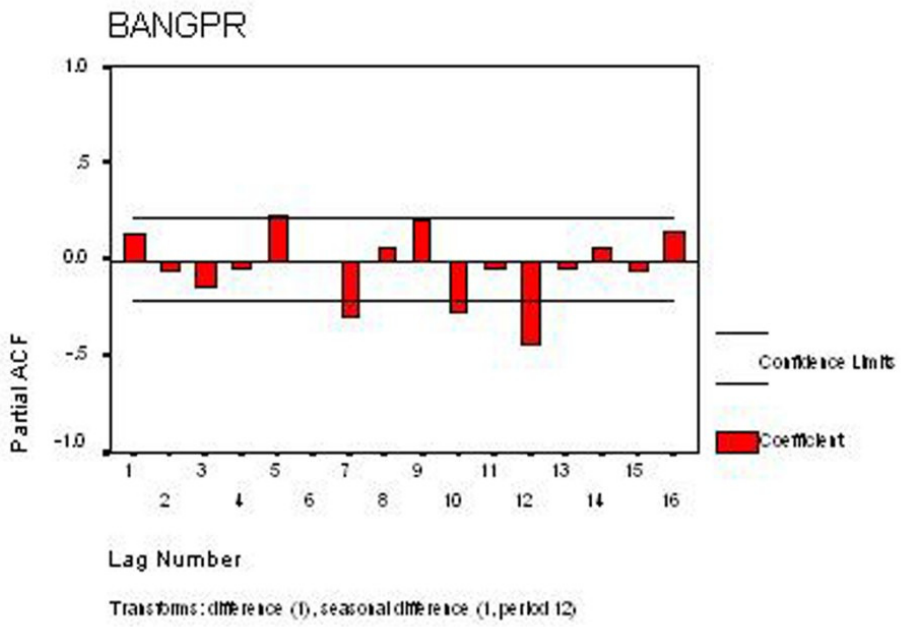


Fig. 4.25 : ACF and PACF of monthly prices of potato in Bangalore

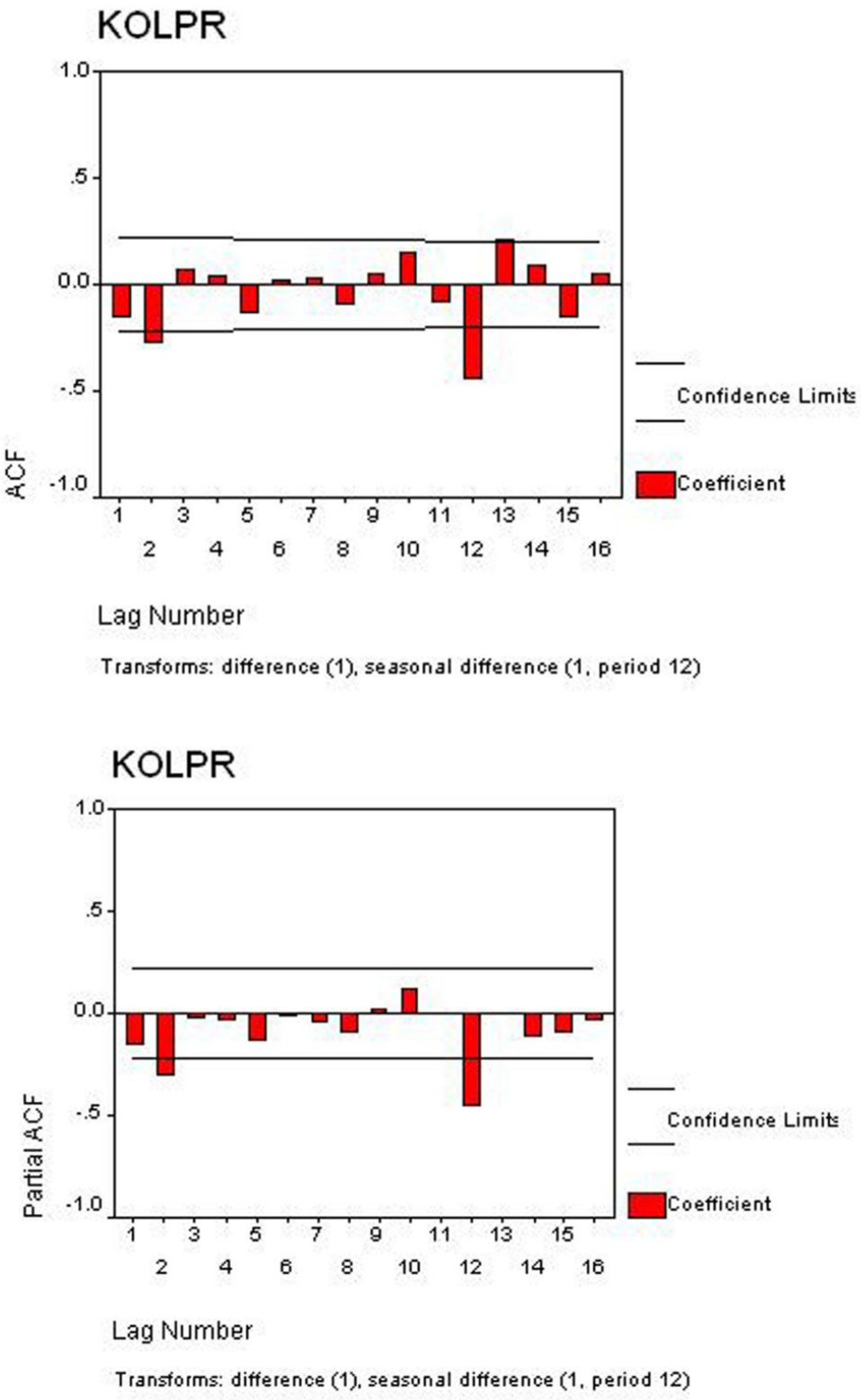
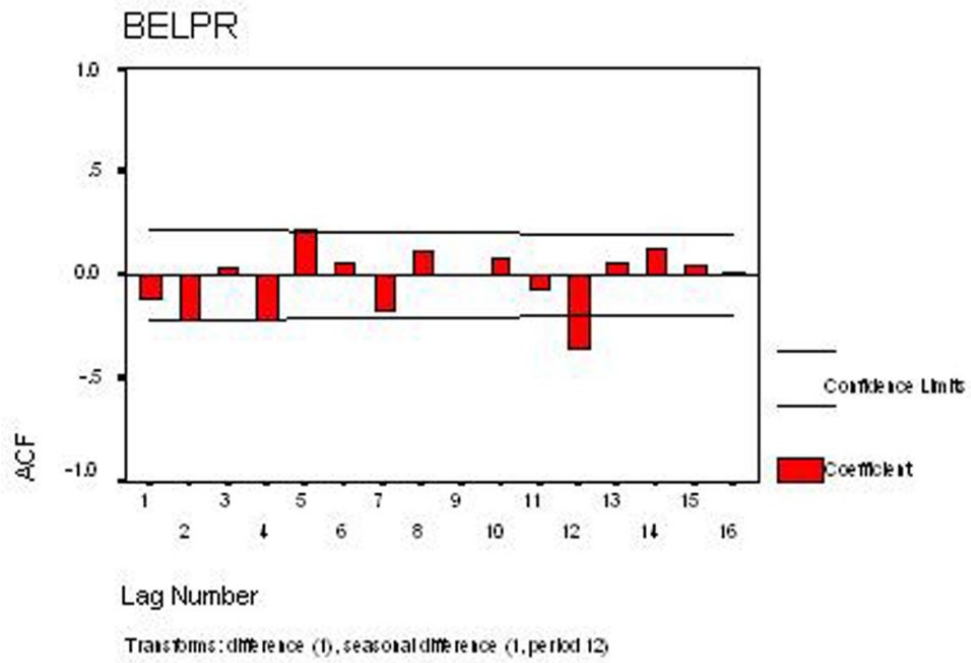


Fig. 4.26: ACF and PACF of monthly prices of potato in Kolar market

Fig. 4.26: ACF and PACF of monthly prices of potato in Kolar market



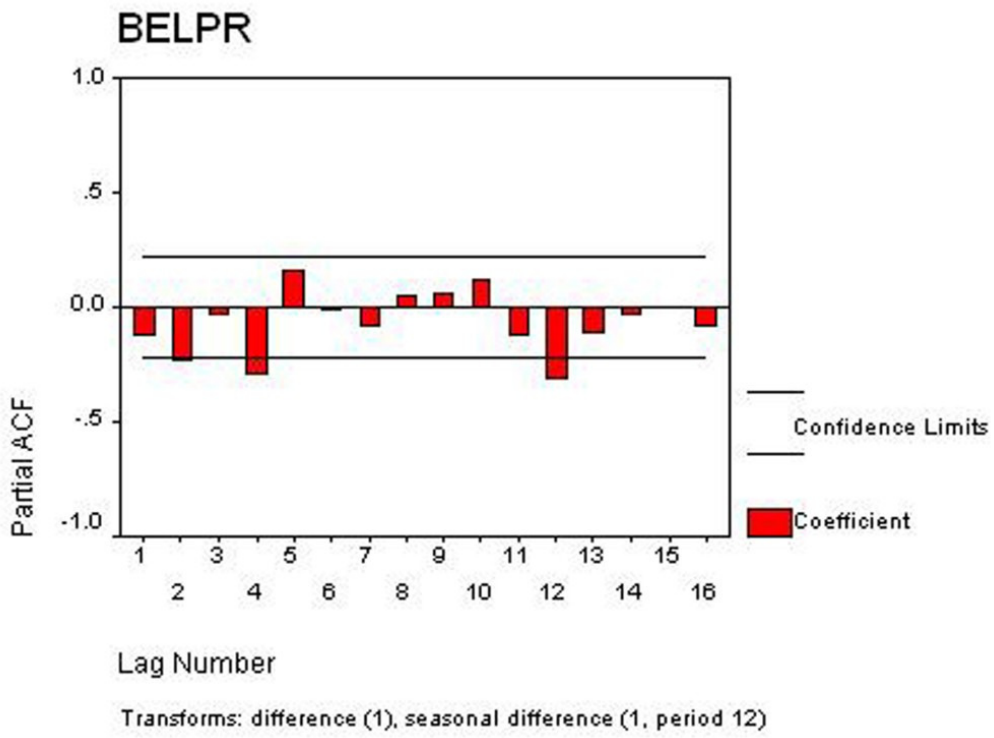


Fig. 4.27: ACF and PACF of monthly prices of potato in Belgaum

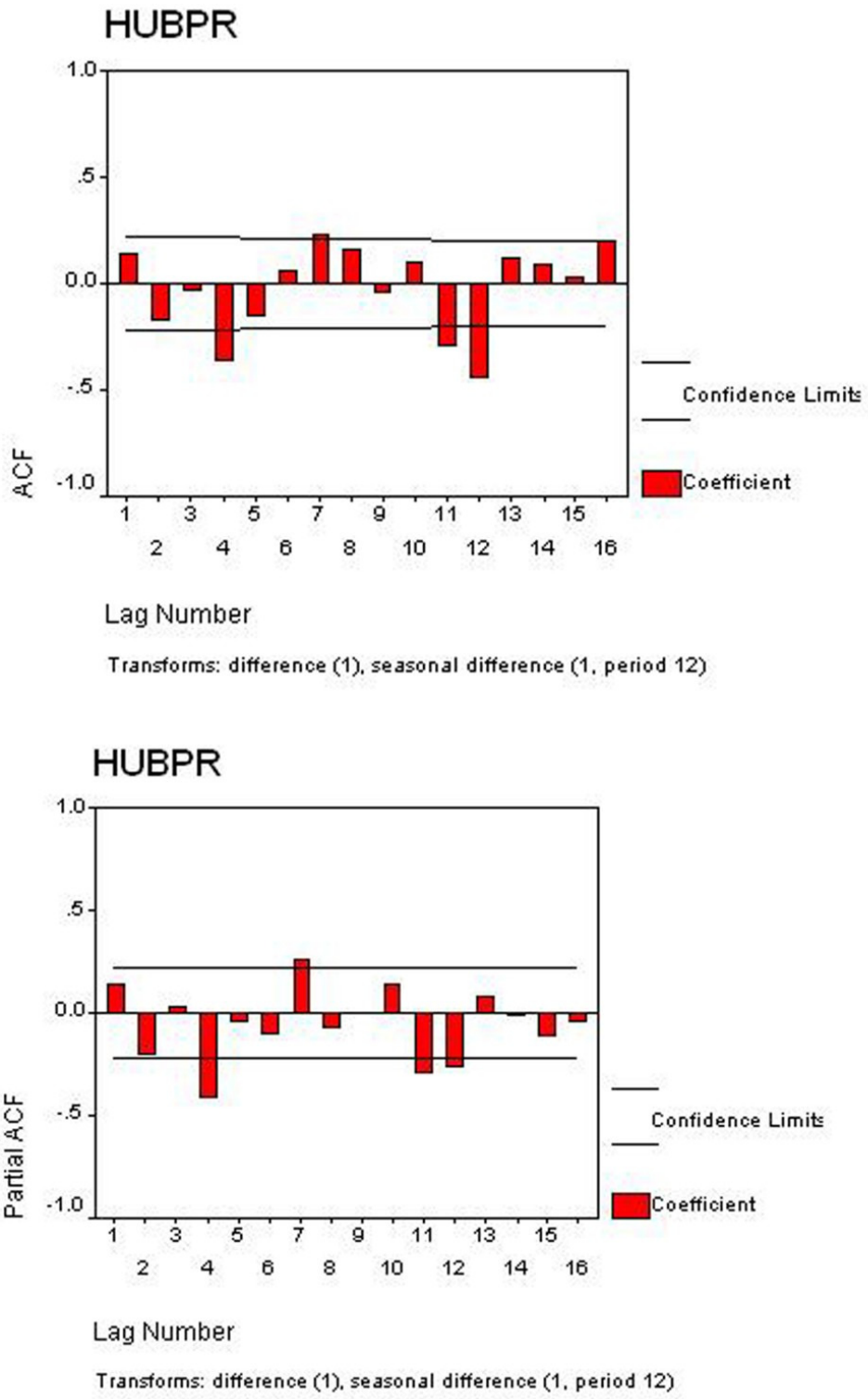


Fig. 4.28. ACF and PACF of monthly prices of potato in Hubli market

4.4.1.3 Diagnostic checking

Residual analysis is carried out to check the adequacy of the models. The ACF if residuals were obtained from all the tentatively identified models by back forecasting. The adequacy of the model is judged based on the values of Box-Pierce "Q" statistics and Akike information coefficient (AIC). The values of there statistics are shown in Table 4.28. For all the tentatively identified model. The model is found to SC best model since it had the lowest value of AIC and Q statistics. The model can also be written with its parameters.

4.4.1.4 Forecasting the arrivals of potato in selected market

The method of forecasting has been explained in chapter III. The forecast was done upto March 2006, the results of Ex-ante and Ex-post forecast were shown in Table from 4.29 to 4.33. Accuracy was tested using the test described in chapter III. The forecasts are also depicted in the Fig. from 4.25 (A) to 4.28 (A).

4.4.2 Price of potato in selected market

4.2.2.1 Identification of the models

The tentative models were first identified based on the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) for the different series Y_t. The computed value of ACF and PACF of different series are shown in Table from 4.26 (B) to 4.30 (B) upto 16 lags. The chart of the ACF and PACF of prices of potato over time lag are shown in Fig from 4.25 to 4.28. An examination of the ACF and PACF revealed no seasonality. However, the series was found to be stationary since the co-efficient dropped to zero after the first or second lag. Each individual co-efficient of ACF and PACF are tested for their significance using 't' test. Further, the absence of peak at first values clearly indicate suitability of the choice of non-seasonal difference d=1, to accomplish stationarity series. So based on ACF and PACF, the tentatively identified models are as follows.

(p. d. q)	(p. d. q)
(2 1 2)	(0 1 1)
(3 1 2)	(1 1 3)
(2 1 3)	(2 1 2)

4.4.2.2 Estimation of models

After identifying the models tentatively the next step is to obtain the estimate by the method of least square estimates of the parameters = (0, 0) such that the error sum of squares is to be minimum. i.e., $S(0, 0) = e_t^2 (0, 0)$

The parameters of the tentatively identified models were estimated by a iterative process and then the residuals of each of the models is to be obtained.

4.4.2.3 Diagnostic checking

Residual analysis is carried out to check the adequacy of the models. The ACF if residuals were obtained from all the tentatively identified models by back forecasting. The adequacy of the model is judged based on the values of Box-Pierce "Q" statistics and Akike information coefficient (AIC). The values of there statistics are shown in Table 4.34. For all the tentatively identified model. The model is found to SC best model since it had the lowest value of AIC and Q statistics. The model can also be written with its parameters.

4.4.2.4 Forecasting the arrivals of potato in selected market

The method of forecasting has been explained in chapter III. The forecast was done upto March 2006, the results of Ex-ante and Ex-post forecast were shown in Table from 4.35 to 4.39. Accuracy was tested using the test described in chapter III. The forecasts are also depicted in the Fig. from 4.29 (B) to 4.33 (B).

Table 4.34 : Residual analysis of monthly prices of potato in selected markets

Model	SE	Akike information coefficient
(0 1 2)	247.25	2968.28
(1 1 3)	264.52	2892.32
(2 1 2)	235.57	2725.12

Table 4.29 : Ex-Ante and Ex-post forecast of monthly arrivals of potato in Balgalore market

Month	Actual value	forecast value	Month	Actual value	forecast value	Month	Actual value	forecast value
01-Apr-1996	51311	*	01-Oct-1999	129795	175817	01-Apr-2003	190928	146697
01-May-1996	45259	*	01-Nov-1999	98562	78061	01-May-2003	172676	158531
01-Jun-1996	110793	*	01-Dec-1999	102917	139951	01-Jun-2003	180110	147933
01-Jul-1996	66845	*	01-Jan-2000	112188	287452	01-Jul-2003	203434	162994
01-Aug-1996	122897	*	01-Feb-2000	142199	84386	01-Aug-2003	153951	262921
01-Sep-1996	312639	*	01-Mar-2000	222738	117670	01-Sep-2003	315412	235666
01-Oct-1996	177286	*	01-Apr-2000	152585	123351	01-Oct-2003	222340	199389
01-Nov-1996	189947	*	01-May-2000	142887	154596	01-Nov-2003	123450	109819
01-Dec-1996	102608	*	01-Jun-2000	161645	129187	01-Dec-2003	128029	167760
01-Jan-1997	115026	*	01-Jul-2000	101648	100020	01-Jan-2004	207485	250749
01-Feb-1997	135705	*	01-Aug-2000	118122	237188	01-Feb-2004	175684	228027
01-Mar-1997	125768	*	01-Sep-2000	298592	162972	01-Mar-2004	202594	151243
01-Apr-1997	160541	154343	01-Oct-2000	255870	185699	01-Apr-2004	*	141604.619
01-May-1997	298592	306994	01-Nov-2000	246422	126437	01-May-2004	*	151722.695
01-Jun-1997	255870	227151	01-Dec-2000	124739	145050	01-Jun-2004	*	146782.418
01-Jul-1997	246422	291946	01-Jan-2001	154191	268096	01-Jul-2004	*	144591.671
01-Aug-1997	124739	414871	01-Feb-2001	183762	139103	01-Aug-2004	*	263238.721
01-Sep-1997	154191	200539	01-Mar-2001	658462	252033	01-Sep-2004	*	217022.445
01-Oct-1997	122897	226308	01-Apr-2001	191318	168859	01-Oct-2004	*	182687.542
01-Nov-1997	312639	189438	01-May-2001	128288	173270	01-Nov-2004	*	122338.857

01-Dec-1997	154191	183163	01-Jun-2001	14659	108909	01-Dec-2004	*	168024.733
01-Jan-1998	183762	205664	01-Jul-2001	134817	125253	01-Jan-2005	*	227162.992
01-Feb-1998	658462	337848	01-Aug-2001	207365	293034	01-Feb-2005	*	232686.985
01-Mar-1998	191318	264632	01-Sep-2001	273525	192232	01-Mar-2005	*	155999.693
01-Apr-1998	128288	271876	01-Oct-2001	391540	249884	01-Apr-2005	*	139554.409
01-May-1998	125436	208419	01-Nov-2001	191579	132461	01-May-2005	*	148486.193
01-Jun-1998	114571	183329	01-Dec-2001	92406	153087	01-Jun-2005	*	142770.054
01-Jul-1998	113272	152960	01-Jan-2002	177197	273042	01-Jul-2005	*	140564.374
01-Aug-1998	73417	249207	01-Feb-2002	177812	256721	01-Aug-2005	*	258892.724
01-Sep-1998	191027	164305	01-Mar-2002	180443	129015	01-Sep-2005	*	212637.403
01-Oct-1998	199230	287046	01-Apr-2002	212344	159619	01-Oct-2005	*	178073.953
01-Nov-1998	57326	94238	01-May-2002	140574	154905	01-Nov-2005	*	117637.775
01-Dec-1998	65816	136851	01-Jun-2002	155479	147983	01-Dec-2005	*	163134.360
01-Jan-1999	148148	402868	01-Jul-2002	126339	146381	01-Jan-2006	*	222157.531
01-Feb-1999	123355	76720	01-Aug-2002	145324	274500	01-Feb-2006	*	227512.524
01-Mar-1999	113355	89480	01-Sep-2002	177509	204283	1-Mar-06	*	268646.302
01-Apr-1999	114732	110745	01-Oct-2002	186539	183313			
01-May-1999	127299	152193	01-Nov-2002	195569	118618			
01-Jun-1999	154158	132480	01-Dec-2002	167988	170641			
01-Jul-1999	114396	89498	01-Jan-2003	211528	261463			
01-Aug-1999	150339	222443	01-Feb-2003	194921	244617			
01-Sep-1999	326106	191000	01-Mar-2003	159025	132799			

Table 4.35 : Ex-Ante and Ex-post forecast of monthly prices of potato in Bangalore market

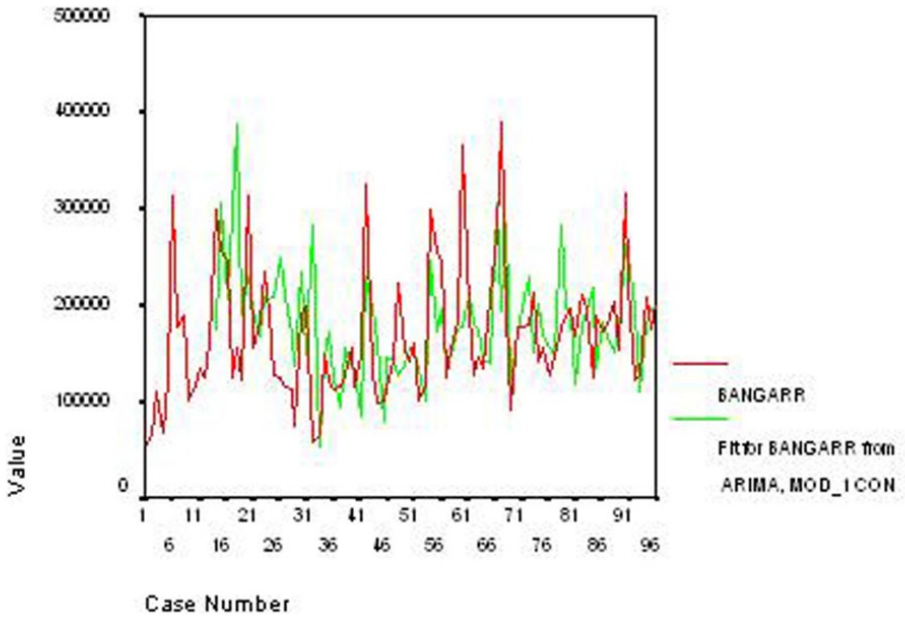
Bangalore prices

Months	Actual value	forecast value	Months	Actual value	forecast value	Months	Actual value	forecast value
01-Apr-1996	585	*	01-Apr-2000	320	376	01-May-2004	*	666.840
01-May-1996	575	*	01-May-2000	350	339	01-Jun-2004	*	685.826
01-Jun-1996	550	*	01-Jun-2000	400	436	01-Jul-2004	*	553.428
01-Jul-1996	590	*	01-Jul-2000	500	493	01-Aug-2004	*	526.416
01-Aug-1996	550	*	01-Aug-2000	380	282	01-Sep-2004	*	667.606
01-Sep-1996	270	*	01-Sep-2000	280	353	01-Oct-2004	*	713.422
01-Oct-1996	350	*	01-Oct-2000	225	300	01-Nov-2004	*	591.936
01-Nov-1996	425	*	01-Nov-2000	260	204	01-Dec-2004	*	526.395
01-Dec-1996	400	*	01-Dec-2000	210	173	01-Jan-2005	*	522.056
01-Jan-1997	450	*	01-Jan-2001	200	123	01-Feb-2005	*	552.816
01-Feb-1997	380	*	01-Feb-2001	210	159	01-Mar-2005	*	606.967
01-Mar-1997	300	*	01-Mar-2001	255	314	01-Apr-2005	*	690.516
01-Apr-1997	350	342	01-Apr-2001	360	442	01-May-2005	*	754.452
01-May-1997	350	328	01-May-2001	750	793	01-Jun-2005	*	839.966
01-Jun-1997	325	366	01-Jun-2001	745	775	01-Jul-2005	*	700.861
01-Jul-1997	340	300	01-Jul-2001	690	604	01-Aug-2005	*	607.290
01-Aug-1997	375	106	01-Aug-2001	350	246	01-Sep-2005	*	719.885
01-Sep-1997	400	499	01-Sep-2001	325	423	01-Oct-2005	*	817.903

01-Oct-1997	400	435	01-Oct-2001	675	792	01-Nov-2005	*	757.452
01-Nov-1997	450	399	01-Nov-2001	800	711	01-Dec-2005	*	678.293
01-Dec-1997	300	371	01-Dec-2001	655	553	01-Jan-2006	*	608.855
01-Jan-1998	325	303	01-Jan-2002	445	383	01-Feb-2006	*	618.675
01-Feb-1998	350	287	01-Feb-2002	405	452	1-Mar-06	*	575.656
01-Mar-1998	400	417	01-Mar-2002	450	571		*	
01-Apr-1998	550	520	01-Apr-2002	580	698			
01-May-1998	800	778	01-May-2002	630	581			
01-Jun-1998	900	952	01-Jun-2002	650	668			
01-Jul-1998	850	855	01-Jul-2002	820	766			
01-Aug-1998	900	766	01-Aug-2002	540	494			
01-Sep-1998	800	830	01-Sep-2002	575	669			
01-Oct-1998	800	869	01-Oct-2002	650	688			
01-Nov-1998	1000	934	01-Nov-2002	625	547			
01-Dec-1998	800	838	01-Dec-2002	425	394			
01-Jan-1999	650	608	01-Jan-2003	370	352			
01-Feb-1999	450	429	01-Feb-2003	305	277			
01-Mar-1999	300	422	01-Mar-2003	375	426			
01-Apr-1999	320	430	01-Apr-2003	400	533			
01-May-1999	350	362	01-May-2003	420	477			
01-Jun-1999	300	279	01-Jun-2003	575	656			
01-Jul-1999	360	386	01-Jul-2003	605	422			

01-Aug-1999	200	104	01-Aug-2003	470	387			
01-Sep-1999	150	193	01-Sep-2003	310	435			
01-Oct-1999	400	516	01-Oct-2003	470	578			
01-Nov-1999	410	257	01-Nov-2003	600	512			
01-Dec-1999	450	420	01-Dec-2003	560	456			
01-Jan-2000	300	230	01-Jan-2004	435	349			
01-Feb-2000	240	197	01-Feb-2004	390	423			
01-Mar-2000	280	356	01-Mar-2004	410	531			

Bangalore arrivals (A)



Bangalore prices (B)

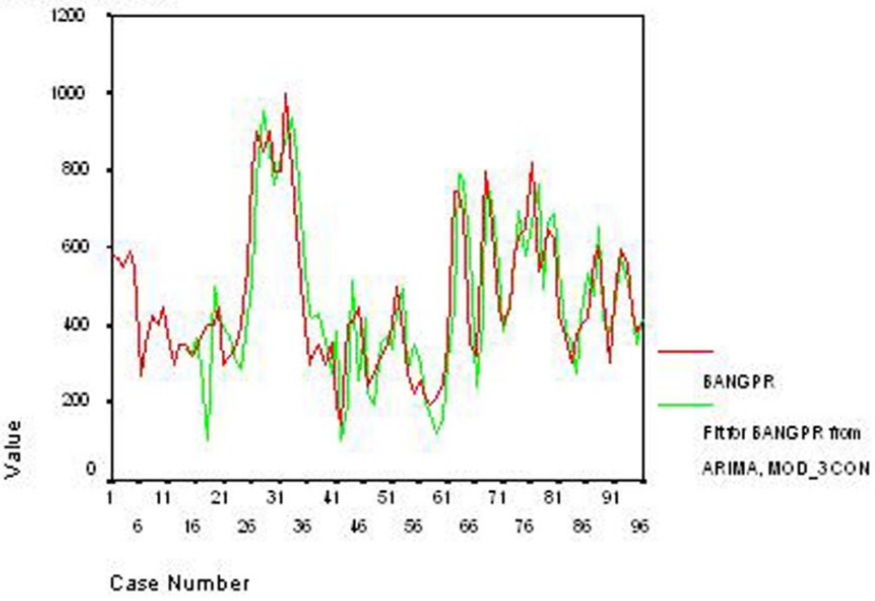


Fig. 4.29 : Ex-ante and Ex-post forecast of monthly arrivals and prices of potato in Bangalore market

Table 4.30 : Ex-Ante and Ex-post forecast of monthly arrivals of potato in Kolar market

Kolar arrivals

Months	Actual value	forecast value	Months	Actual value	forecast value	Months	Actual value	forecast value
01-Apr-1996	10213	*	01-Apr-2000	5865	4051	01-Apr-2004	*	1399.506
01-May-1996	1156	*	01-May-2000	3845	4713	01-May-2004	*	1276.480
01-Jun-1996	1010	*	01-Jun-2000	1480	3445	01-Jun-2004	*	1217.594
01-Jul-1996	1370	*	01-Jul-2000	3565	3945	01-Jul-2004	*	1271.082
01-Aug-1996	1586	*	01-Aug-2000	3010	2731	01-Aug-2004	*	1018.172
01-Sep-1996	1370	*	01-Sep-2000	3250	3309	01-Sep-2004	*	1547.586
01-Oct-1996	1245	*	01-Oct-2000	3653	3725	01-Oct-2004	*	2356.000
01-Nov-1996	1197	*	01-Nov-2000	2338	3706	01-Nov-2004	*	1214.909
01-Dec-1996	1156	*	01-Dec-2000	4913	6907	01-Dec-2004	*	2830.759
01-Jan-1997	1010	*	01-Jan-2001	9302	14478	01-Jan-2005	*	7290.971
01-Feb-1997	1370	*	01-Feb-2001	2255	11835	01-Feb-2005	*	8231.576
01-Mar-1997	4448	*	01-Mar-2001	2540	2148	01-Mar-2005	*	4667.072
01-Apr-1997	8122	2365	01-Apr-2001	6872	4076	01-Apr-2005	*	1335.841
01-May-1997	1547	1235	01-May-2001	2034	1545	01-May-2005	*	2734.151
01-Jun-1997	1540	1209	01-Jun-2001	1043	2905	01-Jun-2005	*	2108.208
01-Jul-1997	4395	3304	01-Jul-2001	2375	1609	01-Jul-2005	*	3323.479
01-Aug-1997	1454	1014	01-Aug-2001	1484	1637	01-Aug-2005	*	3411.916
01-Sep-1997	2035	1365	01-Sep-2001	2580	1616	01-Sep-2005	*	3813.095

01-Oct-1997	2254	1811	01-Oct-2001	4852	3603	01-Oct-2005	*	3070.000
01-Nov-1997	1375	1338	01-Nov-2001	4520	3745	01-Nov-2005	*	3606.000
01-Dec-1997	3884	2667	01-Dec-2001	3526	6060	01-Dec-2005	*	2658.000
01-Jan-1998	3256	2874	01-Jan-2002	7807	10126	01-Jan-2006	*	4795.192
01-Feb-1998	2547	5802	01-Feb-2002	22885	20755	01-Feb-2006	*	5591.955
01-Mar-1998	4563	9328	01-Mar-2002	10552	5393	1-Mar-06	*	8880.568
01-Apr-1998	3898	2051	01-Apr-2002	8120	5154			
01-May-1998	2892	2101	01-May-2002	6035	2419			
01-Jun-1998	3568	3664	01-Jun-2002	2333	4005			
01-Jul-1998	2941	1520	01-Jul-2002	1486	1254			
01-Aug-1998	4637	3249	01-Aug-2002	1041	2059			
01-Sep-1998	1907	1549	01-Sep-2002	1126	1365			
01-Oct-1998	1823	1443	01-Oct-2002	1163	2127			
01-Nov-1998	4926	4486	01-Nov-2002	1119	1142			
01-Dec-1998	4290	3160	01-Dec-2002	1092	5164			
01-Jan-1999	5719	4309	01-Jan-2003	13497	14560			
01-Feb-1999	28912	20637	01-Feb-2003	10030	11492			
01-Mar-1999	42875	29029	01-Mar-2003	15159	8764			
01-Apr-1999	12351	6132	01-Apr-2003	20510	10345			
01-May-1999	13015	11537	01-May-2003	9489	4307			
01-Jun-1999	6496	6758	01-Jun-2003	23561	1931			
01-Jul-1999	6520	7979	01-Jul-2003	23511	2365			

01-Aug-1999	2150	2902	01-Aug-2003	23461	1114			
01-Sep-1999	2976	5459	01-Sep-2003	23411	2546			
01-Oct-1999	3254	3059	01-Oct-2003	23361	3654			
01-Nov-1999	1160	5126	01-Nov-2003	5829	3779			
01-Dec-1999	1168	3341	01-Dec-2003	2546	5232			
01-Jan-2000	10440	17430	01-Jan-2004	1341	7654			
01-Feb-2000	12566	19288	01-Feb-2004	10462	11959			
01-Mar-2000	12394	8993	01-Mar-2004	4490	3779			

Table 4.36 : Ex-Ante and Ex-post forecast of monthly prices of potato in Kolar market

Kolar prices

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	300	*	01-Apr-2000	300	390	01-Apr-2004	*	427.630
01-May-1996	450	*	01-May-2000	350	384	01-May-2004	*	441.284
01-Jun-1996	500	*	01-Jun-2000	460	546	01-Jun-2004	*	489.841
01-Jul-1996	500	*	01-Jul-2000	350	339	01-Jul-2004	*	459.795
01-Aug-1996	500	*	01-Aug-2000	400	481	01-Aug-2004	*	437.150
01-Sep-1996	500	*	01-Sep-2000	350	478	01-Sep-2004	*	504.982
01-Oct-1996	300	*	01-Oct-2000	450	492	01-Oct-2004	*	500.729
01-Nov-1996	300	*	01-Nov-2000	350	345	01-Nov-2004	*	448.380
01-Dec-1996	330	*	01-Dec-2000	300	201	01-Dec-2004	*	314.278
01-Jan-1997	325	*	01-Jan-2001	300	208	01-Jan-2005	*	221.678
01-Feb-1997	150	*	01-Feb-2001	300	318	01-Feb-2005	*	238.886
01-Mar-1997	180	*	01-Mar-2001	300	357	01-Mar-2005	*	337.732
01-Apr-1997	250	399	01-Apr-2001	450	473	01-Apr-2005	*	398.423
01-May-1997	250	313	01-May-2001	600	559	01-May-2005	*	406.306
01-Jun-1997	270	308	01-Jun-2001	600	576	01-Jun-2005	*	458.609
01-Jul-1997	400	402	01-Jul-2001	600	535	01-Jul-2005	*	426.029
01-Aug-1997	300	303	01-Aug-2001	600	565	01-Aug-2005	*	404.262
01-Sep-1997	160	452	01-Sep-2001	400	507	01-Sep-2005	*	470.719
01-Oct-1997	600	541	01-Oct-2001	450	460	01-Oct-2005	*	466.313

01-Nov-1997	200	137	01-Nov-2001	650	571	01-Nov-2005	*	413.003
01-Dec-1997	200	256	01-Dec-2001	600	402	01-Dec-2005	*	278.379
01-Jan-1998	250	452	01-Jan-2002	400	300	01-Jan-2006	*	184.966
01-Feb-1998	200	209	01-Feb-2002	300	316	01-Feb-2006	*	201.519
01-Mar-1998	350	329	01-Mar-2002	280	377	1-Mar-06	*	144.762
01-Apr-1998	600	603	01-Apr-2002	400	463			
01-May-1998	600	547	01-May-2002	480	490			
01-Jun-1998	550	588	01-Jun-2002	340	398			
01-Jul-1998	700	596	01-Jul-2002	625	599			
01-Aug-1998	650	525	01-Aug-2002	630	530			
01-Sep-1998	600	669	01-Sep-2002	610	674			
01-Oct-1998	800	530	01-Oct-2002	600	561			
01-Nov-1998	1200	1022	01-Nov-2002	506	479			
01-Dec-1998	1000	793	01-Dec-2002	525	365			
01-Jan-1999	400	309	01-Jan-2003	400	300			
01-Feb-1999	220	372	01-Feb-2003	300	311			
01-Mar-1999	280	508	01-Mar-2003	300	396			
01-Apr-1999	230	375	01-Apr-2003	400	462			
01-May-1999	270	392	01-May-2003	460	455			
01-Jun-1999	280	462	01-Jun-2003	550	593			
01-Jul-1999	300	359	01-Jul-2003	530	496			
01-Aug-1999	300	332	01-Aug-2003	395	406			

01-Sep-1999	600	748	01-Sep-2003	415	521			
01-Oct-1999	600	579	01-Oct-2003	400	423			
01-Nov-1999	500	508	01-Nov-2003	490	481			
01-Dec-1999	460	302	01-Dec-2003	385	248			
01-Jan-2000	300	205	01-Jan-2004	380	305			
01-Feb-2000	300	368	01-Feb-2004	265	255			
01-Mar-2000	250	353	01-Mar-2004	265	379			

Table 4.31 : Ex-Ante and Ex-post forecast of monthly arrivals of potato in Hassan market

Hassan arrivals

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	1828	*	01-Apr-2000	4544	33834	01-Apr-2004	*	8123.262
01-May-1996	2564	*	01-May-2000	9035	6372	01-May-2004	*	11672.515
01-Jun-1996	8952	*	01-Jun-2000	61152	37693	01-Jun-2004	*	2546.000
01-Jul-1996	10584	*	01-Jul-2000	16055	15634	01-Jul-2004	*	12546.000
01-Aug-1996	9870	*	01-Aug-2000	17120	29947	01-Aug-2004	*	35206.178
01-Sep-1996	8564	*	01-Sep-2000	32654	68330	01-Sep-2004	*	62549.516
01-Oct-1996	7895	*	01-Oct-2000	94382	32637	01-Oct-2004	*	23651.807
01-Nov-1996	6587	*	01-Nov-2000	25212	19974	01-Nov-2004	*	10016.324
01-Dec-1996	4586	*	01-Dec-2000	21995	26386	01-Dec-2004	*	11254.000
01-Jan-1997	1605	*	01-Jan-2001	3053	10148	01-Jan-2005	*	45872.000
01-Feb-1997	2509	*	01-Feb-2001	3342	16923	01-Feb-2005	*	21512.000
01-Mar-1997	2909	*	01-Mar-2001	13241	17115	01-Mar-2005	*	4562.000
01-Apr-1997	4578	5201	01-Apr-2001	6721	30901	01-Apr-2005	*	2600.455
01-May-1997	5890	12040	01-May-2001	44837	61498	01-May-2005	*	6444.270
01-Jun-1997	2560	6250	01-Jun-2001	71269	31109	01-Jun-2005	*	5141.000
01-Jul-1997	3654	7002	01-Jul-2001	7183	13932	01-Jul-2005	*	5231.000
01-Aug-1997	2564	4663	01-Aug-2001	7190	81110	01-Aug-2005	*	29527.299
01-Sep-1997	2654	1956	01-Sep-2001	59681	48955	01-Sep-2005	*	56766.216

01-Oct-1997	4562	2564	01-Oct-2001	20235	65858	01-Oct-2005	*	17752.421
01-Nov-1997	6530	3645	01-Nov-2001	37724	8991	01-Nov-2005	*	4005.312
01-Dec-1997	1060	2354	01-Dec-2001	5789	21159	01-Dec-2005	*	9518.000
01-Jan-1998	4568	4887	01-Jan-2002	5258	6643	01-Jan-2006	*	5441.000
01-Feb-1998	1789	3568	01-Feb-2002	5995	20677	01-Feb-2006	*	8270.000
01-Mar-1998	2597	4130	01-Mar-2002	2879	5912	1-Mar-06	*	6495.000
01-Apr-1998	1708	2201	01-Apr-2002	5814	43109			
01-May-1998	6082	6495	01-May-2002	1478	39392			
01-Jun-1998	3564	3686	01-Jun-2002	1302	6287			
01-Jul-1998	4526	4944	01-Jul-2002	2288	13499			
01-Aug-1998	3191	3658	01-Aug-2002	5066	59063			
01-Sep-1998	2437	3212	01-Sep-2002	48922	78150			
01-Oct-1998	3658	2658	01-Oct-2002	69671	18184			
01-Nov-1998	2894	3256	01-Nov-2002	26743	10036			
01-Dec-1998	930	2359	01-Dec-2002	14774	3783			
01-Jan-1999	1592	3689	01-Jan-2003	2758	1819			
01-Feb-1999	6396	4982	01-Feb-2003	4163	3967			
01-Mar-1999	1698	4256	01-Mar-2003	5237	3279			
01-Apr-1999	1836	5492	01-Apr-2003	5329	15900			
01-May-1999	59583	34347	01-May-2003	7564	21165			
01-Jun-1999	31582	7660	01-Jun-2003	4984	6952			
01-Jul-1999	5936	11056	01-Jul-2003	5942	8797			

01-Aug-1999	4923	3190	01-Aug-2003	5155	49178			
01-Sep-1999	19133	17271	01-Sep-2003	24284	58183			
01-Oct-1999	9367	3957	01-Oct-2003	60114	19417			
01-Nov-1999	2713	6191	01-Nov-2003	34481	10639			
01-Dec-1999	3568	3552	01-Dec-2003	22242	2836			
01-Jan-2000	7354	10437	01-Jan-2004	3421	3652			
01-Feb-2000	3246	2097	01-Feb-2004	11744	6912			
01-Mar-2000	2344	6252	01-Mar-2004	5711	5623			

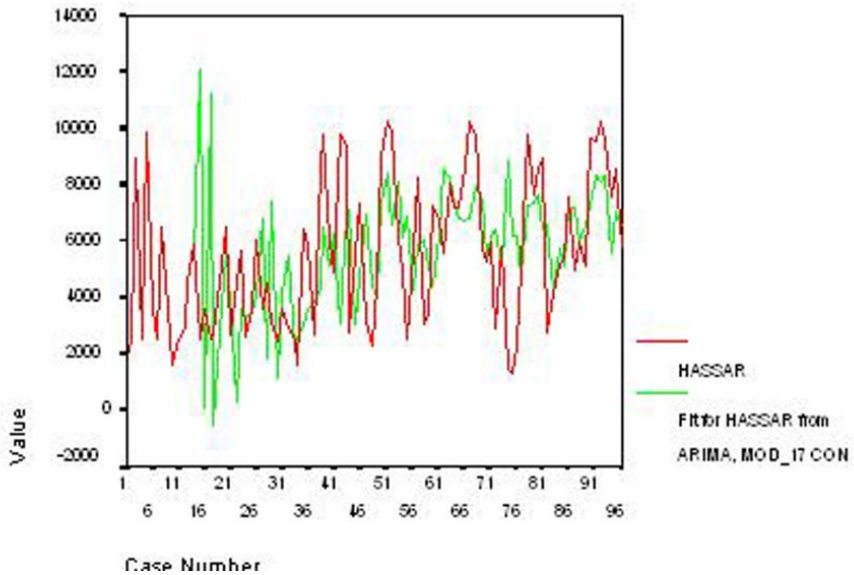
Table 4.37 : Ex-Ante and Ex-post forecast of monthly prices of potato in Hassan marketHassan prices

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	400	*	01-Apr-2000	400	412	01-Apr-2004	*	555.097
01-May-1996	350	*	01-May-2000	425	432	01-May-2004	*	597.058
01-Jun-1996	435	*	01-Jun-2000	475	485	01-Jun-2004	*	603.373
01-Jul-1996	550	*	01-Jul-2000	440	401	01-Jul-2004	*	524.960
01-Aug-1996	500	*	01-Aug-2000	440	472	01-Aug-2004	*	494.515
01-Sep-1996	325	*	01-Sep-2000	280	331	01-Sep-2004	*	513.606
01-Oct-1996	350	*	01-Oct-2000	265	272	01-Oct-2004	*	493.189
01-Nov-1996	300	*	01-Nov-2000	250	342	01-Nov-2004	*	555.647
01-Dec-1996	520	*	01-Dec-2000	260	332	01-Dec-2004	*	535.069
01-Jan-1997	575	*	01-Jan-2001	275	251	01-Jan-2005	*	449.952
01-Feb-1997	350	*	01-Feb-2001	275	264	01-Feb-2005	*	443.880
01-Mar-1997	350	*	01-Mar-2001	350	410	01-Mar-2005	*	521.598
01-Apr-1997	415	365	01-Apr-2001	525	498	01-Apr-2005	*	562.501
01-May-1997	350	437	01-May-2001	600	556	01-May-2005	*	609.825
01-Jun-1997	300	437	01-Jun-2001	750	662	01-Jun-2005	*	619.755
01-Jul-1997	425	398	01-Jul-2001	775	636	01-Jul-2005	*	543.575
01-Aug-1997	340	193	01-Aug-2001	500	460	01-Aug-2005	*	514.428
01-Sep-1997	400	406	01-Sep-2001	325	346	01-Sep-2005	*	534.238
01-Oct-1997	300	248	01-Oct-2001	510	447	01-Oct-2005	*	514.212

01-Nov-1997	350	548	01-Nov-2001	565	551	01-Nov-2005	*	576.885
01-Dec-1997	250	348	01-Dec-2001	700	635	01-Dec-2005	*	556.436
01-Jan-1998	360	170	01-Jan-2002	650	522	01-Jan-2006	*	471.409
01-Feb-1998	300	292	01-Feb-2002	350	335	01-Feb-2006	*	465.411
01-Mar-1998	300	345	01-Mar-2002	375	466	1-Mar-06	*	406.727
01-Apr-1998	350	286	01-Apr-2002	410	451			
01-May-1998	425	409	01-May-2002	580	600			
01-Jun-1998	450	532	01-Jun-2002	675	649			
01-Jul-1998	350	294	01-Jul-2002	675	564			
01-Aug-1998	425	355	01-Aug-2002	600	533			
01-Sep-1998	450	378	01-Sep-2002	650	624			
01-Oct-1998	600	519	01-Oct-2002	600	537			
01-Nov-1998	600	575	01-Nov-2002	575	595			
01-Dec-1998	550	578	01-Dec-2002	575	565			
01-Jan-1999	450	306	01-Jan-2003	450	373			
01-Feb-1999	500	463	01-Feb-2003	400	406			
01-Mar-1999	300	370	01-Mar-2003	385	484			
01-Apr-1999	400	391	01-Apr-2003	450	515			
01-May-1999	475	479	01-May-2003	475	549			
01-Jun-1999	450	489	01-Jun-2003	525	563			
01-Jul-1999	400	397	01-Jul-2003	525	481			
01-Aug-1999	300	311	01-Aug-2003	425	444			

01-Sep-1999	550	548	01-Sep-2003	315	399			
01-Oct-1999	500	484	01-Oct-2003	325	368			
01-Nov-1999	300	359	01-Nov-2003	345	447			
01-Dec-1999	400	445	01-Dec-2003	525	527			
01-Jan-2000	400	350	01-Jan-2004	450	382			
01-Feb-2000	320	282	01-Feb-2004	425	420			
01-Mar-2000	350	425	01-Mar-2004	450	521			

Hassan arrival (A)



Hassan Prices (B)

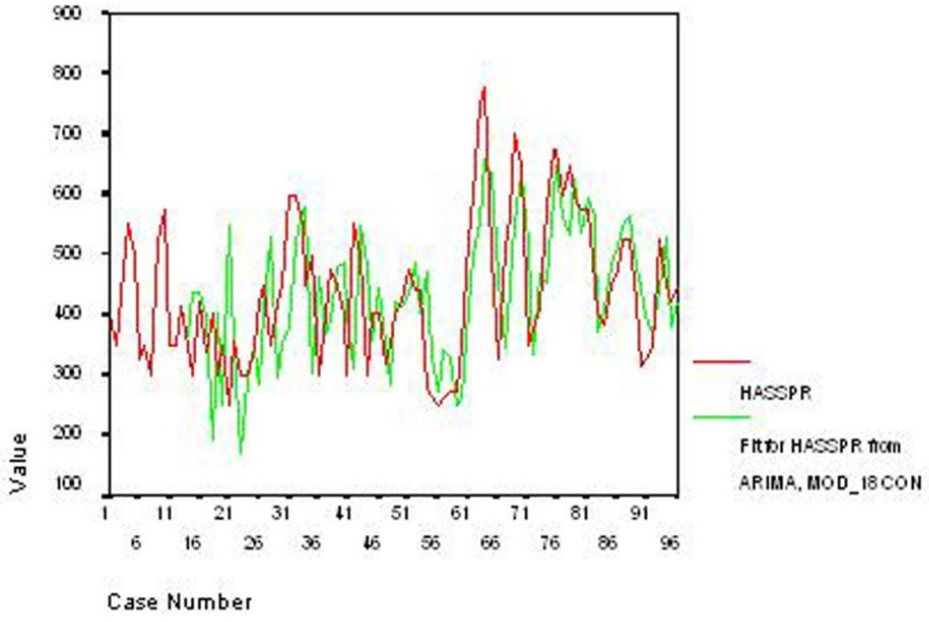


Fig. 4.31: Ex-ante and Ex post forecast of monthly arrivals and prices of potato in Hassan market

Table 4.32 : Ex-Ante and Ex-post forecast of monthly arrivals of potato in Belgaum market

Hassan arrivals

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	25649	*	01-Apr-2000	67631	44777	01-Apr-2004	*	36691.273
01-May-1996	21617	*	01-May-2000	39418	41449	01-May-2004	*	24366.930
01-Jun-1996	10653	*	01-Jun-2000	26185	41721	01-Jun-2004	*	25202.424
01-Jul-1996	9875	*	01-Jul-2000	25070	44209	01-Jul-2004	*	11032.415
01-Aug-1996	19568	*	01-Aug-2000	25747	66181	01-Aug-2004	*	78145.716
01-Sep-1996	41280	*	01-Sep-2000	32548	65017	01-Sep-2004	*	127465.716
01-Oct-1996	10904	*	01-Oct-2000	113278	102848	01-Oct-2004	*	158569.910
01-Nov-1996	12658	*	01-Nov-2000	125210	57771	01-Nov-2004	*	60222.672
01-Dec-1996	11896	*	01-Dec-2000	68298	32228	01-Dec-2004	*	29189.176
01-Jan-1997	16983	*	01-Jan-2001	29671	26680	01-Jan-2005	*	28312.520
01-Feb-1997	13654	*	01-Feb-2001	25200	46330	01-Feb-2005	*	37169.934
01-Mar-1997	23098	*	01-Mar-2001	45345	69085	01-Mar-2005	*	34924.673
01-Apr-1997	30366	26342	01-Apr-2001	52068	55306	01-Apr-2005	*	39695.172
01-May-1997	23658	14072	01-May-2001	35463	48716	01-May-2005	*	26974.904
01-Jun-1997	26060	16967	01-Jun-2001	20907	50339	01-Jun-2005	*	27518.566
01-Jul-1997	15951	26341	01-Jul-2001	27161	51874	01-Jul-2005	*	13141.294
01-Aug-1997	20564	47462	01-Aug-2001	5103	68352	01-Aug-2005	*	80108.305
01-Sep-1997	25461	15699	01-Sep-2001	18652	119699	01-Sep-2005	*	129325.739
01-Oct-1997	12036	17347	01-Oct-2001	234811	116321	01-Oct-2005	*	160358.715

01-Nov-1997	8562	16251	01-Nov-2001	84106	70439	01-Nov-2005	*	61962.732
01-Dec-1997	47263	19088	01-Dec-2001	25575	46320	01-Dec-2005	*	30896.605
01-Jan-1998	15643	15849	01-Jan-2002	21257	42641	01-Jan-2006	*	29998.868
01-Feb-1998	16243	25825	01-Feb-2002	22874	61119	01-Feb-2006	*	38843.483
01-Mar-1998	20365	33770	01-Mar-2002	41617	72200	1-Mar-06	*	41193.198
01-Apr-1998	43388	27228	01-Apr-2002	41215	56027			
01-May-1998	19815	26054	01-May-2002	40734	40314			
01-Jun-1998	16254	20326	01-Jun-2002	21611	41142			
01-Jul-1998	9563	27606	01-Jul-2002	22123	25679			
01-Aug-1998	13510	39134	01-Aug-2002	22048	33651			
01-Sep-1998	27564	20324	01-Sep-2002	97753	167900			
01-Oct-1998	78441	8138	01-Oct-2002	210811	76326			
01-Nov-1998	56248	26535	01-Nov-2002	96845	20811			
01-Dec-1998	15632	12776	01-Dec-2002	40441	6692			
01-Jan-1999	45621	10145	01-Jan-2003	29344	6357			
01-Feb-1999	19486	18003	01-Feb-2003	36541	24940			
01-Mar-1999	27946	38502	01-Mar-2003	2403	40142			
01-Apr-1999	25634	27535	01-Apr-2003	26891	40303			
01-May-1999	34743	25699	01-May-2003	38315	25782			
01-Jun-1999	28764	20029	01-Jun-2003	26891	27822			
01-Jul-1999	27725	25069	01-Jul-2003	25952	23505			
01-Aug-1999	24327	39457	01-Aug-2003	5242	79130			

01-Sep-1999	48877	63702	01-Sep-2003	81245	205824			
01-Oct-1999	25631	57124	01-Oct-2003	81292	127892			
01-Nov-1999	116847	30513	01-Nov-2003	194646	51462			
01-Dec-1999	63042	37408	01-Dec-2003	69731	29492			
01-Jan-2000	15642	28663	01-Jan-2004	27154	32860			
01-Feb-2000	12564	41912	01-Feb-2004	23127	20770			
01-Mar-2000	36368	49125	01-Mar-2004	45950	31782			

Table 4.38 : Ex-Ante and Ex-post forecast of monthly prices of potato in Belgaum market

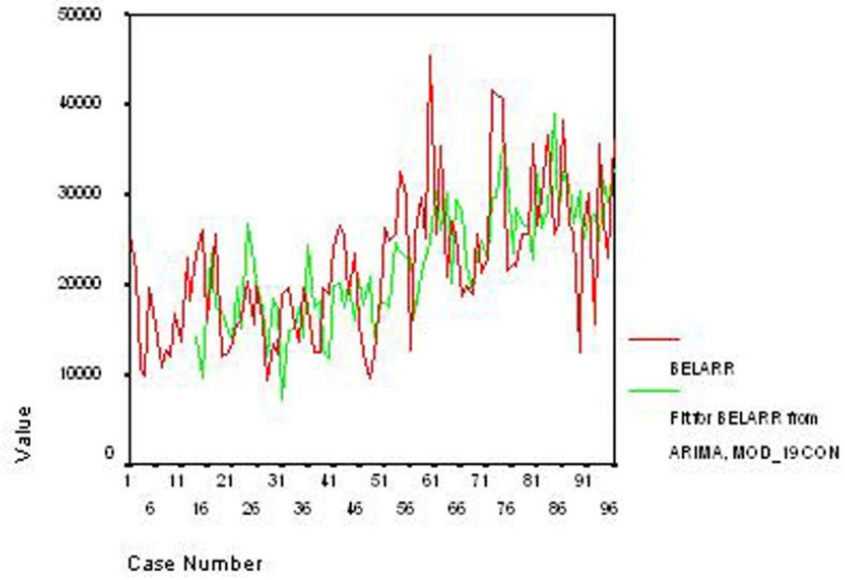
Bangalore prices

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	550	*	01-Apr-2000	350	436	01-Apr-2004	*	494.566
01-May-1996	600	*	01-May-2000	350	317	01-May-2004	*	542.013
01-Jun-1996	675	*	01-Jun-2000	400	378	01-Jun-2004	*	532.150
01-Jul-1996	525	*	01-Jul-2000	410	504	01-Jul-2004	*	586.822
01-Aug-1996	500	*	01-Aug-2000	400	392	01-Aug-2004	*	525.615
01-Sep-1996	600	*	01-Sep-2000	350	421	01-Sep-2004	*	528.653
01-Oct-1996	220	*	01-Oct-2000	400	348	01-Oct-2004	*	511.784
01-Nov-1996	250	*	01-Nov-2000	300	215	01-Nov-2004	*	473.114
01-Dec-1996	350	*	01-Dec-2000	280	397	01-Dec-2004	*	473.549
01-Jan-1997	550	*	01-Jan-2001	300	200	01-Jan-2005	*	439.678
01-Feb-1997	300	*	01-Feb-2001	425	341	01-Feb-2005	*	411.787
01-Mar-1997	350	*	01-Mar-2001	360	351	01-Mar-2005	*	453.772
01-Apr-1997	300	350	01-Apr-2001	350	404	01-Apr-2005	*	506.884
01-May-1997	350	425	01-May-2001	560	484	01-May-2005	*	556.485
01-Jun-1997	340	211	01-Jun-2001	860	698	01-Jun-2005	*	546.898
01-Jul-1997	375	329	01-Jul-2001	900	853	01-Jul-2005	*	602.242
01-Aug-1997	360	404	01-Aug-2001	600	585	01-Aug-2005	*	541.351
01-Sep-1997	400	25	01-Sep-2001	500	626	01-Sep-2005	*	544.863

01-Oct-1997	450	360	01-Oct-2001	550	505	01-Oct-2005	*	528.375
01-Nov-1997	300	301	01-Nov-2001	700	590	01-Nov-2005	*	490.135
01-Dec-1997	275	520	01-Dec-2001	950	895	01-Dec-2005	*	490.973
01-Jan-1998	380	151	01-Jan-2002	475	443	01-Jan-2006	*	457.519
01-Feb-1998	525	532	01-Feb-2002	450	516	01-Feb-2006	*	430.037
01-Mar-1998	500	353	01-Mar-2002	515	536	1-Mar-06	*	398.574
01-Apr-1998	500	548	01-Apr-2002	615	690			
01-May-1998	750	682	01-May-2002	565	597			
01-Jun-1998	520	466	01-Jun-2002	610	639			
01-Jul-1998	450	478	01-Jul-2002	700	705			
01-Aug-1998	1000	923	01-Aug-2002	800	719			
01-Sep-1998	850	569	01-Sep-2002	750	754			
01-Oct-1998	1200	1015	01-Oct-2002	600	602			
01-Nov-1998	1100	912	01-Nov-2002	610	617			
01-Dec-1998	650	897	01-Dec-2002	500	528			
01-Jan-1999	680	723	01-Jan-2003	430	443			
01-Feb-1999	400	569	01-Feb-2003	450	430			
01-Mar-1999	325	468	01-Mar-2003	475	527			
01-Apr-1999	550	702	01-Apr-2003	400	476			
01-May-1999	400	404	01-May-2003	450	528			
01-Jun-1999	400	434	01-Jun-2003	600	582			
01-Jul-1999	450	596	01-Jul-2003	500	556			

01-Aug-1999	475	518	01-Aug-2003	600	564			
01-Sep-1999	330	415	01-Sep-2003	450	476			
01-Oct-1999	450	418	01-Oct-2003	370	409			
01-Nov-1999	400	265	01-Nov-2003	430	402			
01-Dec-1999	350	454	01-Dec-2003	410	400			
01-Jan-2000	500	331	01-Jan-2004	440	387			
01-Feb-2000	450	398	01-Feb-2004	465	406			
01-Mar-2000	275	336	01-Mar-2004	425	445			

Belgaum arrivals (A)



Belgaum prices (B)

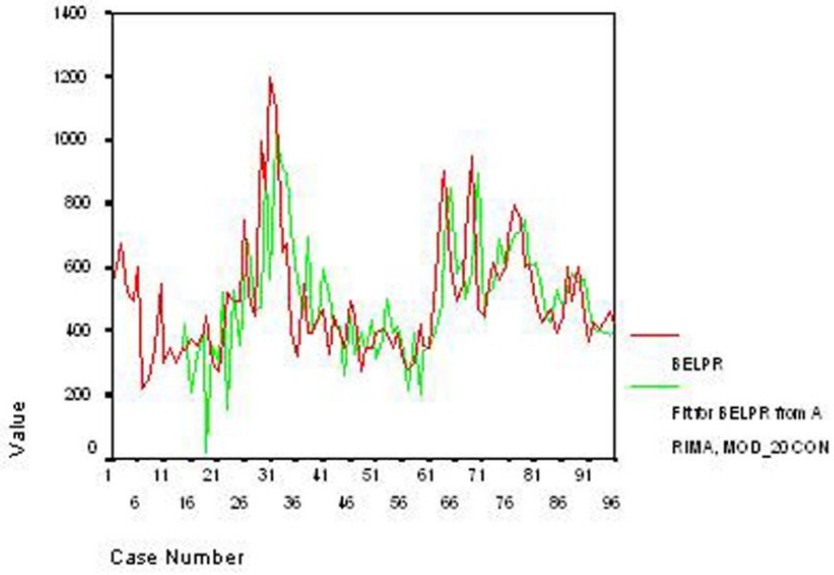


Fig. 4.32: Ex-ante and Ex-post forecast of monthly arrivals and prices of potato in Belgaum market

Table 4.33 : Ex-Ante and Ex-post forecast of monthly arrivals of potato in Hubli market

Hubli arrivals

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	7341	*	01-Apr-2000	16200	14208	01-Apr-2004	*	3968.631
01-May-1996	8145	*	01-May-2000	21200	19163	01-May-2004	*	3947.849
01-Jun-1996	1265	*	01-Jun-2000	19600	15237	01-Jun-2004	*	3125.401
01-Jul-1996	1236	*	01-Jul-2000	19800	17553	01-Jul-2004	*	2220.319
01-Aug-1996	1203	*	01-Aug-2000	12654	20823	01-Aug-2004	*	5832.992
01-Sep-1996	1025	*	01-Sep-2000	21546	16017	01-Sep-2004	*	3313.249
01-Oct-1996	1652	*	01-Oct-2000	12673	30144	01-Oct-2004	*	10166.567
01-Nov-1996	2541	*	01-Nov-2000	24809	28102	01-Nov-2004	*	8575.952
01-Dec-1996	2564	*	01-Dec-2000	22000	12840	01-Dec-2004	*	1158.000
01-Jan-1997	1235	*	01-Jan-2001	15150	16128	01-Jan-2005	*	1470.000
01-Feb-1997	2506	*	01-Feb-2001	10700	12606	01-Feb-2005	*	2405.000
01-Mar-1997	1500	*	01-Mar-2001	9800	12135	01-Mar-2005	*	3562.000
01-Apr-1997	6312	6991	01-Apr-2001	8900	12717	01-Apr-2005	*	3044.000
01-May-1997	2554	4526	01-May-2001	14350	15823	01-May-2005	*	2781.000
01-Jun-1997	13394	6576	01-Jun-2001	11100	12024	01-Jun-2005	*	3611.000
01-Jul-1997	3265	3165	01-Jul-2001	10100	11396	01-Jul-2005	*	4581.000
01-Aug-1997	2564	1951	01-Aug-2001	10000	18298	01-Aug-2005	*	1077.000
01-Sep-1997	1456	2345	01-Sep-2001	10035	9459	01-Sep-2005	*	3714.000
01-Oct-1997	2654	3270	01-Oct-2001	19150	29135	01-Oct-2005	*	3015.988

01-Nov-1997	34307	16938	01-Nov-2001	17001	22639	01-Nov-2005	*	1301.327
01-Dec-1997	28861	16152	01-Dec-2001	21400	10863	01-Dec-2005	*	7241.000
01-Jan-1998	12858	11871	01-Jan-2002	13840	12743	01-Jan-2006	*	8995.000
01-Feb-1998	10684	10243	01-Feb-2002	7630	8844	01-Feb-2006	*	10025.000
01-Mar-1998	6598	15935	01-Mar-2002	8900	8979	01-Mar-2006	*	9568.000
01-Apr-1998	2546	7568	01-Apr-2002	11350	11895			
01-May-1998	3564	9473	01-May-2002	10900	11739			
01-Jun-1998	5896	4095	01-Jun-2002	9760	8947			
01-Jul-1998	4856	4973	01-Jul-2002	9850	8981			
01-Aug-1998	21536	11662	01-Aug-2002	13564	15943			
01-Sep-1998	41256	22411	01-Sep-2002	11000	9850			
01-Oct-1998	16200	30103	01-Oct-2002	12550	22385			
01-Nov-1998	34000	26920	01-Nov-2002	12650	18482			
01-Dec-1998	22000	15270	01-Dec-2002	8230	4374			
01-Jan-1999	14500	14865	01-Jan-2003	11200	7853			
01-Feb-1999	11960	12433	01-Feb-2003	8550	6727			
01-Mar-1999	12000	15743	01-Mar-2003	8800	6809			
01-Apr-1999	5050	10490	01-Apr-2003	7600	7802			
01-May-1999	7300	12770	01-May-2003	7500	7409			
01-Jun-1999	12400	10090	01-Jun-2003	10600	6674			
01-Jul-1999	13800	17388	01-Jul-2003	16741	9696			
01-Aug-1999	4670	18009	01-Aug-2003	12602	12451			

01-Sep-1999	11500	9015	01-Sep-2003	16271	9573			
01-Oct-1999	14526	29989	01-Oct-2003	15648	19629			
01-Nov-1999	26200	22306	01-Nov-2003	11473	13951			
01-Dec-1999	41600	21760	01-Dec-2003	7990	3055			
01-Jan-2000	11850	13916	01-Jan-2004	5748	3632			
01-Feb-2000	18600	14450	01-Feb-2004	6823	3771			
01-Mar-2000	15620	14206	01-Mar-2004	7986	4182			

Table 4.39 Ex-Ante and Ex-post forecast of monthly prices of potato in Hubli market

Hubli prices

Months	Actual value	Forecast value	Months	Actual value	Forecast value	Months	Actual value	Forecast value
01-Apr-1996	540	*	01-Apr-2000	350	326.947	01-Apr-2004	*	512.626
01-May-1996	630	*	01-May-2000	400	392.725	01-May-2004	*	506.536
01-Jun-1996	575	*	01-Jun-2000	450	424.339	01-Jun-2004	*	509.512
01-Jul-1996	650	*	01-Jul-2000	400	448.117	01-Jul-2004	*	541.757
01-Aug-1996	650	*	01-Aug-2000	400	311.552	01-Aug-2004	*	472.936
01-Sep-1996	525	*	01-Sep-2000	320	431.737	01-Sep-2004	*	519.832
01-Oct-1996	415	*	01-Oct-2000	360	346.758	01-Oct-2004	*	511.886
01-Nov-1996	450	*	01-Nov-2000	200	113.553	01-Nov-2004	*	470.926
01-Dec-1996	425	*	01-Dec-2000	200	257.915	01-Dec-2004	*	439.897
01-Jan-1997	475	*	01-Jan-2001	200	186.994	01-Jan-2005	*	430.451
01-Feb-1997	450	*	01-Feb-2001	180	215.337	01-Feb-2005	*	451.243
01-Mar-1997	350	*	01-Mar-2001	400	468.600	01-Mar-2005	*	495.275
01-Apr-1997	400	490.412	01-Apr-2001	450	418.778	01-Apr-2005	*	548.548
01-May-1997	325	262.829	01-May-2001	700	698.406	01-May-2005	*	553.586
01-Jun-1997	350	472.175	01-Jun-2001	750	612.824	01-Jun-2005	*	541.583
01-Jul-1997	275	239.802	01-Jul-2001	730	768.378	01-Jul-2005	*	578.000
01-Aug-1997	300	257.008	01-Aug-2001	730	535.247	01-Aug-2005	*	502.807
01-Sep-1997	325	192.278	01-Sep-2001	450	530.585	01-Sep-2005	*	551.330
01-Oct-1997	250	296.794	01-Oct-2001	600	560.090	01-Oct-2005	*	540.773

01-Nov-1997	200	141.437	01-Nov-2001	650	539.480	01-Nov-2005	*	500.556
01-Dec-1997	200	276.948	01-Dec-2001	650	610.256	01-Dec-2005	*	468.576
01-Jan-1998	200	145.806	01-Jan-2002	600	545.408	01-Jan-2006	*	459.590
01-Feb-1998	350	267.659	01-Feb-2002	480	491.561	01-Feb-2006	*	480.173
01-Mar-1998	425	440.315	01-Mar-2002	500	554.871	01-Mar-2006	*	
01-Apr-1998	525	512.761	01-Apr-2002	500	542.018			
01-May-1998	450	380.862	01-May-2002	550	549.340			
01-Jun-1998	300	302.138	01-Jun-2002	680	680.664			
01-Jul-1998	350	370.577	01-Jul-2002	580	558.571			
01-Aug-1998	430	367.246	01-Aug-2002	700	646.496			
01-Sep-1998	450	346.107	01-Sep-2002	720	737.954			
01-Oct-1998	950	953.645	01-Oct-2002	600	556.812			
01-Nov-1998	1000	758.955	01-Nov-2002	650	612.066			
01-Dec-1998	600	573.414	01-Dec-2002	650	590.378			
01-Jan-1999	450	468.155	01-Jan-2003	450	418.392			
01-Feb-1999	400	384.255	01-Feb-2003	400	469.787			
01-Mar-1999	350	458.199	01-Mar-2003	410	454.264			
01-Apr-1999	350	341.412	01-Apr-2003	450	552.646			
01-May-1999	470	460.597	01-May-2003	410	397.303			
01-Jun-1999	401	371.026	01-Jun-2003	460	533.308			
01-Jul-1999	401	482.820	01-Jul-2003	450	462.796			
01-Aug-1999	500	444.671	01-Aug-2003	400	378.072			

01-Sep-1999	275	378.484	01-Sep-2003	420	506.294			
01-Oct-1999	325	386.910	01-Oct-2003	350	341.246			
01-Nov-1999	300	178.720	01-Nov-2003	300	314.552			
01-Dec-1999	270	301.092	01-Dec-2003	400	393.312			
01-Jan-2000	350	364.087	01-Jan-2004	410	393.392			
01-Feb-2000	300	264.711	01-Feb-2004	450	491.656			
01-Mar-2000	350	448.486	01-Mar-2004	410	424.485			

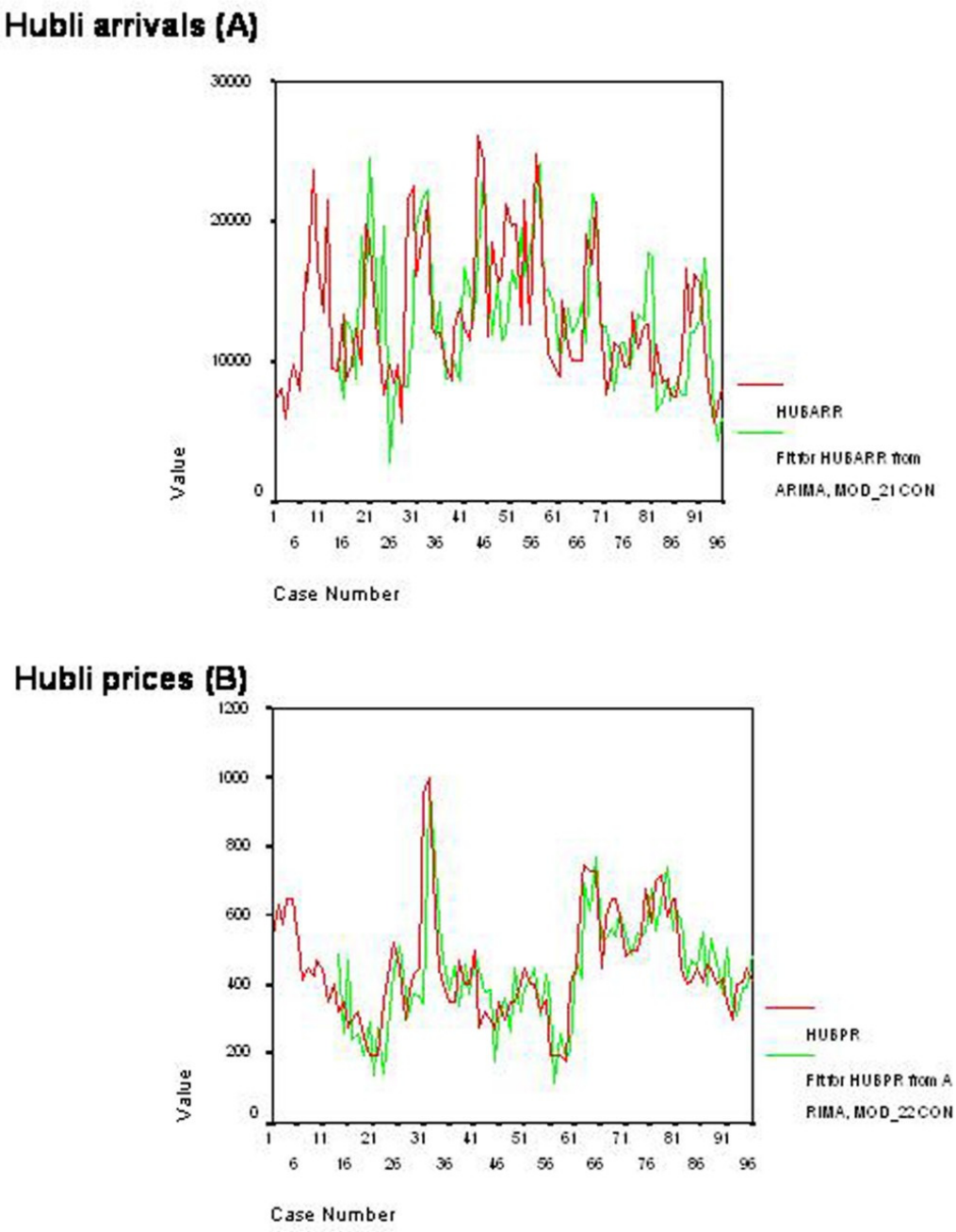


Fig. 4.39: Ex-ante and Ex-post forecast of monthly arrivals and priced of potato in Hubli market

V. DISCUSSION

The results of the investigation presented in the previous chapter, are discussed in this chapter. In this chapter a brief discussion of the findings of the results will be presented, keeping in view, a comparison of these markets with respect to the extent of integration among the market as the central purpose in the discussion.

The potato is one of the nutrient food, in Peru Bolivia and European it is used as a main food. But in Asian countries like India still it is used as vegetable. Potato can be grown both under rainfed and irrigated conditions. Every year potato is being grown in an area of 38,000 ha in Karnataka. In Bangalore and Kolar districts potato was growing in summer and monsoon season also. But in Hassan, Belgaum and Dharwad districts potato crop was grown only in monsoon.

The present study revealed that the period of August (177.6), September (112.8), October (176.9) and November (208.5) was accounted for more arrivals, in the selected markets.

In general the market arrivals increased after September in Hassan market. The nature of the produce was sold soon after the harvest probably for want of cash or lack of storage facilities. However, farmers who are financially sound can store their produce in cold storage and exports their produce to other places where there is high demand.

5.1 SEASONALITY IN ARRIVALS AND PRICES OF POTATO IN SELECTED MARKETS

5.1.1 Seasonality in arrival of potato in selected markets

The presence of seasonality was observed in all the markets except in Kolar market. In Bangalore market, the peak season was during January the slight variation is because of importing the produce from its near by markets. In brief one may identify four months August (177.6), September (112.8) October (176.9) and November (208.5) months appears to be peak months for all the markets. While, other months are lean months. George and Gobindan (1975) and Jain and Kaul (1980) reported similar findings on seasonality of potato arrivals.

The two way ANOVA showed that, the potato arrivals were significant among months and years except for potato arrivals in Kolar market. In monthly of potato in all the markets, there is a significant difference between months as well as years.

5.1.2 Seasonality in prices of potato in selected markets

There is a seasonality in prices indicated by significant difference between months and years. It can be observed that, there was a considerable seasonal variation in prices in all the markets.

Seasonal indices computed for all the markets, for monthly prices of potato shows a similar pattern in price, peak during the months of July (116.7), August (127.7) in Bangalore market, August (177.6), November (130.1) and December (177.8) in Kolar and Belgaum markets, June (108.2), July (116.5) and August (116.3) in Hassan and Hubli markets and lowest prices were recorded in March and April in all the selected markets. Since we know that when more quantity of arrivals came into the markets are by (off season), the prices were naturally high in all the selected markets. The produce had arrived into market immediately after the harvest resulting reduction in prices. Similar results were observed by Singh *et al.* (1993), Keith *et al.* (1997) and Mipramavar and Gummagolmath (1998).

In comparison, seasonality for both monthly and yearly prices in selected markets showed almost similar seasons high and low prices. Monthly set up data on prices shows clear cut seasons high and low prices compared to yearly set of data on prices.

5.1.3 Trends in arrivals and prices of potato in selected markets

5.1.3.1 Trends in monthly arrivals of potato

The analysis of trends in arrivals of monthly data presented in the Fig. 1 to 10 indicates positive trends in all the markets under study. The arrivals have increased in all the markets except in Hubli market, but the quantum of increasing arrivals varied from market to market. The highest increase in potato arrivals was noticed in August, September and October months in all the markets. This may be because of increased potato production in that respective areas. The increased arrivals are due to increase in area under the selected potato crop in the selected districts, coupled with the use of high yielding varieties of the potato crop by farmers. The increased arrivals in all the markets clearly showed that farmers are slowly and gradually developing a positive attitude towards the remunerative crop in the hinterlands regulated markets.

5.1.3.2 Trends in monthly prices of potato

The secular trend, which is captured with the help of polynomial regression equation of the appropriate order revealed that in trend varied between markets. The long run behaviour of prices could broadly classified into stagnant, but the variable rising. All the selected markets shows a increasing trend over years, but large oscillations were noticed in prices of potato in Belgaum and Hubli markets and there was not perceptible increase.

The trend curve was fitted after elimination of seasonal and cyclical effects from the original series. The trends in monthly prices of potato was analyzed for a period of eight years from 1996-97 to 2003-04. The prices of selected potato crop except in Belgaum and Hubli markets showed increasing trend in all the selected markets, which may be due to increasing population, which inturn increase the demand for potato coupled with inflationary trend in prices of agricultural commodities.

The decrease in monthly trend in prices for potato in Belgaum and Hubli markets is because of the prices of potato high during March and April months which marks the summer season and thereafter decreased due to increase area of potato under cultivation and also increase in market inflow from near by markets. The similar results were observed for vegetables by Sharma and Sharma (1996), Mali *et al.* (1999), Nawadkar *et al.* (1999) and Balappa Shivaraya (2002).

5.1.4 Cyclical variation in arrivals and prices of potato

From the Fig. 11 to 20 it could be observed that there existed no cycle in any selected potato markets. This mainly because cycle can be observed only if a time series data for 20 years and above are analyzed. As the current was restricted for analysis using only the past 8 years data (1996-97 to 2003-04), cycle were not observed in any selected markets. The similar results were observed for potato by Ausepharampil Joson Jose (2002), Satish (1990) and Birukal (2001).

5.2 ASSOCIATION BETWEEN ARRIVALS AND PRICES OF POTATO

The correlation coefficients are computed among the selected markets for arrivals and prices of potato. Correlation analysis of the average monthly arrivals and prices of the potato in selected markets and is presented in Table 4.21. The table revealed that the correlation coefficient between arrivals and prices of potato. The correlation coefficient were worked out to know the degree of association between arrivals and prices. The table indicates that significant difference between the arrivals and prices of potato except in Bangalore market. From this we note that the monthly arrivals have negative and significant effect at five per cent level of significance. This shows that the arrivals and prices are moving in slight apposite direction in the long run and also the increase in arrivals of a particular crop decreases the prices of that crop. The correlation coefficients of all the selected five markets were negative, indicating that increase in arrivals of a particular produce decreases the prices of that particular produce and vice versa.

5.3 CO-INTEGRATION

Co-integration is the technique to asses the market integration. Co-integration between potato prices of selected markets was assessed. This co-integration analysis can be regarded as an empirical manifestation of a long run relationship between the variables.

Determining the order of integration of the price series is the first step and is presented in Table 4.22. Which reveals that all the markets achieve stationarity at same orders of integration. The ADF values are negative and significant indicating that there is co-integration between all the selected markets.

As far as the price series of all the selected five markets achieve stationarity without difference *i.e.,* at the original level and so is of order zero, denoted by I(0). Since all the market shows negative and significance at their original price series, conclusion can be drawn that all the markets were co-integrated. Therefore, the law of one price (LOP) holds good. Same findings were found by Girish (1995), Bangalore market was highly integrated with Belgaum market which inturn is influenced by Mumbai. Belgaum acted as proxy for Mumbai of Maharashtra state as a whole and as such any instability created at Belgaum is reflected at Bangalore.

5.4 BOX-JENKINS MODEL

ARIMA models are intensively used to study market fluctuations particularly of agricultural commodities. The singular advantage of this class of models lies in its ability to quantify random variation present in many economic time series. Hence, the monthly data on arrivals and prices of potato in Bangalore, Kolar, Hassan, Belgaum and Hubli markets were subjected to ARIMA analysis to quantify the random variation.

As explained earlier (chapter III), fitting Box-Jenkins model, the other name ARIMA model involves four stages of procedure. The discussion is presented in the same order.

5.4.1 Identification of the model

Identification of the model is the first step which involves a greater deal of skill. It is done based on conjunction of the sample auto correlation function (ACF) with the partial auto correlation function (PACF). Since, the method of identification does not lay down any hard and fast roles, several possible models were tentatively identified and the following yielded the best results. The best was decided on the Box-Pierce “Q”, AIC *etc*.

5.4.2 Estimation

Having tentatively identified the model, the parameters which minimizes the Sum of squares of errors are estimated. The estimated modules for all the ten series are shown below.

1. Monthly arrivals of potato in Bangalore market : (2 1 2) (0 1 1)
2. Monthly prices of potato in Bangalore market : (2 1 2) (0 1 1)
3. Monthly arrivals of potato in Kolar market : (2 1 2) (0 1 1)
4. Monthly prices of potato in Kolar market : (2 1 2) (0 1 1)
5. Monthly arrivals of potato in Hassan market : (2 1 2) (0 1 1)
6. Monthly prices of potato in Hassasn market : (2 1 2) (0 1 1)
7. Monthly arrivals of potato in Belgaum market : (2 1 2) (0 1 1)
8. Monthly prices of potato in Belgaum market : (2 1 2) (0 1 1)
9. Monthly arrivals of potato in Hubli market : (2 1 2) (0 1 1)
10. Monthly prices of potato in Hubli market : (2 1 2) (0 1 1)

5.4.3 Diagnostic checking

The residual of estimated models were examined for testing the randomness of series and analyzed to determined the adequacy of the estimated models.

For all the ten series of potato arrivals and prices the model is (2 1 2) (0 1 1). Which yielded Box-Pierce “Q” statistic which was significant and AIC was minimum. Seasonality was found and forecast consideration was the best, so this model was chosen.

5.4.4 Forecasting

Ex-ante and Ex-post forecast obtained by the Box-Jenkins methods are presented in Table 4.29 to 4.39. The forecast from the various models are checked for their efficacy by comparing them with the actual values.

VI. SUMMARY

Potato is an edible starchy tuber produced by certain plants of the Genus-Solanum and family-solanaceae. Potato is wholesome and nutritious food. The major portion of the potato growing area is covered by rainfall in kharif season. During the *rabi* season, potato is cultivated only in Bangalore and Kolar districts. Where tube wells form the main source of irrigation for the crop.

The major APMC markets for potato are Bangalore, Kolar, Hassan, Belgaum, Hubli and Chickaballapur. Bangalore attracts the largest share of arrivals of potato among these markets.

The present study is the modest attempt in this direction. It tries to identify some of the causes responsible for the wide marketing margins witnessed in the rate of potato of the selected markets. The markets are located in potato producing tract of Bangalore, Kolar, Hassan, Belgaum and Hubli markets of Karnataka.

The information on monthly data of arrivals and prices of potato were collected from the Karnataka state Agricultural Marketing Board, (KSAMB), Bangalore.

A multiplication model of time series was used on arrivals and prices of each of these markets. The Box-Jenkins model was also applied to selected markets. A twelve months centered moving average was calculated for the purpose of estimating final stabilized seasonal indices.

The trend cycle components were obtained by dividing the original observation by seasonal index of corresponding months. The chart of trend cycle components was examined to the presence of cycles. When ever the presence of cycle is detected the periodicity of cycle was found out. The moving average of length equal to span of the periodicity of cycle is computed. Then the trend cycle component was divided by corresponding month of seeds cyclical index.

The order of polynomial regression was determined based on the highest significant R^2 values. The seasonal relatives and cyclical components were subjected to two way ANOVA. A significant difference between the months indicated the presence of seasonality, a significant differences among years indicated the changing pattern of seasonality.

Co-integration analysis was employed to examine the extent of integration among the markets. This study was done by testing whether the law of one price (LOP) holds good in all these markets.

The Box-Jenkins models are fitted to the all arrivals and prices of potato of selected markets. If there is seasonality in the data, then seasonal ARIMA model is used. Before going to application of Box-Jenkins analysis, more the data should be stationary series. If the series is non-stationary, it could be removed by differencing the differenced series does not distort the features of the series.

Making use of differential series (which is stationary), the ACF and PACF are computed because, it helps in the tentatively identify the models. Then the parameters of all tentatively identified models were estimated by iterative process. These estimated models are subjected to diagnostic checking in order to determining the adequacy of models. The residues of estimated models are examined for testing the randomness of series and for its significance. The ACF and PACF of residuals were tested using Box-Jenkins “Q” statistic. Both Ex-ante and Ex-post forecast for all the best models.

Summery of the findings are as follows

Seasonality

In arrivals, there is presence of seasonality within a year and seasonal pattern changes over years in selected markets except in case of monthly arrivals of potato in Kolar market. However, in the price series there is a presence of seasonality in all the markets.

Trends

The pattern of trends in arrivals and prices of potato are not similar in all the selected markets.

For all the markets the 6^{th} order polynomial regression equation shows wide fluctuating trend for both arrivals and prices. This shows that the market are not much efficient in functioning and the arrivals are not regulated.

Cyclicity

No cyclic pattern was observed in both arrivals and prices of potato in all the selected markets. The cyclical indices of arrivals and prices in all the markets showed that there were no constant period between cycles in both arrivals and prices.

Association between arrivals and prices

To assess the nature and magnitude of the association between arrivals and prices of potato, the correlation analysis was employed.

Co-integration

Co-integration was employed to examine whether any selected market is integrated with another market. This study was done by testing weather the law of one price (LOP) holds good in these markets.

Box-Jenkins model

For monthly arrivals and prices of potato in all the selected markets, the following tentatively identified models yielded the best results, hence we concluded that these are the best models.

Potato markets

Arrivals : (2 1 2) (0 1 1)

Prices : (2 1 2) (0 1 1)

POLICY IMPLICATIONS

A careful study of the findings would suggest that the farmer suffers from various handicaps, which must be removed if their financial position is to be strengthened. Some of the measures that could be adopted to achieve this result are indicated below.

1. The results of the study help the farmers to take decision on sale of their produce to which month, he gets maximum price
2. The impact of market arrivals on prices has been found negative in all the markets. In the light of such findings, fluctuations in market arrivals were reduced their proper storage facilities and reduce the risk of fluctuation in price would be minimized
3. The wider and frequent fluctuations in wholesaler prices, wide variation in arrivals, perishable nature of produce etc., effected the returns to the potato grower. In order to encourage the farmers to continue in potato product in price should be stabilized by introducing fairly high degree of competition among the wholesale functionaries and traders, introduced in close tender system of sale, establishment of potato marketing co-operatives and fixation of minimum and maximum prices for the potato.
4. The wide seasonal fluctuation in arrivals has consequential unfavourable impact on prices in regulated markets over different months of the year. The huge quantity of arrivals during post harvest months of the year lead to decline in prices. The effective use of ware housing facilities and credit to the producer-seller against ware house receipts would go a long way in avoiding seasonal variation in arrivals and prices.
5. With the help of forecasting by using ARIMA model, usually the arrivals were high in the months of August, September and October and high prices in April, June and July months were observed in all the selected markets.
6. The farmers can plan to sell their produce in all the selected markets during the months of April, July, August and September as the prices were high.

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A STATISTICAL STUDY OF VARIATION IN ARRIVALS AND PRICES OF POTATO IN THE SELECTED MARKETS OF KARNATAKA

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ABSTRACT

Potato is an edible starchy tuber produced by certain plants of the genus – solanum and family – solanaceae. Potato is the fourth most important food crop in the world exceeded only by wheat, rice and maize for human consumption. The present study was conducted in Bangalore, Belgaum, Kolar, Hassan and Hubli markets during 1996-97 to 2003-04. The secondary data pertaining to monthly model price rupees per quintal, monthly total arrivals in quintals were collected from Karnataka State Agriculture Marketing Board, Bangalore. For evaluation of different objectives, multiplicative time series analysis, two way ANOVA, correlation coefficient, co-integration test and ARIMA model were used.

The study shows, the peak arrivals season in the months of August, September and October, whereas the prices are high during April, June and July months were observed in all the selected markets. It was noticed in all the selected markets that there was an positive trend. The arrivals have increased in all the selected markets except in Hubli market, but the quantum of increasing arrivals varies from market to market. The cyclical component was not found in all the selected markets for both arrivals and prices.

The correlation coefficients were calculated between the arrivals and prices of all the selected markets, which indicated that the coefficient are significant except Bangalore market. All the selected markets are integrated with zero order of integration.

Since, the trend forecast is not precise for owing to non-stationarity of data, it is not always reliable. So, Box-Jenkin's method is applied for precise forecasting of arrivals and prices of potato for monthly data to all the selected markets.