Determinants of Potato Prices and its Forecasting: A Case Study of Punjab, Pakistan

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Abstract

Potato figures among the principal crop in Pakistan. This paper describes the determinants of potato prices in Punjab, Pakistan. Annual data for the period 1998-2014 were analyzed to identify factors affecting the prices of potato. Results indicated that temperature and world oil prices were significantly affecting price. Seasonal variation of prices are also analyzed in this paper. This paper also use ARIMA and ARMA model to forecast the prices. These results suggest that temperature increase above the limit will lead to increase in prices and support prices also.

Key Words: Whole sale potato prices, pricing factors, determinants of potato, ARIMA & ARMA, forecasting.

1. Introduction

Potato (aalo) belongs to Solanaceae family of flowering plants. It originated and was first domesticated in the Andes Mountains of South America. Potato was introduced to Indian Subcontinent in the early 17th century, and by the close of 19th century it had spread to various parts of it.

Potato is the third most important food crop in the world after wheat and rice in terms of food consumption. The potato is an integral part of the global food system, as it is rich in starch and carbohydrates. More than a billion people worldwide eat potato, as it is the world's number one non-grain food commodity. Potato is a good and cheaper source of carbohydrates, vitamins, minerals and proteins. It provides most of the trace elements, which can meet the energy requirements of the people living in the developing countries (Rahman, 1986). This crop is financially more remunerative than cereals from food security and can be recommended as a partial replacement of cereals.

Potato consumption is expanding strongly in developing countries, which now account for more than half of the global harvest and where the potato's ease of cultivation and its high energy contents have made it a valuable cash crop for millions of farmers. In Pakistan, per capita consumption of potato per month during 2011-12 was 1.19 kg. At the same time, the potato (unlike major cereals) is not a globally traded commodity. Only a fraction of its total production enters foreign trade, thus potato prices are determined usually by local factors such as production costs, cultivated area and yield, not by the vagaries of international markets. It is, therefore, a highly recommended food security crop that can help low income farmers and vulnerable consumers ride out extreme events in world food supply and demand.

Consumer prices of essential commodities of daily use are a very sensitive issue. The consumer suffers in case prices of consumable items are high. On the other hand, producer suffers when prices are too low to recover the cost of production. The price of consumable items is determined by the demand and supply of that particular commodity. The supply of

agricultural products depends mainly on nature so there is a great element of uncertainty. If supply is in short of demand then price will increase. The other main influencing factor is supply of that commodity. Export of potato to China and Russia created shortage in the supply of global market and during September 2015, wholesale and retail prices in the Punjab were Rs. 61.33 and Rs. 70.26 per kg respectively. Contrary to these wholesale and retail prices of potatoes, during the month of August and May 2015 were as low as Rs. 9.03 per kg. Such large fluctuations in the prices is a matter of concern so there is need to identify the influencing factors of these fluctuations.

2. Study Objectives

The objective of this study is to analyze various factors which affect the prices of potatoes in Punjab over a period of time. Moreover, to quantify the impact of these factors on prices in order to understand changes in prices accurately. The aim is also to forecast future prices of potatoes by taking into account past trends and fluctuations in the prices.

3. Literature Review

The prices of potatoes are highly fluctuating. Hussain. Z & Rehman. S (1993) analyzed the price fluctuations of potato and onion crops in Pakistan for the period of 1972-1991 by using different supply side variables. They found that storage capacity is not enough and causing fluctuations in prices about 50 percent in prices because of limited storage capacity. The study also analyses the price elasticity of demand and found that potato and onion is highly inelastic in rural and urban areas.

Erdal, H., Erdal, G., & Esengun, K. (2009) analyzed the relationship between prices and amount of potato produced and distributed under free market conditions in Turkey were studied using Koyck model of distributed lag models. According to the results, potato production in Turkey has been influenced by the lag value of average price formed in the market. The most striking result of the study is that the time required for the changes in the potato prices in Turkey to have an effect on potato production is 12.33 years.

Bakhsh, K. (2007) has applied stochastic frontier production function and ordinary least squares (OLS) estimates to identify yield level of production function. It derived production elasticity estimates which indicated that seed, plant protection measures, irrigation, labor used to perform various farming activities and the use of NPK nutrients were significantly contributing in vegetable yields. Further, showed that potato production is more risky than any other vegetable.

Khan, N. P., & Akhtar, J. (2006) did a competitiveness analysis clearly indicates that potato production is nationally profitable for import substitution but are not profitable for export promotion. It is further explains that all the three cropping zones cannot produce potato for export purpose under existing agro-climatic and topographic conditions of the area and policies; however this crop can be produced with comparative advantage for food self-sufficiency/import substitution.

The policy analysis shows that for import substitution regime for potatoes, the farmers are receiving less than the world prices and also farmers are taxed both in output and input markets. While, for export promotion, the farmers are receiving more than world reference prices and thus farmers are subsidized both in output and input markets. This implies that the current sets of agricultural and macro-economic policies are not consistent with competitiveness of potato production for both import substitution and export promotion regimes.

The demand for this food item remains round the years but due to short supply during June-November the price triggers up beyond the reach of the consumers. Pakistan's international trade of potato (including seeds) lacks stability. As a matter of fact, the export of potato is “surplus based”. The price of potato over the years is showing a cyclical trend, this continuous change in the prices is due to the mismanagement and lack of planning. Sometimes farmers produce the crop in excess as compare to its demand and sometimes they lag behind. Such fluctuations in supply and its prices put adverse effect on producer as well as consumers. To stabilize the prices in the market especially during off seasons, it is imperative for the researchers, administrators and policy makers in Pakistan to think and reshape the ways and means to assess the country’s demand and promote potato production at least for food self-sufficiency/import substitution for food security purpose accordingly.

The policy recommendations given by this study are mainly that potato yield is low relative to the other potato growing countries of the world and therefore is recommended that the scientists and policy makers should introduce new high yielding, disease resistant potato varieties in the area. The existence of small landholdings and high return to land for potato crops in the area, the farmers do not follow the crop management practices like crop rotation, which hampers the crop yield day by day. The agriculture extension services should be strengthened in the area and train the farmers about the best crop management practice and cropping patterns.

Thorne, F. S. (2012) analyzed the supply and demand factors affecting the farm level price for Irish potatoes. In terms of the factors affecting potato price, the estimation resulted indicated that potato prices decrease with increasing volumes and increase with increasing consumption levels.

A report by Indian Karvy Comtrade Limited analyzed the seasonality of the potato production. According to the report, potato is mainly a Rabi season crop. The Rabi crop is sown in the month of October and harvested in March. The arrival of the winter crop potato is the major contributor to total production. Potato harvesting in Punjab stretches between Dec-Jan to March-April. There are three kinds of usages of potatoes as a vegetable (table purpose) potato is used as a major vegetable throughout the world and in the preparation of a number of recipes either by using potato alone or by combining it with other vegetables, pulses, cereals, etc. As a seed medium-sized tubers are used normally in the northern plains. In the northern and eastern hills, is used as seed. As processed food it is utilized in a variety of ways, such as dehydrated potato products like chips, wafers, flakes, granules, flour, starch, potato powder and potato biscuits. It is also used to prepare frozen foods like potato patties, puffs, wedges, pancake, dehydrated mashed potatoes, canned potato, etc.

The factors which affect the prices of potatoes are mainly fluctuations in area, weather, production and yield, irrigation facility, demand for potato in cities and from food-processing industries, input cost for potato cultivation, transportation charges, labor availability during planting and harvesting, storage capacity and stock position in cold

storage. Potato can be stored in cold storage for 5-6 months, outbreak of pest attack or disease in key growing areas and price of other vegetables.

Huang C. & Lin B. uses the panel data to estimate the price premiums and discounts associated with fresh tomatoes among regional markets, focusing on the organic attribute. The results suggest that consumers paid $0.25/lb more for organic fresh tomatoes in the New York–Philadelphia market. The organic premium estimated to be $0.14/lb in the Chicago–Baltimore/Washington and Los Angeles–San Francisco markets and $0.29/lb in the Atlanta–San Antonio market. Furthermore, tomato prices consumers paid in 2004 varied by household characteristics, including income, age, and the race and ethnicity of the head of the household.

Aslam M., et al. (2012) attempts to evaluate impact of major factors affecting prices of seed cotton in district Khanewal using primary source of data. A representative sample of 40 cotton farmers was selected using stratified random sampling technique. The impact of major factors on prices of seed cotton was estimated employing double log form of regression analysis. The findings of analysis revealed that color, length, and strength of seed cotton were the significant variables affecting its prices whereas the variables (low evidence of contamination and less use of pesticides) showed insignificant impact.

In the U.S., Ethridge and Davis (1982) estimated a hedonic price model for cotton using ordinary least squares and found that micronarie and the color of the cotton were important variables affecting its prices while fiber length and trash content were less important variables. Ethridge and Neeper (1987) estimated hedonic producer prices for fiber strength uniformity for the southwest U.S. cotton market using seemingly unrelated regression and found fiber strength and length uniformity as significant determinants of cotton prices. Producer prices were more responsive to fiber length and micronaire than its color and strength. Hudson et al. (1995) developed a hedonic model to explain the daily price of cotton as a function of the specific quality attributes of cotton. The model was used to estimate parameters, which were used to compute prices, premiums, and discounts for various qualities of cotton.

Economists have applied the Hedonic Prices model to agricultural products and have exploring price-quality relationships to estimate the implicit values of product characteristics (Ladd and Martin 1976; Ladd and Suvannunt 1976; Rosen 1974; Wilson 1984). Hedonic modeling efforts rely on the fact that consumers and producers recognize these product attributes in approximately the same ways and that choices each group makes lead to an equilibrium condition that neither the consumers nor the suppliers have any incentive to change.

The underlying assumption in the development of a hedonic model is that products can be distinguished simply and uniquely by their characteristics. Thus, demands for various desired characteristics can be derived from consumer willingness to pay for a product. As a result, marginal or implicit values can be estimated for each attribute at the observed purchase price which is linked with the amount of characteristic contained in goods purchased. In essence, the hedonic approach is the disaggregation of commodities into characteristics and the estimation of implicit prices for units of the characteristics. Statistical measurement of the relationship between prices paid by consumers for a product and the quality mixes contained in that product can be used to interpret these marginal values in monetary terms.

Sharma et al. (1992) analyzed the influence of vegetable, pulse, and potato production on the retail price of potatoes. Annual potato production, availability of seasonal vegetables and pulses, general price levels, and other factors accounted for a 64% fluctuation in retail prices, while monthly price differences accounted for i 9%. The seasonal index could explain 53% of the monthly differences. Potato production together with vegetable and pulse prices could account for 82-89% of the behavior of retail potato prices in all the markets. In general, the cost of vegetables contributed 42%, pulses 22%, and potato 36% toward fluctuations in potato prices. This supports their influence on the determination of potato prices. The contribution of potato production in price determination was, however, more (about 42%), relative to other variables in Jamshedpur, Calcutta, and Delhi, while that of vegetables was more in the other three markets.

Nayar et al. (1987) found that, based on data for 1979-80 to 1984-85, lean period prices were strongly related to commodity market arrivals in Delhi, while peak arrival period

prices behaved randomly when related with arrivals. The authors used yearly trend and potato production figures (both from predominantly potato producing areas and nationally) in developing the forecasting models for the Farrukhabad and Delhi markets.

Another technique for forecasting potato prices was followed in subsequent outlook surveys conducted at Shimla. This techniques consists of estimating the peak period prices through a quick potato outlook survey, and then calculating the monthly forecast prices with the help of seasonal indices worked out over the past 17 years (Sharma et al. 1987).

Chandran, K. P., & Pandey, N. K. (2007) used seasonal ARIMA model in order to forecast potato prices in India.

4. Data Sources

There are two types of prices which are available for these commodities; the wholesale prices and the retail prices collected from the Federal Bureau of Statistics, Punjab. The wholesale prices for the 13 commodities are available on monthly basis from January 1998 to July 2015. The retail prices for the 13 commodities are available on daily and monthly basis from July 1997 to July 2015 and it is available division wise too.

The production of potato (thousand tons) in Punjab is available from the years 1985 to 2014 from Agricultural Statistics of Punjab Book. Likewise the data for area cultivated for Potatoes in Punjab (thousand hectors) and yield of Potatoes in Punjab (ton per hector) is available from the years 1985 to 2014 obtained from the same source.

The data for the total cost of production for only potatoes is available from 1998 till 2015 obtained from the Crop Reporting Department Punjab. The break-up of the cost of production for potatoes only is available from 2005-06 to 2014-15.

The prices of crude oil (Rs/Barrel) and CPI Inflation are available from 1995-2014 obtained from the Economic Survey of Pakistan. The support prices for potatoes are available from 1995 till 2015. The data for temperature and precipitation of Punjab is available division wise from the year 1995-2015 obtained from Agricultural Statistics of Punjab Book.

5. Descriptive Analysis

5.1 World Production of Potatoes

World potato production has increased at an annual average rate of 4.5 percent over the last 10 years, and it was 376,453,000.00 tons in 2013. These are produced in more than 100 countries worldwide. Since the early 1960s, the growth in potato production area has rapidly overtaken all other food crops in developing countries, and more than half of global potato production now comes from these countries (FAO).

5.2 Pakistan's Production of Potatoes

Since Pakistan's independence, the area under potato cultivation has increased from 3000 hectare to around 107000 hectare, and average yield of it has increased around 9 metric ton to 20 metric ton per hectare. Pakistan is self-sufficient in potatoes for household consumption and relies for more than 99% on locally produced seed potatoes. Presently, it is estimated that the total annual domestic production amounts to around 1.8 Million MT, of which 280000 MT is used as seed and 1.8 Million MT is available for consumption after postharvest losses. This large increase in acreage is result of intensified cultivation in existing potato growing areas, introduction of crop in new areas and to new farmers.

5.3 Provincial Shares in Area and production

Nature has bestowed Pakistan with diverse agro-climatic conditions. In the plains, we are raising two crops of potato namely spring and autumn crops, while third one is grown in hilly areas during summer season. Punjab accounts for 94.1 percent of the total area and 96.12 percent potato production nation-wise during the year 2012-13. The share of other province Sindh, KPK and Baluchistan in potato cultivation area is 0.3, 4.3, and 1.27 and in production is 0.11, 2.89 and 0.87 percent, respectively. This indicates that supply of potato mainly depends on Punjab production. The shares of autumn, spring and summer crops in the annual production are estimated at 75, 10 and 15 percent, respectively.

Table 5.1: Provincial Supply Cycle of Potato

Punjab	Sindh	KPK	Baluchistan
November – June (88.50%)	December- January (0.19%)	July-October (9.70%)	October-November (1.61%)
2.743 M. Tons	**0.006 M. Tons**	**0.301 M. Tons**	**0.050 0.050**

Source: *Pakistan Bureau of Statistics*

5.4 Potato Producing Punjab Districts

Punjab main districts that significantly contributed in potato production are Okara, Sahiwal, Kasur, Sialkot, Sheikhupura, Jhang, Lahore, Narowal, Pak pattan, Gujranwala, T.T. Singh and Khanewal; and their share in production and area are given in the following tables.

Table 5.2: Districts' Share in Area and Production in 2013-14

District's Name	Area (Acres)	% Share	Production (Tonnes)	% Share
Okara	126500	34.44	914968	33.35
Sahiwal	55675	15.16	426573	15.55
Kasur	42891	11.68	346854	12.64
Sialkot	11617	3.16	83467	3.04
Sheikhupura	9350	2.55	86745	3.16
Jhang	2120	0.58	16182	0.59
Lahore	4485	1.22	42501	1.55
Narowal	1621	0.44	7709	0.28
Pak-Pattan	3700	1.01	311018	11.34
Gujranwala	1638	0.45	11932	0.43
T.T. Singh	10020	2.73	73037	2.66
Khanewal	13470	3.67	103055	3.76

Source: *Agricultural Statistics of Punjab*

As the demand for potatoes is highly price inelastic (-0.07 and -0.13) in rural and urban areas (Najmi, 1991), thus the demand side variable have not been incorporated in the model. Moreover, the supply of potato is measured by the total production, cultivated area and yield in (Rana, Z. H. and Rao, S. R. 1993). As the supply of potatoes in the market increase, the prices fall by following the supply principle. Thus, all the variables inferring the production of potatoes have indirect relation with the market prices of potatoes. In Pakistan, production of potatoes during the last two decades has increased at an annual rate of 5.88 percent solely due to an increase in area by 6.19 percent. Expansion in the production of crop took place due to increase in area in Punjab by 7.04 percent. Thus, in order to measure production; the cultivated area represents the closest proxy.

The cost of production mainly impacts the market prices of potatoes. As the total cost of production increases, this leads to rise in the market prices. However, there are evidences of cost of production and production to be highly correlated. (Srivastava, B. N.1980). This can lead to biased results.

Weather impacts immensely on the production of potato. According to research conduction by Pakistan Agricultural Research Council, the average mean daily temperature of 15-30 degrees is the viable temperature for optimal potato growth. The level of precipitation and irrigation facilities also impacts the production of potatoes. If the weather conditions go adverse i.e. moving away from the benchmark, then this leads to rise in prices of potatoes. Potato is grown under temperate, subtropical and tropical conditions. It is essentially a "cool weather crop", with temperature being the main limiting factor on production. Optimum temperature for germination, vegetative growth and tuber formation in potato is 25°C, 20°C and 16-24°C respectively. Tuber growth is sharply inhibited in temperatures below 10°C (50°F) and above 30°C (86°F); while optimum yields are obtained where mean daily temperatures are in the 18 to 20°C (64 to 68°F) range.

Potatoes are easy to grow, but they prefer cool weather. The time for plantation of autumn crop, which contributes more than 70% of the total yield, starts in early October and ends in mid-November. Spring crop contributing less than 10% to the total yield, can be sown from mid-December to mid-February while the summer crop contributing more than 15% is sown in early April up to mid-May.

Table 5.3: Seasonal Crop Production Shares

Crop	Planting	Harvesting	Production Share
Spring	Jan-Feb	April-May	7.10%
Summer	Mar-May	August-Oct	15-20%
Autumn	Sept-Oct	Jan-Feb	70-75%

Source: *Pakistan Agricultural Research Council*

The Potato crop in Pakistan is affected by many pests and diseases. From these diseases potato viruses, powdery scab, potato cyst nematode, aphids and white grub are the most damaging ones. Surveys done by Pakistani workers have revealed that viruses, powdery scab and aphids are wide spread, white grub are serious problems in the northern hilly areas. These diseases eventually impact the production of potatoes.

Potato crop matures in 100 – 120 days. Drying of vines, hardening of potato skin and yellowing of leaves are the indications that the tubers have gained maximum size and weight. Potatoes are reaped either using a mechanical harvester or manually using spade for their digging. Tubers if kept under shade for 2 – 3 days harden their skin to avoid its removal during grading and packaging. Tubers are graded for separate packaging of superior grade to get high prices. Potato tubers which are uninjured, clean, dry and free from diseases are packed in clean, disinfected and unspoiled bags. Potatoes to be kept for seed purposes are stored at 3-4°C while the ones to be marketed after 2-3 months can be stored at 10 – 15°C. However, no study provides the estimates about the stored potatoes.

Poor post-harvest handling, including transport and storage practices, causes unnecessary damage and losses and reduction of consumption quality. Sufficient cold store space is available in Pakistan. The handling of potatoes in storage is unsatisfactory and poorly managed. Finally, the farmers and consumers are faced with serve cyclical fluctuations in price, as production moves from glut to shortage, so preventing the farmers from enjoying a reliable income and inhibiting the consumer from including potato as a regular staple part in his diet.

One of the major factors which affect the market prices of potatoes is the prices of oil. As the major component of the wholesale prices are the transportation costs. As the prices of

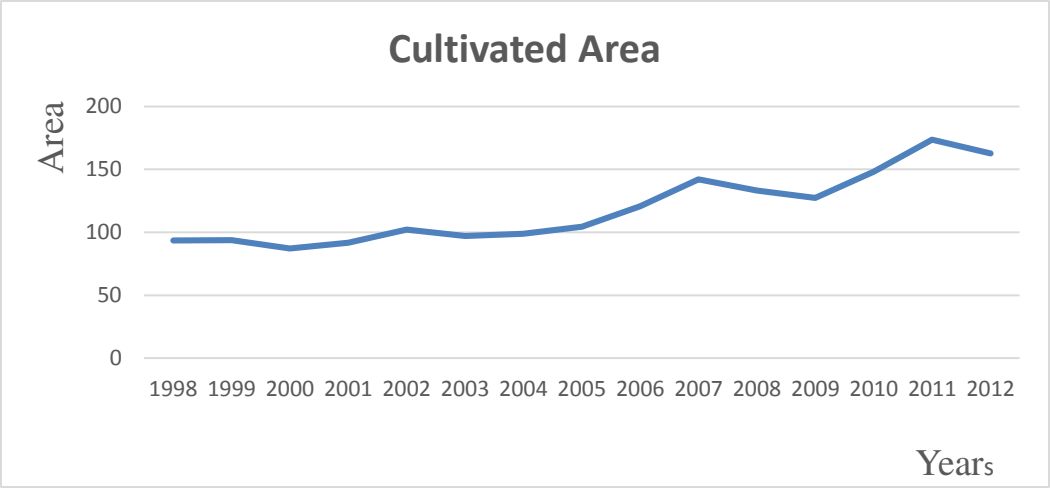
crude oil in Pakistan increase, the market prices of potatoes also tend to rise as well (Abedullah. Et.al. 2007).

Table 5.4 : Descriptive Analysis of Variables

	Area	Prices	OP	SP	Temp
Mean	118.4	1323.5	4215.4	311.7	21.2
Minimum	87.1	471.5	612.8	214.2	18.8
Maximum	173.7	2286.9	9900.5	528.0	23.6
S.D	27.9	641.9	3085.6	106.8	1.4

The average cultivated area of potatoes is mainly 118 hecters, wholesale price of potatoes per 100 kg is Rs. 1323.5, the price of crude oil per barrel is mainly Rs. 4215.4. The average support price is mainly Rs. 311.7 and mean temperature is 21.2 degree centigrade. The market prices of potatoes deviate by Rs. 641.9 from the mean and the area by 28 hecters. The lowest support prices offered by the government was the Rs. 214.2. The temperature varies from the minimum value of 18.5 to maximum value of 23.6 degrees.

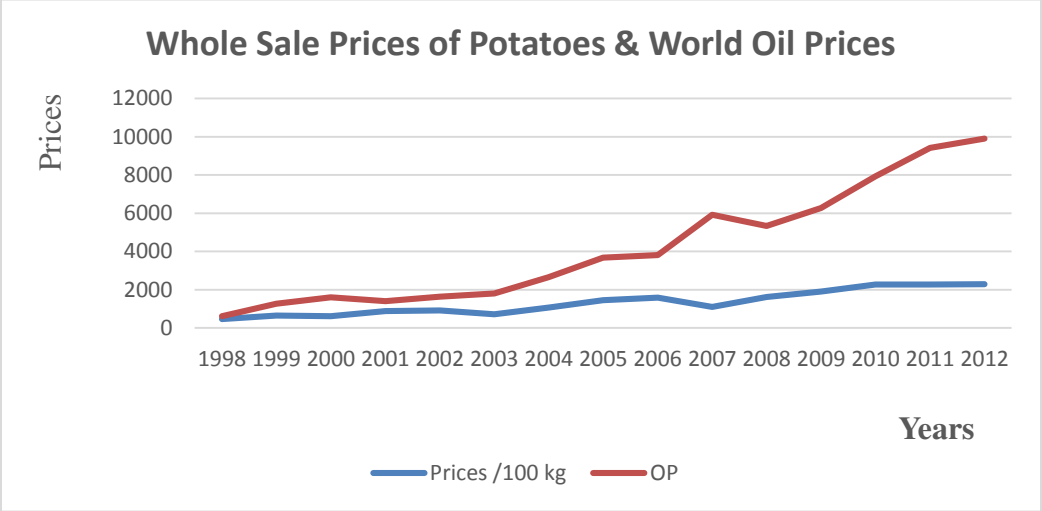
Figure 5.1: Total Cultivated Area in Punjab (Ha)



The above figure represents that over the years the cultivated area in Punjab for potatoes has increased. This is mainly due to rise in demand for potatoes and the emergence of new

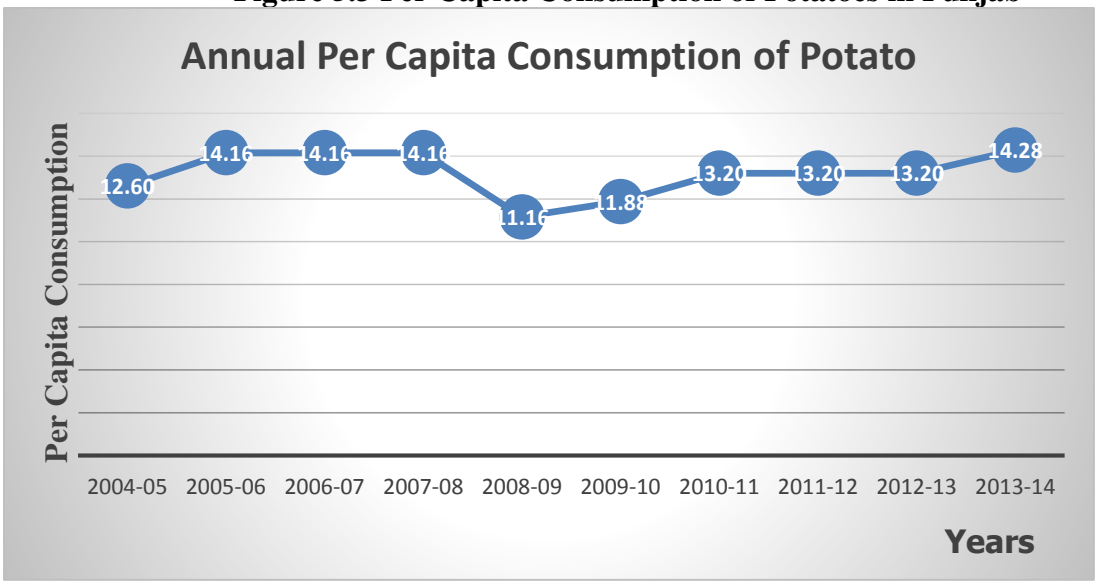
fast food chains opening in the province. In the past decade, the cultivated area has increased by 80 percent.

Figure 5.2: Wholesale Prices of Potatoes and World Oil Prices



The world oil prices have a significant impact on the market prices of potatoes. The above graph shows a rise trend in the recent years. Moreover, the similar trend for both of the prices shows that the increase in oil prices directly increase the market prices of the potatoes. As the transportation costs increase due to rise in oil prices; the market prices of potatoes also increase.

Figure 5.3 Per Capita Consumption of Potatoes in Punjab



The above graph shows that the annual per capita consumption of Potatoes in Punjab has increased over the years. In the year 2013-14, each person consumes 14.28 kilograms annually.

Figure 5.4 Prices of Potatoes

The above graph shows that the wholesale prices of potatoes have increased over the years. In the recent years, they have been constant but overall they show a rising trend. In comparison to the year 1998, the wholesale prices of potatoes have increased by 80%.

Table 5.5 : Production Cost and its Determinants (Rs./Acre)

Year	Preparatory Tillage Ploughing &Seed Bed Preparation	Farm Yard Manure +Fertilizer	Seed & Sowing Operation	Irrigation	Harvest	Others	Prod. Cost
2010-11	5460	16971	28700	3926.3	4700	10775	70532.3
2011-12	7034	25219	33110	4481.3	5500	11025	86369.3
2012-13	7317	25042	17722	4736.3	5000	13700	73517.3
2013-14	7754	25990	23020	4964.3	5000	13825	80553.3
2014-15	7989	26274	42871	5234.3	5131	14150	101649.3

Figure 5.5: Distribution of Cost of Production 2011-12

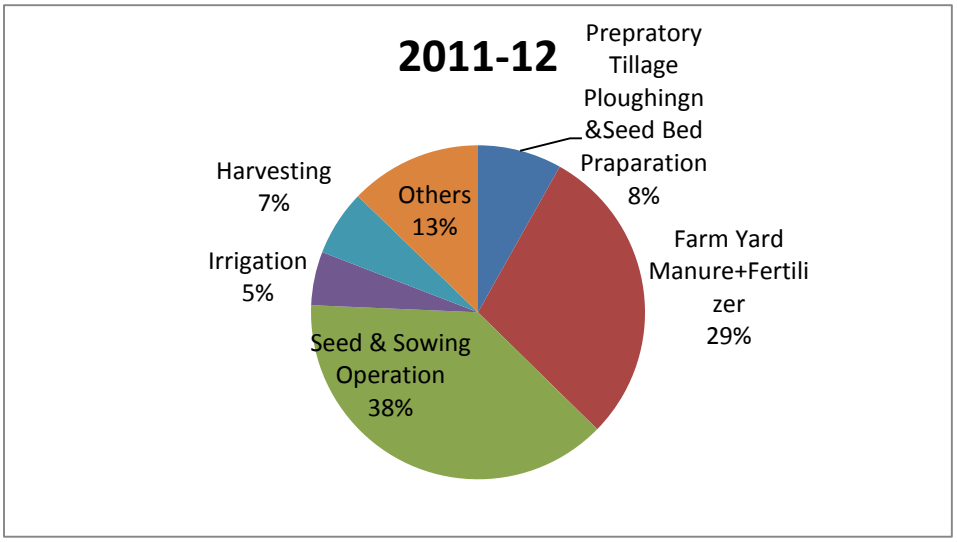


Figure 5.6: Distribution of Cost of Production 2012-13

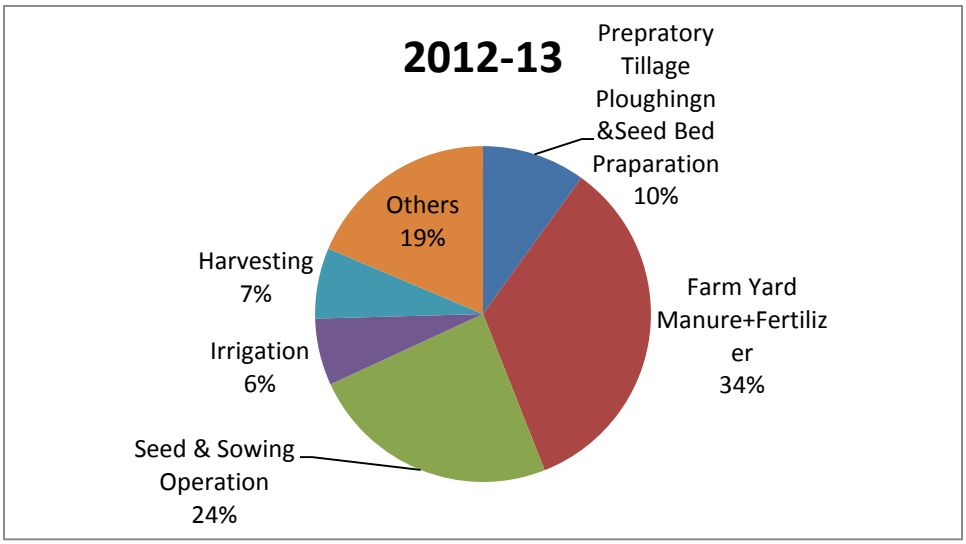
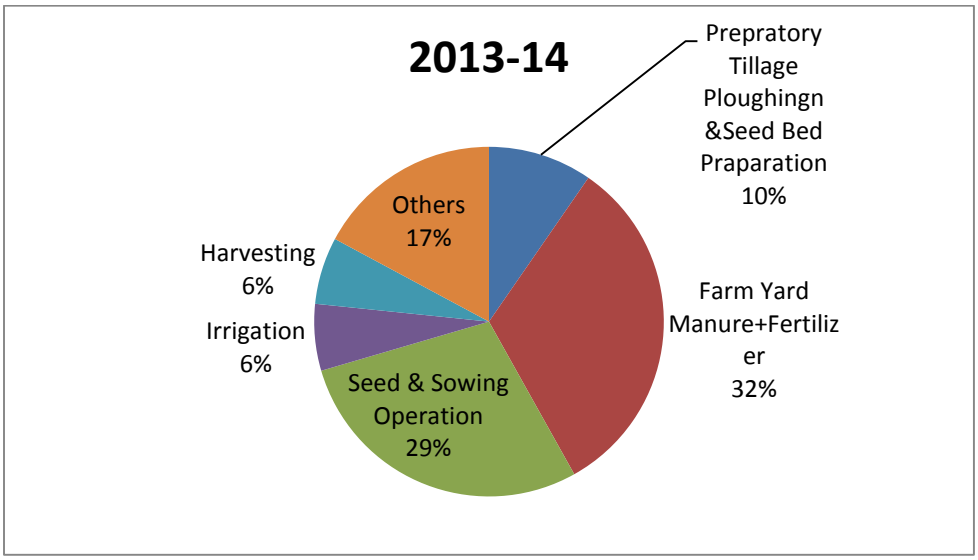


Figure 5.7: Distribution of Cost of Production 2013-14



The above charts are the indicator of the fact that fertilizer is the major contributor in the total cost of production of potatoes. In contrast to 2011-12, the cost of seed used to contribute 38% of the total cost of production. However, in the year 2013-14 the share of seed in the cost of production of potato has reduced to 29%. In the year 2014-15, the trend again reverses and the cost of seed again becomes the major contributor in the total cost of production of the potatoes.

Figure 5.8: Distribution of Cost of Production 2014-15

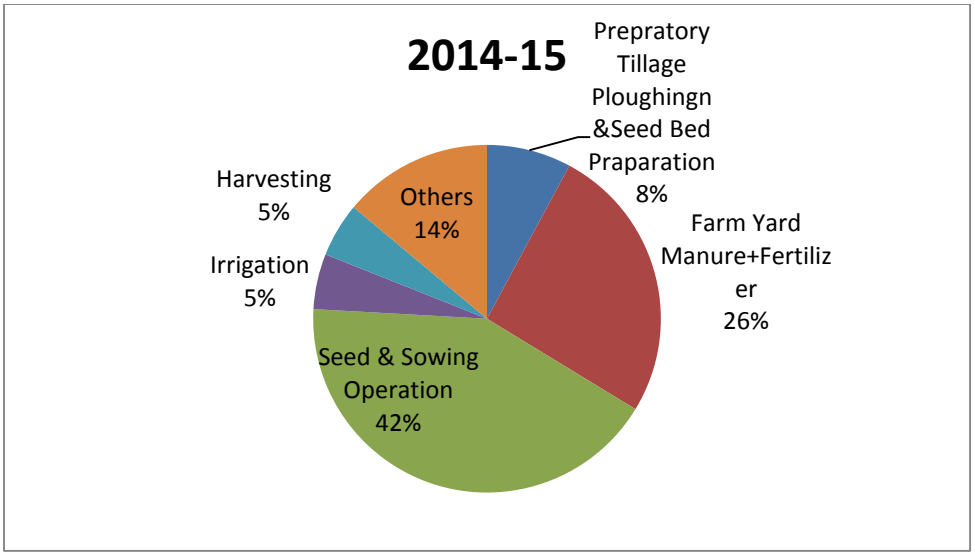


Table 5 and pie diagrams show that the share of seed & sowing operation and farm manure plus fertilizer remains dominant (more than 65%) in total cost of production over the last five year. This implies that these factors play an important role in determining the supply of potato and thereby price of it. The cost of preparatory tillage ploughing & seed bed preparation is reduced from 10% in 2013-14 to 8% in 2014-15 due to reduction in POL at international level. POL prices have also reduced the irrigation cost from 6% to 5% during the time period 2013-14 to 2014-15. Cost of farm yard manure and fertilizer was reduced from 32% to 26% from 2013-14 to 2014-15 due to reduction in DAP from Rs.3900/bag to 35000/bag.

6. Methodology

The primary focus of this study was to determine the effects of cost of production, weather conditions and cultivated area on potato prices in Punjab. Therefore, the use of ordinary least squares procedure to obtain the estimation of the hedonic price relationships is of most interest and appropriate to the study objectives.

The methodology adopted for the study of potatoes is mainly based on the secondary data. The hedonic model is applied in order to estimate the factors which affect the prices of potatoes. In order to forecast the prices of potatoes, the Auto Regressive moving Average (ARMA) and Auto Regressive Integrated Moving Average (ARIMA) techniques have been used.

The price paid by the consumer for each product consumed equals the sum of the marginal monetary values of the product's characteristics, and the marginal monetary value of each characteristic equals the quantity of the characteristics obtained from the marginal unit of the product consumed multiplied by the marginal implicit price of characteristic (Ladd and Suvannunt 1976). It describes a competitive equilibrium price reached by both sides of the market simultaneously in terms of the amount of product characteristics that the producers supplied and consumers demanded (Rosen 1974). In other words, the hedonic price equation is determined by the bids that consumers are willing to make for different bundles of characteristics and the offers of those bundles by suppliers (Palmquist 1984).

The hedonic price model is as follows:

Pi = f (Zi)

Where Pi = Price of Commodity i and Zi = (z1, z2, z3,….zj) – Set of j attributes that commodity i has.

Price fluctuations are a matter of concern among consumers, farmers and policy makers and its accurate forecast is extremely important for efficient monitoring and planning. Several attempts have been made in the past to develop price forecast models for various commodities (Sharma et al., 1992, Ghosh and Prajneshu, 2003, Pavlista and Feuz, 2005). Potato prices fluctuate over seasons due to the variations in production and market arrival. Thus, modelling and forecasting the monthly price behaviour over the years is of much practical importance.

A variety of statistical techniques have been employed in the past to study price fluctuations. For improving the accuracy of forecast, two approaches have generally been employed. First approach considers price as "explicit" function of various external factors and incorporates the information on these variables in prediction, whereas in the second approach, temporal variations in price are studied by applying either polynomial models or Box-Jenkins approach. Here, response variable at any time 't' is assumed to be expressible as a linear function of its values at past epochs t-1, t-2, … Thus, role of various predictor variables enter into the model "implicitly" through response variable observations at past epochs. One advantage of "Implicit modelling" approach is that data requirements are much less. In this study, one of these approaches, seasonal Auto Regressive Moving Average (SARMA) model was employed to study and forecast the wholesale potato price of Punjab markets.

The seasonal univariate Box-Jenkins model, often referred to as SARMA is one of the important and useful tools for time series modelling (Box et al., 1994). It requires differencing non-stationary series one or more times to achieve stationarity. The model includes difference operators, autoregressive terms, moving average terms, seasonal difference operators, seasonal autoregressive terms, and seasonal moving average terms. The first step in developing this model is to determine if the series is stationary and if there is any significant seasonality that needs to be modeled. The Augmented Dickey-Fuller

(ADF) and Phillips-Perron (PP) tests were used for the test of stationarity, both seasonal and non-seasonal.

The general empirical model for the price of fresh tomatoes, pi, was specified as:

$$\ln Pi = c + \beta_1 AREA + \beta_2 COST + \beta_3 TEMP + \beta_4 POIL + \beta_5 PSUPP + \mu_i$$

Where Pi is the whole price of potato per hundred kgs in Rupees; AREA represents the cultivated area in hectors; COST presents the cost of producing potatoes per hundred kgs; TEMP represents the average mean yearly temperature of Punjab; POIL represents the prices of crude oil per barrel in Rupees; PSUPP represents the support prices set by the government and ui is the error term.

7. Results and Discussion

A multiple regression model is used to estimate the Determinants of Potato's Prices in Punjab. The result of this regression is given below in table 1.1.

The regression coefficient of COST (cost of production) is 0.0093 which indicate that as COST increases say by a unit prices of potatoes will increase by 0.0093 unit. The variable is showing a positive relationship between prices and cost of production. However the variable is statistically insignificant but according to the theory it is proven that cost of production is positively associated with the prices of potatoes.

Table 7.1: Multiple Linear Regression results for the determinants of Potato's Prices

Dependent Variable : Log Price			
Method : Least Square			
Observations : 1998 – 2013			
Independent Variables	**Coefficients**	**Standard Error**	**P- Value**
Constant	5.0916	1.2413	0.003
Cost	0.0093	0.0115	0.438
Temperature	0.1245	0.0534	0.045
Area	-0.0141	0.0078	0.105
Oil Prices	0.0002	0.00008	0.022
Support Prices	-0.0176	0.0223	0.450
R- Squared	0.9148	**Durbin-Watson Stat**	2.306
Adjusted R-Squared	0.8674		

The variable of Temperature has a coefficient value is 0.1245 shows a positive relationship with prices of potatoes. If temperature increase by a unit prices of potatoes increase by 0.1245 unit. This variable is highly significant at four percent level.

Area value of coefficient is -0.0141 means that a negative relation between area under cultivation and prices of potato's. If area under cultivation will increase definitely there will be an increase in production which means more supply in the market and prices go down according to the basic theory of economics. If there is one unit increase in area under cultivation then there will 0.0141 unit decrease in the prices of potato's however this variable is statistically insignificant in this model.

The regression result coefficient of Oil Prices (International oil Prices) is 0.0002 showing a positive relation with prices of potato's. If oil prices increases say by a unit prices of potatoes will also increase by a 0.0002 unit. This variable is highly significant at two percent level and have a string impact in this model.

The theory also suggest the positive relation of world oil prices and prices of potato's because world oil prices having an effect on the overall economic activities.

Coefficient value of Support Prices is -0.0176 means a negative relation with the dependent variable which is the prices of potatoes. The theory also suggest a negative relation of support prices and the dependent variable. If support prices increase by a unit dependent variable will decrease by a 0.0176 unit.

The variable of adjusted R-squared is 0.86 indicate that the model is good and 86 percent of the total variation is explained by the explanatory variable in this model.

We applied Breuch- Pagan test to check the heteroscedasticity and we found the results which are given in Annexure showing us that there is no problem of heteroscedasticity because chi2(1) value is very low.

To check the multicollenearity in this regression we used VIF method and the results of this diagnostics test is given in Annexure.

The results of this method indicates that there is no multi-collinearity in this regression because as tolerance value which is 1/VIF approaches to one it shows that there is no multi-collinearity in this regression. If tolerance value is less than 0.5 then we say there is a weak multi-collinearity and if tolerance values is closer to zero then we can say that there is strong multi-collinearity in the regression.

Durbin-Watson Stat is used to check the auto-correlation in the model. As the Durbin-Watson stat is 2.306 indicate that there is no autocorrelation in this model.

8. Forecasting of Potato Prices

Potato wholesale prices of Punjab market were analyzed using univariate seasonal ARMA model. Seasonal indices calculated showed that generally the price is low from December to May and it picks up from June, and reaches the maximum in October. Based on the Shwartz Bayes Criterion (SBC) and Akaike Information Criterion (AIC), the estimated best model was ARMA (2, 1). Short-term forecasts based on this model were close to the observed values.

Secondary data for this study was wholesale potato price of Punjab markets from January 1998 to July 2015 and monthly pricedata were collected from the publications of Punjab Bureau of Statistics.

Kwiatowski-Phillips-Schmidt-Shin (KPSS) statistics give us the P-value 0.113 which is less than the critical values at all level. So we accept Null hypothesis which is saying that Series is stationary. After checking stationarity of data different AR and MA lags were employed to check the actual lags in the data and the result shows that there are AR(2) and MA(1) lags in this model.

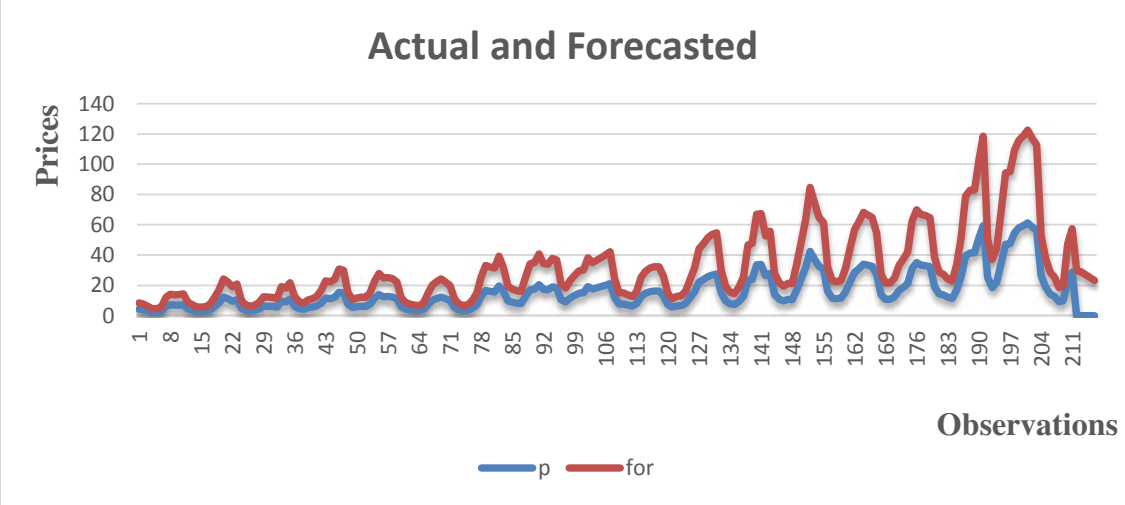
As the first step, the monthly time series data from Jan., 1998 to July 2015 was decomposed into different components to study the temporal pattern. Seasonal indices calculated have shown that generally the price as low from December to May and it picked up from June and reached the maximum in October (Table1).

Table 8.1 Seasonal Indices of wholesale potato prices of Punjab, Pakistan

Month	Seasonal Index
January	0.53
February	0.51
March	0.56
April	0.65
May	0.80
June	1.10
July	1.34
August	1.44
September	1.44
October	1.45
November	1.43
December	0.74

The figure shows a seasonal trend on wholesale prices of potatoes (Fig. 8.1)

Figure 8.1: Actual and Forecasted Wholesale Prices of Potatoes



The figures in the parentheses indicate the corresponding standard errors. The seasonal ARMA was fitted in form of graph for whole sale potato price data of Punjab (Fig. 9.1).

AIC value for the above model was computed as. The forecasts for the next 4 months are given in Table 8.2.

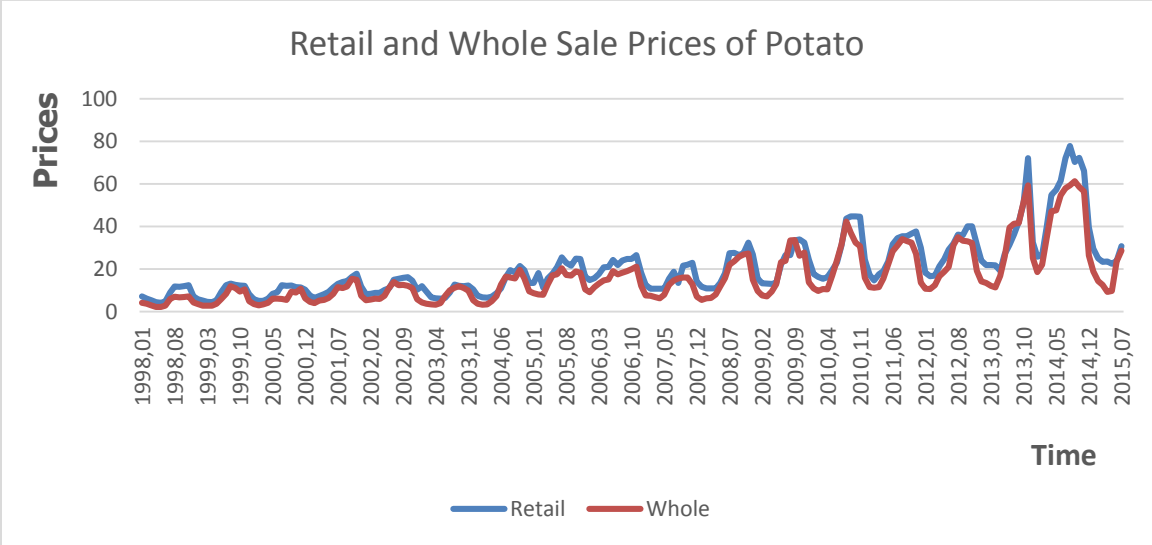
Table 8.2: Forecasts based on the fitted SARMA Model				
Month	**Actual (Rs/Kg)**	**Forecast (Rs/Kg)**	**Difference**	**+/- SE**
Feb 2015	14.36	14.24	0.12	5.28
March 2015	12.62	12.14	0.48	8.53
April 2015	9.30	11.60	-2.30	10.69
May 2015	9.77	11.90	-2.13	11.97
June 2015	23.68	17.06	6.62	12.63
July 2015	28.75	19.95	8.80	12.92
August 2015	--	29.81	--	4.98
September 2015	--	28.89	--	7.96
October 2015	--	27.08	--	10.04
November 2015	--	25.02	--	11.39
December 2015	--	23.07	--	12.21

It can be concluded that ARMA model was found to be good in forecasting potato wholesale price of Punjab.

The forecasted retail prices are as follows:

Table 8.3: Retail Forecasts based on the fitted SARMA Model				
Month	**Actual (Rs/Kg)**	**Forecast (Rs/Kg)**	**Difference**	**+/- SE**
May 2015	22.52	22.65	-0.13	5.41
June 2015	23.86	25.57	-1.71	8.00
July 2015	30.76	32.77	-2.01	9.57
August 2015	38.31	33.59	4.72	9.34
September 2015	--	33.92	--	10.55
October 2015	--	37.64	--	10.86
November 2015	--	37.53	--	11.04
December 2015	--	37.24	--	11.06

Figure 8.2: Retail and Whole Sale Prices of Potato



9. Conclusion

Potato is a major Rabi crop. The prices of potato have a seasonal trend and for its forecasting SARMA model has been applied. The cost of production has the major impact on the prices of potatoes. However, there are other variables which need to be incorporated such as the storage of potatoes. Moreover, division wise data is also available for prices for which an arbitrage can be calculated. Thus, a detailed analysis and forecasting of perishable commodities can be done in detail.

10. Policy Issues

There are following issues in the potato supply chain that must be addressed by the authority to regulate the price in the market.

1. Lack of credit for farm inputs and credit system for farmers
2. The use of low quality seeds
3. Lack of availability of sufficient quantities of good seeds and low purchasing power of the farmers, forcing them to rely on seed sources of unreliable quality
4. No proper gene pool is available in the country
5. Inappropriate usage of Fertilizers for better quality yield.

6. The pesticides used not only damage the quality of crop but also affect its nutritional value thus having damaging impact on our potato export.
7. Lethal pesticides banned worldwide are manufactured as well as used in Pakistan without any restriction.
8. DDT or Thiabendazone is used for potato crop for which, the effect of cooking is zero percent pesticides residue reduction.
9. The trading partners concern about the level of aflatoxin maximum residues level and drug residues in different agriculture and food items are growing with each passing day. Supply of raw material from farm to plant is usually accomplished in an open environment with raw material exposed to pathogenic microorganisms and their toxins, pests, and rats.
10. Lack of processing plants and inefficient quality assurance system.
11. Fake quarantine certification for the execution of shipments.
12. No standardization of crop quality in terms of size and variety. Absence of certifications required to meet international hygienic standards.
13. Lack of descriptive labeling
14. Lack of free market access because of the food safety in major potato importing countries.
15. Absence of cold chain and limited cold storage facilities causing wastages of potato crop.
16. Absence of pricing mechanism causing uncertainty and subsequently hampering the confidence of the exporters for negotiating the export deals. High transportation cost which result high price of potato and cannot compete in the international market.

11. Limitations

The limitations of this research are as follows:

1. The data for storage of potato is not available; however, hoarding does impact the market prices of potatoes.
2. The imports and exports of potatoes within a year of Punjab are not available.
3. Unable to incorporate the seasonal effect due to monthly variations in the hedonic model because the cost of production on monthly basis is not available.
4. The data for potato diseases remain unavailable.
5. The overall data is available for only 17 years which is insufficient for a time series analysis.
6. The break-up of the cost of production is not available for years before 2005-06.
7. The daily wholesale prices are not available.
8. There is no information available about the number of wholesale and retail markets in Punjab.

12. Way Forward

1. An analysis of division-wise with Punjab can be done for the prices of potatoes.
2. The results of hedonic analysis can be made more valid with the help of more data.
3. Forecasting models can be applied to the other commodities
4. The margins between the wholesale prices and the retail prices can be calculated.

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Annexure:

Table: List of Commodities		
Serial No.	**Commodities**	**UNIT**
1	WHEAT ATTA (THAILA)	20 KG
2	RICE BASMATI	KG
3	RICE IRRI-6/IRRI PAK	KG
4	GRAM	KG
5	MASOOR (DAL)	KG
6	MASH DAL (WASHED)	KG
7	MOONG DAL (WASHED)	KG
8	CHILLIES GROUND	250 GM
9	SUGAR WHITE	KG
10	POTATOES	KG
11	ONIONS	KG
12	TOMATOES	KG
13	MAIZE	KG

Table 7.2: Results of Heteroscedasticity test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity
Ho: Constant variance
Variables: fitted values of prices
chi2(1) = 0.00
Prob > chi2 = 0.9514

Table 7.3: Test Results of Multicollenearity

Variable	**VIF**	**1/VIF**
Cost	1.78	0.56
Temperature	1.19	0.84
Area	1.34	0.74
Support Prices	1.26	0.79
Oil Prices	1.45	0.68
Mean VIF	1.49	