"Forecasting Wheat Production of Pakistan"

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CERTIFICATE

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Dedicated to

My Parents, my Family and all my Teachers

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Chapter No. 1

Introduction

"A good forecaster is not smarter than everyone else, he merely has his ignorance better organized." "Forecasting future events is often like searching for a black cat in an unlit room, that may not even be there."

Steve Davidson. *

1.1 BACKGROUND AND MOTIVATION

A statement concerning unknown, in particular future events is called forecast or expectation. Expectations are made due to many reasons. One of them is that our present decisions depend on the events about which we do not know at the present time as they occur in future. For instance, a person does not know whether it will rain in the day when he/she comes back to home from his/her office. The person has to decide now on the basis of his/her judgment to carry umbrella or leave it at home. A good decision about the day, in the morning is important for the person. Similarly economic agents must be able to make predictions in order to make wise decisions well before time. Such phenomenon may happen on macro as well as on micro levels.

The government must be able to predict the things like inflation, unemployment and poverty rates, grain needs of the population etc. in order to make important policy decisions. Macroeconomic policy makers are interested in knowing grain needs of population in the coming years. If the grain forecasts are alarming then they suggest the authorities to import food grains right now, so that the remedy starts before occurring of the disease. Forecasting is an important exercise in the context of time series analysis.

According to Yin-Wong et al. (1997) a large industry is involved in the forecasting of key macroeconomic variables.

Due to its contribution to the economic and social well being of the nation through its influence on GDP, employment and foreign exchange earnings, agriculture has the importance like backbone of the economy of Pakistan. In food grain crops, wheat and rice are the most important crops, wheat being staple food for the majority of Pakistanis. The contributions of wheat and rice to value added in agriculture are 13.8 % and 5.4 %, respectively, while their contributions to GDP are 3.4 % and 1.3 %, respectively.

In Pakistan, the real grim is the race between food supply and increasing population. Wheat is the main staple food for Pakistani people. During the past years the water shortage and extraordinary drought conditions have sophisticatedly affected the wheat crop, though in recent past Pakistan experienced good wheat crops that made it possible to pile up healthy strategic stocks.

Literally other crops in general and wheat in particular provide leakages and through which it is possible to provide stimulus to economic growth in other sectors. The wheat crop has been suffering from various problems, such as shortage of irrigation water, low yields, traditional methods of farming and shortage of good quality key inputs and less use of modern technology in this sector. Pakistan has experienced ups and downs in wheat production. Prices of wheat and flour fall drastically when there is a surplus wheat production and boost up during low production seasons. However, surplus of wheat production occurred for few years and during such periods farming community suffered heavy losses due to inadequate marketing facilities in the country. Moreover, farmers do not know future prospects of wheat production and prices while deciding to allocate area for this and other crops. There is a dire need to forecast production as well wheat yield in Pakistan.

1.2 OBJECTIVES AND SCOPE

Since the forecasting of food grains is such an important issue in agriculture economics, in this study we determine future prospects of wheat in Pakistan as well in its four provinces using the past trends. We make wheat forecasts for Pakistan and for its four provinces for the period of 2005 and 2006 and compare them with actual production in this period. Thus the difference between the predicted and actual production is the wheat forecast error. A positive forecast error means that wheat production has been underestimated and vice versa.

We try to find a basis for future wheat forecasting and after finding a basis for forecasting, we make forecasts for the period of 2007 to 2015. We see what will be the trend in wheat production in Pakistan as well as in its four provinces. Thus this study provides update wheat forecast estimates for Pakistan as well as its four provinces.

We find elasticities of wheat output with respect to different inputs in Pakistan as well as in its four provinces and determine the inputs that are crucial in the production of wheat. We rank them according to their role in the determination of wheat production. We also see whether the role of different inputs is the same or different across the four provinces in the determination of wheat production.

1.3 Organization of the study

The organization of the study is as follows. In chapter 2, we review the existing literature on forecasting wheat production and empirical findings of the subject. In chapter 3 we present methodology. Data and estimation are presented in chapter 4. Results are presented in chapter 5. Finally, chapter 6 concludes the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

For the last many years important developments have taken place in agriculture economics, with substantial contribution to both theory and empirical understanding of the forecasting wheat production. But a number of challenges remain unresolved. Most of the existing literature both theoretical and empirical focuses on the forecasting of wheat production either for only one province or on aggregate level in Pakistan. In Pakistan, no paper attempted to forecast wheat production for each of the four provinces and on aggregate level too.

In this chapter we discuss the existing literature on forecasting wheat production: both on micro and macro level. Remaining portion of this chapter is organized as follows. In section 2.2 the role of rainfall in wheat production of Pakistan is described. In section 2.3 we describe the relationship between fertilizer input and wheat production and in section 2.4 relationship between tractor use and wheat production is provided. Labor and wheat production relationship is described in section 2.5. Literature on wheat forecasts in Pakistan is provided in section 2.6 and section 2.7 concludes this chapter.

2.2 THE ROLE OF RAINFALL IN WHEAT PRODUCTION

There is positive relationship between rainfall and wheat production. The rainfall in the pre-sowing, sowing and post sowing seasons affects the wheat production positively.

However the rainfall in the harvesting and threshing season has negative impact on the wheat production. The possible reasons for this may be that rainfall in the harvesting and threshing season makes it difficult to harvest the crop and it also affects the quality of grains and causes their spoilage. Moreover, rainfall makes it difficult to thresh the wheat bushels and quality of grains is affected by it.

Cole, John S. and Mathews, O. R. (1923) made the conclusion that in the Great Plains of the United States of America, the high correlation of the total water used with the portion obtained from reduction of the soil water content indicates that under the conditions specified for spring wheat studies the stored water is a more dependable source of supply than the current precipitation. After using the past data both on dependent and independent variables, they draw the main conclusion from their paper that soil moisture can never be great enough to carry a crop of spring wheat through without some decrease from normal yield if the spring precipitation is below its normal level. Precipitation 12 to 18 months previous to harvest affects the supply of moisture available for the crop must to be stores in some form previous to the seeding date for the crop.

In another study by Mathews (1925) indicates that in the Great Plains of the United States of America, the plants quite often use the stored moisture to a depth of four feet. They used the data from 1914 to 1922. The study states that seldom can precipitation from one harvest to another build up the previously depleted by copious rains for a period longer than twelve months. In years when the crop uses moisture from the third and fourth feet are left with a more than normal reserve for the subsequent crop. In years when the growing crop uses heavily from the fourth foot, the moisture in this fourth foot would seldom be restored to its normal water carrying capacity within a twelve months period.

In another study, Halstead and Coles (1930) show a strong relationship between soil moisture at the time for seeding winter wheat and the yield of wheat. The study deals with the moisture in the upper three feet of soil at seeding time under various methods of culture. With continuous wheat on early listed ground the study showed a correlation coefficient between soil moisture and yield of +0.8268 ±0.0533. The correlation coefficient for the same factors for continuous wheat on late plowing is among the highest: +.8523 ±0.0447. The fallow plots had the highest moisture content at seeding and showed the lowest correlation of all methods. This would indicate that if the better methods of seed bed preparation are being practiced by more farmers each year the relationship between soil moisture readings and production is apt to decrease rather than increase. The low correlation shown by early preparation is probably due to more nutrients made available for plant growth by the precipitation retained from spring rains previous to fall sowing. This also tends to show the effect of a crop or no crop on the subsequent crop.

In another study, Henney (1932) estimated a function relating to wheat production in only a section of Kansas comprising of fourteen of the largest wheat producing counties of the United States of America. For that purpose, the data from 1914 to 1929 was used for the analysis. The study found that yields tend to be influenced more by the rainfall previous to seeding time and by the soil moisture present at seeding time than by rainfall that occurs after seeding. Both temperature and rainfall have always been considered important in determining the yield of most agricultural crops, especially wheat. In areas where wheat acreage is less than one-half the acreage in cultivated crops, there is a much stronger relationship between the late rainfalls rains and yield than in any other type of farming. Following years of large corn, kafir, and wheat yields, in diversified areas there tends to be a smaller yield of wheat than fall rainfall would indicate. The fact that precipitation can account for so much of the variation in total production indicates that winter killing and other limiting factors play only minor roles unless accompanied by a deficiency of rainfall. July rainfall preceding sowing is probably more important in recent years since improved methods of early seedbed preparation are in more general use. Rainfall for a month or two before and after seeding of winter wheat in Kansas, combined with spring precipitation one year previous to harvest apparently has more influence on production than precipitation in the spring just previous to harvest.

Azhar *et al* (1972, 1974) estimated a function relating to wheat production in the Punjab province of Pakistan. They regressed total wheat production in thousand tones on area under the Mexi-Pak wheat verities, area under local varieties, fertilizer and rainfall in the months of November, December and January. For that purpose they used data for the 1962-63 to 1971-72 periods. They found that rainfall in the months of November, December and January was the fourth most significant variable particularly in Barani areas, after area under the Mexi-Pak wheat, area under local varieties and fertilizer.

Qureshi (1974) estimated a function relating to wheat production in Jhelum, Cambellpur, and Rawalpindi districts of Punjab province of Pakistan. Wheat production was taken to be a function of wheat acreage, actual rainfall in inches during july to September, actual rainfall in inches during October to December and maximum-effective rainfall during January to March

. For that purpose they used production and climate data for the 1931-62 to 1960-61 periods. In that study, it was found that an increase in rainfall by one inch during the sowing period leads to an increase in wheat acreage by 3774, 5003 and 18916 acres respectively in Rawalpindi, Jhelum and Cambellpur districts. One additional inch of rain during the pre-sowing period increases wheat acreage by 1241 and 871 acres in Jhelum and Cambellpur, but it reduces the wheat acreage in Rawalpindi by 251 acres.

Chaudhry and Kemal (1974) concluded on the basis of the R-Squared that it would seem that the three-months absolute level of rainfall in the Barani areas and seven-months absolute level of rainfall in the irrigated areas, along with other explanatory variables best explains the variations in wheat production. The investigations confirm that the relationship between wheat production and the explanatory variables is necessarily of the linear type. Whereas in the earlier papers, three-month absolute level of rainfall (November to January) was assumed to be the appropriate rainfall for wheat production, their statistical verifications in the present paper with alternative definitions of rainfall fail to confirm that assumption. Instead they found that seven months (July to January) actual rainfall deviations from normal are more appropriate for explaining wheat production variations. Using seven-month deviations of rainfall the earlier forecast was replaced by a revised forecast of wheat production which came to 6.8 million tons of wheat during 1973-74. This compared favorably with the government target of 6.5 million tons of wheat in the Punjab and confirmed that the actual wheat production was in excess of the fixed target for 1973-74.

A study conducted by the Food and Agriculture Organization (1983) in Jordan for developing an early warming system for wheat indicated that early rainfall (rainfall in October, November and December) is highly correlated with total rainfall, and that a high correlation exists between production and the intensity and distribution of rainfall.

Khan Sarfraz Qureshi (1974), Ozsabuncuoglu (1998), Austin *et al* (1998) *)* and Emad *et al (2002* have provided the relationship between the rainfall and wheat production and wheat acreage in numeric terms i.e. a 1 Millimeter increase in rainfall will lead to so much increase or decrease in the wheat production. Rainfall in harvesting and threshing season has negative impact on the wheat crop. The rainfall in harvesting season makes it difficult to harvest the crop and it also affects the quality of grains and causes their spoilage. Moreover, rainfall makes it difficult to thresh the wheat bushels and quality of grains is affected by it. So the rainfall in the harvesting and threshing season (the month of April in Pakistan) has negative impact on the wheat crop.

Chaudhry and Kemal (1974) and Grifithes *et al* (1999) pointed out that sometimes, using the rainfall in absolute terms better explains the variations in wheat production and sometimes if the rainfall is used after taking the deviations from the normal rainfall and breaking it into more than one part is likely to be more appropriate for explaining wheat production variations.

Another study by Shepley (1988) examined wheat subsidy policies in Jordan to study the effectiveness of price policies in increasing domestic production. He estimated a functional relationship between wheat production as the dependent variable and wheat market price, rainfall, planted area and yield for the period 1980-1986. He concluded that production in rain fed areas was correlated with date of onset, duration and intensity of seasonal rainfall.

Another study by Saleem (1989) using the data from 1960 to 1986, pointed out that in dry land wheat production areas of Jordan, the farmer's attitude towards risk is explained by their choice of an appropriate date for planting: Risk-averse farmers wait until late rainfall, they get rid of weeds, and if there is enough rainfall they decide to grow either wheat or barley.

In another study, Katkhuda and Yassin (1997) using past data, classified the factors causing low and variable wheat production into four main categories, environmental, technical, organizational and economic factors in Amman region of Jordan. One of the main factors is low and erratic rainfall, which, in many years, is not sufficient for crop requirement during the germination and flowering periods.

Ozsabuncuoglu (1998) estimated a function relating to wheat production in Southeastern Anatolia. Wheat production was taken to be a function of the planted area, temperature, and precipitation during the growing period and precipitation during the harvest season. For that purpose they used production and climate data for the 1963-1989 periods. It was found that additional millimeter of rainfall during the growing season would increase wheat production by 5500.2 metric tons. Rainfall during the harvesting season reduced the outputs by 34097.2 tons.

In another study *Austin et al.* (1998) found wheat and barley yields in the Ebro river valley in Spain to be strongly dependent on seasonal rainfall, particularly rainfall during November-January and March-May of the cropping season. Yields increased by 5.9 and 9.4 kg/ha for wheat and barley, respectively, per millimeters of extra rainfall during the entire cropping season.

Griffiths *et al.* (1999) predicted wheat output in Corrigin Shire in Western Australia using separate equations for yields and planted area. They pointed out that breaking rainfall into more than one part is likely to produce important variables influencing farmers' decision to plant wheat. Rainfall in the first three months in the season was included in the yield equation to represent the importance of rainfall during germination, growing and flowering-periods.

Emad *et al (2002)* estimated a function relating to wheat production in Irbid region of Jordan. Wheat production was taken to be a function of cultivated area of wheat, air temperature, the accumulated seasonal rainfall until the end of November, rainfall in December, rainfall in January, and the average monthly temperature during the growing season up to that time. For that purpose they used data for the 1970-1997 periods. In that study, it was found that additional one-millimeter of rainfall in December and January will increase wheat production by 120 and 111 tons, respectively. So the results suggest that the rainfall is very critical for wheat production in Jordan.

2.3 FERTILIZER INPUT AND WHEAT PRODUCTION

A positive relationship between fertilizer application and wheat production has been found in literature. The fertilizer application has positive relationship with the growth of the wheat plants. So farmers can have a good crop if they apply fertilizer on their crops in time and on proper time. As if the fertilizer has not been applied on time, it becomes difficult to achieve the desired outcomes.

Azhar et al (1972, 1974) regressed total wheat production in thousand tones on fertilizer among other variables using the data from 1962-63 to 1971-72 and found that fertilizer was the third most significant variable after area under the Mexi-Pak wheat and area under local varieties.

A study by Salam (1981) a comparative analysis of yield data indicates that tractor farms use higher amounts of chemical fertilizers on their wheat crop. A part of the gains in productivity may be attributed to a more balanced and higher use of fertilizers induced by tractorization. The impact of farm size and tube well irrigation on wheat productivity and fertilizer use among the sample farms was also analyzed. Interestingly enough the influence of these factors, either on fertilizer use or on productivity, turned out to be insignificant. Also the farms using phosphate fertilizers showed significantly higher wheat yield.

A study by Mukhtar and Mukhtar (1988) compared the Pakistani and Indian Punjabs on the basis of input use and productivity across farm sizes. They concluded that Empirical results indicate that tubewell intensity, fertilizer intensity of use of high-yielding varieties of seeds have a uniform pattern in Pakistani Punjab in a sense that role of these inputs in wheat production is same in all the areas. The small farms are using the lowest amount of these inputs, whereas in India, it is the small farms that have the highest intensities of these inputs. In Pakistani Punjab medium-sized farms tend to exhibit highest use of canal and tubewell water, fertilizer and high-yielding verities. The results indicate that in Pakistan the semi-elasticity of fertilizer, and hence, fertilizer productivity changes positively as more area is allocated from small to medium-sized, but at a higher level of fertilizer use this change tends to diminish and ultimately becomes negative. In Indian Punjab, on the other hand, the marginal product of fertilizer is highest for medium-sized farms and lowest for large farms,which tend to become more efficient while large farms become increasing inefficient in the use of fertilizer.

Another study by Mubarak (1990) specified a model to simultaneously estimate the price response, assuming interdependence among crops. The model is applied to estimate own and cross-price elasticities of five major crops in Pakistan, viz., wheat, cotton, rice, sugarcane, and maize based on the production and expected wholesale price data for the period 1957-86. The fertilizer-price elasticities are the higher for cash crops such as cotton, sugarcane, and rice, and are the lowest for food crops such as wheat. A 10 percent increase in fertilizer price will decrease the production of cash crops by about 3.5 percent, while the production of wheat will decrease by 2.5 percent. Maize is not responsive to fertilizer price. Long-run supply elasticities with respect to fertilizer price are the highest for cash crops, viz., rice, followed by cotton and sugarcane. Wheat has comparatively low fertilizer-price elasticity of supply. In general farmers are found to be responsive to output and fertilizer prices.

A study by Deolalikar and Vosti (1993) regressed total wheat production in thousand tones on fertilizer among other variables using the data from 1986 to 1989 found that an increase in the price of wheat might more than offset any decrease in total fertilizer use brought about by the removal of a price control on that important input.

Khan *et al (2003)* regressed total wheat production in thousand tones on fertilizer among other variables using the data from 1962-63 to 1971-72 and found that there exist positive relationship between fertilizer use and wheat production in Pakistan.

2.4 TRACTOR USE AND WHEAT PRODUCTION

A positive relationship between tractors use for the wheat crop and wheat production has been found in literature. The farms making use of tractors are capable of providing greater level of output level as compared to traditional farms growing crops with the help of bullocks.

Salam (1981) showed that wheat yields on tractor farms are significantly higher than those on bullock farms. It was also found that tractor farms use higher amounts of chemical fertilizers on their wheat crop. The results of production function analysis also confirm the significant contribution of tractorization in achieving higher what yields. As a general rule higher productivity obtains on tractor farms than on bullock farms. A part of the gains in productivity may be attributed to a more balanced and higher use of fertilizers induced y tractorization. This study also pointed to the employment-generating potential of tractorization: the use of hired labor on tractor farms tended to be relatively high. Production function analyzed also supported the findings that wheat productivity tends to be higher on tractor farms. The overall efficiency in wheat production, reflected in lower unit cost of wheat output, also appears to be grater on tractor farms than on bullock farms.

A study by Deolalikar and Vosti (1993) tried to investigate the demand for inputs and the supply of output in Pakistan. Harvested quantity of wheat was taken to be the function of tractors use among other inputs using the data from the year 1986 to 1989. The study found that increase in tractor use in response to a decrease in tractor hire rates would lead to a decrease in the quantity of hired and family male labor use and an increase in family female labor use.

2.5 LABOR AND WHEAT PRODUCTION

A study by Mushtaq Syed Hussain (1964) found that for un-irrigated wheat, gram and Jowar, constituting about 30 percent of the total cropped area in West Pakistan, there is no significant response to price changes. Pakistani farmers growing cash crops are quite responsive to price changes. The responsiveness in the case of subsistence crops is less; since farmers employ most of their land to produce rice or wheat for their own consumption, little land is left for making a choice among the various crops on the basis of relative prices.

Elasticities of wheat output with respect to different variables have also been found in literature. These elasticities show the change in wheat production due to a given change in a particular input. Qureshi (1974) found that the production elasticities with respect to rainfall during the sowing period are of the same magnitude in Jhelum, Cambellpur, and Rawalpindi districts of Punjab province of Pakistan. However, there are remarkable inter-district differences regarding the elasticities with respect to presowing and growing-period rainfall. Production is relatively more elastic wit respect to actual rainfall in inches during the pre-sowing period in Cambellpur and Jhelum than in Rawalpindi. Mubarak (1990) found little potential to enhance overall agricultural productivity by increasing the single crop price, since either the own-price elasticities were low or, otherwise, the negative cross-price effects on the production of other crops were high. The fertilizer-price elasticities are the higher for cash crops such as cotton, sugarcane, and rice, and are the lowest for food crops such as wheat. A 10 percent increase in fertilizer price will decrease the production of cash crops by about 3.5 percent, while the production of wheat will decrease by only 2.5 percent. Maize is not responsive to fertilizer price. All own-price elasticities are highly significant, except in the case of wheat, in which it is significant at the 20-percent level. The coefficients of lagged production are highly significant for all crops except maize. Long-run supply elasticities with respect to fertilizer price are the highest fro cash crops, viz., rice, followed b cotton and sugarcane. Wheat has comparatively low fertilizer-price elasticity of supply. Farmers are responsive to output and fertilizer prices. Short-run own-price elasticities of all the five major crops are significant. A price change in one crop affects the production of other crops in all of the three possible ways: competition, complementary, and unrelated. Food crops having relatively low own-price elasticities have little effect on the production of other crops. On the other hand, changes in the prices of cash crops, which have higher own-price elasticities, strongly affect the production o other crops. Technology is an important non-price factor that enhances crop production.

Salam (1981), Mukhtar and Mukhtar (1988), and Deolalikar and Vosti (1993) concluded that there exists positive relationship between labor force working for the production of wheat crop and wheat production

A study by Salam Abdul (1981) making a comparative analysis of yield data indicates that the use of hired labor on tractor farms tended to be relatively high as compared to the bullock farms.

A study by Mukhtar and Hamid (1988) compared the Pakistani and Indian Punjabs and found that labor intensity declines as the farm size increases. Productivity on small farms which use relatively higher amount of labor per unit of land. In both Punjabs, productive of labor is highest on medium-sized farms as they most likely combine the best mixture of input accessibility, better supervision of labor and land quality.

Another study by Ali Mubarak (1990) specified a model to estimate own and cross-price elasticities of five major crops in Pakistan, viz., wheat, cotton, rice, sugarcane, and maize based on the production and expected wholesale price data for the period 1957-86. The study found that the coefficients of lagged production are highly significant for all crops viz., wheat, cotton, rice and sugarcane except maize. The current production of these crops also depends on the past production level along with other variables.

Deolalikar and Vosti (1993) found that in wheat production increased use of tractors tends to lead to a decrease in the quantity of hired and family male labor used, and an increase in family female labor used.

2.6 WHEAT FORECASTS IN PAKISTAN

Azhar *et al* (1972, 1974), Iqbal *et al* (2005) forecasted the wheat production in Pakistan and then compared these forecasts to the actual production and then ultimately found the forecast errors. The forecast error is either positive or negative. A positive forecast error shows that actual wheat production is greater than predicted wheat output and wheat production is thus underestimated. On the other hand a negative forecast error indicates that wheat output is overestimated.

Azhar et al (1972) estimated a function relating to wheat production in the Punjab province of Pakistan. They regressed total wheat production on area under the Mexi-Pak wheat, area under local varieties, fertilizer and rainfall in the months of November, December and January, using the data for the 1962-63 to 1971-72 periods. They found that the observed and estimated values of output are very close to each other. The difference between the two values further reduces to insigficance if the estimated values are calculated on the basis of equations separately for irrigated districts and barani districts.

In a similar study, Azhar et al (1974) again made an attempt to forecast wheat production for 1973-74 on the basis of the same model as used in Azhar *et al.* (1972). For comparison, they also included a forecast for 1972-73 based on the model. The forecasting of wheat production involved the use of data at the disaggregated district level. The results showed that the prediction exceeded the final wheat estimate during 1972-73, but is less than wheat production target for 1973-74. The difference between the forecast and the final wheat estimate for 1972-73 is insignificant and may be ignored. The authors attributed the difference to the following factors. Firstly, target is fixed on the basis of the conditions in previous years, the assumed conditions, however, may vary as is the case of fertilizer application. Secondly, the accuracy of forecast may be tested by incorporating the fertilizer consumption data of 1972-73 instead of 1973-74, the use of this data will raise the forecast to 6.3 millions tons of wheat. Thirdly, it should be noted that the model does encompass the increased production of wheat resulting from greater acreage under wheat in the flood affected areas, but it does not consider the possible productivity increases in the flooded areas.

Another study was made by Iqbal *et al.* (2005) to forecast the area and production of wheat in Pakistan up to 2022 using last thirty years data of area and production of wheat for modeling purpose. The ARIMA model showed that production of wheat would be 29774.8 thousand tones in 2022. The scope of higher area and production lies in adequate availability of government policies regarding wheat cultivation in the country.

2.7 CONCLUSION

Various studies have focused on finding the impact of different inputs on the wheat production. The wheat forecasts have been made either for only one province or two but not for all the four provinces of Pakistan. Wheat forecasts that were made for individual provinces have history in 1970s A recent study by Iabal *et al.* (2005) provides wheat forecasts on aggregate level in Pakistan. So a study is needed that can provide update estimates of wheat forecast both for Pakistan as well as its four provinces and that can tell about the future trend in the production of wheat in next few years. That can tell what are the inputs that are crucial in the production of wheat in Pakistan as well as in its four provinces and what is their ranking in the determination of wheat production. It is in this context that the present study aims to propose a wheat forecast model for Pakistan.

Chapter 3

METHODOLOGY

3.1 INTRODUCTION

Macroeconomic policy makers are interested in knowing grain needs of population in the future years. If grain needs in future are expected to increase further than the growth of grain supplies, then they suggest the authorities to import food grains right now, so that the remedy starts before occurring of the disease. On the other hand, if they expect surplus on this side they suggest the authorities to find the markets for the export of their produce. Forecasting is an important exercise in time series analysis. So it has always been a key issue to forecast supply of food grains, especially prior to the harvesting time so that appropriate policy may be made regarding the import/export of food grains. These forecasts can be made by using any appropriate forecasting technique. Efforts have also been made to know about the inputs/factors, which are crucial in the determination of wheat production, and what is their order of ranking in the determination of wheat production.

One way to know about what inputs are crucial in the production of wheat output is to calculate elasticities of wheat output with respect to these inputs. Elasticity shows the percentage change in the dependent variable, say wheat output per hectare, due to one percent change in independent variable, say labor force per hectare employed for the wheat crop. These elasticities can be found by estimating a production function with an appropriate functional form. The reason for estimating a production function rather than a supply function is that production function shows how much output of a particular product can be produced for given amounts of the inputs assuming that the most efficient production methods are used. While supply function shows that supply of a particular commodity depends only on prices assuming other things as constant. To know about what inputs are crucial in the production of wheat output, we estimate Cobb-Douglas production using Generalized Least Squares methods, taking the dependent and independent variables in log form. The reason for taking the dependent and independent variables in log form is that by regressing the dependent variable in log form on the independent variable in log form directly provides us the elasticities of the dependent variable with respect to independent variable.

3.2 FRAMEWORK OF WHEAT FORECASTING

Log wheat output per hectare is assumed to be function of labor force per hectare, number of tractors per hectare, fertilizer use per hectare, rainfall in the months of November, December, January, February, March and April, weighted standard deviation of rainfall in the months of November, December, January, February and March, and lag wheat output per hectare. We use panel data for the four provinces of Pakistan from 1979 to 2006.

The coefficients that are obtained from estimating Cobb-Douglas production function by GLS method and that are elasticities in fact are important in two ways. On one side they tell us how much wheat output per hectare is influenced in percentage terms due to one percent change in the independent variable and on the other side these coefficients are used for finding predicted values of wheat output at province level and then on aggregate level. Forecasting performance is then checked by finding wheat forecast errors as well as percent errors for Pakistan and its four provinces for the period of 2005 and 2006. For forecasting purpose we need two important pieces of information. These are a) future value of inputs used in wheat production and b) the parameters (elasticities in our case) that link inputs to wheat output. The elasticity parameters are obtained from the estimated production function as mentioned above.

The future values of various inputs are obtained by estimating a separate Auto Regressive Integrated Moving Average (ARIMA) model for each input. Dynamic forecasts for the required forecasting period are then made using this model. This exercise is performed for each input and for each province separately using the time series data from 1979 to 2006.

For evaluating the ability of the model in forecasting wheat output the entire analysis is conducted using the time period 1979 to 2004 and making forecasts for the years 2005 and 2006. These forecasts are then compared with actual values of wheat output realized to assess the quality of forecasts.

In section 3.3, we present Cobb-Douglas Production Function and in section 3.4, we describe the Generalized Least Squares method. ARIMA model is presented in section 3.5. The Box-Jenkins (BJ) Methodology has been described in section 3.6.

3.3 COBB-DOUGLAS PRODUCTION FUNCTION

The Cobb-Douglas Production Function in its stochastic form may be expressed as

$$Y_i = ß1\, X_{2i}^{\beta 2} X_{3i}^{\beta 3} e^{ui} \qquad i = 1, 2, 3, \ldots\ldots\ldots\ldots n \qquad (3.1)$$

Where Y, X_2 and X_3 are the quantities of Output, Capital and Labor, u and e are stochastic disturbance term and base of natural logarithm, respectively. B_1 is the scale parameter and β_2 and β_3 are parameters that measure productivity of capital and labor. The function has positive and diminishing marginal products, is strictly quasi-concave and is homogeneous of degree β2+β3. In its original form, it is assumed that the production function is homogeneous of degree one that is it is subject to constant returns to scale and therefore β_2 and β_3 sum to one.

From, Equation (3.1) it is clear that the relationship between output and the two input is nonlinear. However, if we log-transform this model, we obtain;

$$ln\ Y_i = ln\ \beta_1 + \beta_2 ln\ X_{2i} + \beta_3 X_{3i} + u_i$$

$$= \beta_1 + \beta_2 ln\ X_{2i} + \beta_3 X_{3i} + u_i \qquad (3.2)$$

where ß1 = ln ß1

The Cobb-Douglas production function can be generalized to any number of inputs and for the production function of wheat we propose the following specification.

$$lnYt = \beta 1 + \beta_2 lnLt + \beta_3 Tt + \beta_4 lnFt + \beta_5 lnR1t + \beta_6 lnR2t + \beta_7 lnSRt + \beta_8 lnYt\text{-}1 + u_t \quad (3.3)$$

where Yt = Wheat output per hectare

Lt = Labor force per hectare

Tt = Number of tractor per hectare

Ft = Fertilizer use per hectare

$R1t$ = Weighted average of rainfall in the Months of November, December, January, February and March

$R2t$ = Weighted average of rainfall in the Month of April

SRt = Weighted standard deviation of rainfall in the Months of November, December, January, February, and March.

$Yt\text{-}1$ = Lag output per hectare

u = stochastic disturbance term

Although Cobb-Douglas production function has not been very common in empirical literature in the past two decades or so, it is still the most cited functional form. The reason is that Cobb-Douglas production function has played a vital role in some of the recent advancement in the literature. It is useful to analyze production relationship when the number of data points is not large enough to introduce flexibility in the relationship between inputs and output.

3.4 MODEL OF SEVERAL TIME SERIES; THE METHOD OF GENERALIZED LEAST SQUARES (GLS)

We have time series data from 1979 to 2006 for four provinces of Pakistan, namely Baluchistan, NWFP, Punjab, and Sindh. Ideally we would like to devisee the estimating scheme in such a manner that observations coming from populations with greater variability are given less weight than those coming from populations with smaller variability. Unfortunately, the usual OLS method does not follow this strategy and therefore does not make use of the 'information' contained in the unequal variability of the dependent variable. Thus OLS method assigns equal weight or importance to each observation. But a method of estimation, known as Generalized Least Squares (GLS), takes such information into account explicitly and is therefore capable of producing estimators that are asymptotically BLUE. That is:

$$Y_i^* = \beta_1^* X_i^* + \beta_2^* X_i^* + u_i^* \tag{3.4}$$

where the starred, or transformed, variables are the original variables divides by, variance) σ_i (using β_1^* and β_2^* to differentiating it from the OLS parameters $\beta\hat{1}$ and $\beta\hat{2}$).

where $\quad \text{var}\,(u_i^*) = \text{E}(u_i^*)^2 = \text{E}(\frac{ui}{\sigma_i})^2$

$$= \frac{1}{\sigma_i^2} E\,(u_i^2) \text{ since } \sigma_i^2 \text{ is known}$$

$$= \frac{1}{\sigma_i^2}(\sigma_i^2) \text{since} = \sigma_i^2$$

$$= 1$$

This is constant. That is, the variance of the transformed disturbance term u_i^* is now homoscedastic and we still are retaining other assumptions of the classical model. If we apply OLS to the transformed model, it will produce estimators that are now asymptotically BLUE.

The procedure of transforming the original variables in such a way that the transformed variables satisfy the assumptions of the classical model and then applying OLS to them is known as the method of Generalize Least Squares (GLS). In short, GLS is OLS on the transformed variables that satisfy the standard least-squares assumptions. Thus in GLS the weight assigned to each observation is inversely proportional to its σ_i that is, the observations coming from a population with larger σ_i will get relatively smaller weight and those from a population with smaller σ_i will get proportionately larger weight in minimizing the residual sum of squares. (see Gujrati (2003)).

3.5 AUTOREGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA) MODELS

Forecasting is an important part of econometric analysis, for some agents probably the most important. How do we forecast economic variables, such as GDP, inflation, exchange rates, stock prices, unemployment rates, and many other economic variables. Broadly speaking, there are five approaches to economic forecasting based on time series data. These are as Exponential Smoothing Methods, Single-equation Regression Models, Simultaneous-equation Regression Models, Vector auto-regression, and Autoregressive integrated moving average models (ARIMA). We use the last one i.e. ARIMA model.

The publication by Box and Jenkins (1974) ushered a new generation of forecasting tools. Popularly known as the Box-Jenkins (BJ) methodology, the emphasis of these methods is not on constructing single-equation or simultaneous-equation models but on analyzing the probabilistic, or stochastic, properties of economic time series on their own under the philosophy of letting the data speak for themselves. Unlike the regression models, in which Yt is explained by k regressor X1, X2, X3,.....,Xk, the BJ-type time series models allow Yt to be explained by past, or lagged, values of Y itself and stochastic error terms.

If a time series is stationary, we can model it in a variety of ways. Let Y_t represent the variable of interest at time t. if we model Y_t as

$$(Yt - \delta) = \alpha 1\ (Yt - 1 - \delta) + \mu t \qquad (3.5)$$

where δ is the mean of Y and where μ_t is an uncorrelated random error term with zero mean and constant variance σ^2 (i.e. it is white noise); then we say that Yt follows a first-order autoregressive, or AR (1), stochastic process. Here the value of Y at time t depends on its value in the previous time period and a random term; the Y values are expressed as deviations from their mean value. In other words, this model says that the forecast value of Y at time t is simply some proportion (=α1) of its value at time (t – 1) plus a random shock or disturbance at time t; again the Y values are expressed around their mean values. But if we consider the following model,

$$(Yt - \delta) = \alpha 1\ (Yt - 1 - \delta) + \alpha 2\ (Yt - 2 - \delta) + \mu t \qquad (3.6)$$

then we say that Yt follows a second-order autoregressive, or AR (2), process. That is, the value of Y at time t depends on its values in the previous two periods, Y values being expressed around their mean value δ.

In general, we can have

$$(Y_t - \delta) = \alpha 1\ (Y_t - 1 - \delta) + \alpha 2\ (Y_t - 2 - \delta) + \ldots + \alpha p\ (Y_t - p - \delta) + u_t \qquad (3.7)$$

in which case Y_t is a pth-order autoregressive, or AR (p), process. The AR process just discussed is not the only mechanism that may have generated Y. Suppose we model Y as follows:

$$Y_t = \mu + \beta_0 u_t + \beta 1 u_{t-1} \qquad (3.8)$$

where μ is a constant and u, as before, is the white noise stochastic error term. Here Y at time t is equal to a constant plus a moving average of the current and past error terms. Thus, in the present case, we say that Y follows a first-order moving average, or an MA (1), process. But if Y follows the expression

$$Y_t = \mu + \beta_0 u_t + \beta_1 u_{t-1} + \beta_2 u_{t-2} \qquad (3.9)$$

then it is an MA (2) process. More generally,

$$Y_t = \mu + \beta_0 u_t + \beta_1 u_{t-1} + \beta_2 u_{t-2} + \ldots + \beta_q u_{t-q} \qquad (3.10)$$

is an MA(q) process. In short, a moving average process is simply a linear combination of white noise error terms.

Of course, it is quite likely that Y has characteristics of both AR and MA processes and is, therefore, ARMA. Thus, *Yt* follows an ARMA (1, 1) process if it can be written as

$$Y_t = \theta + \alpha_1 Y_{t-1} + \beta_0 u_t + \beta_1 u_{t-1} \qquad (3.11)$$

In general, in an ARMA (p,q) process, there will be p autoregressive and q moving average terms.

The time series models are based on the assumption that the time series involved are (weakly) stationary. But we know that many economic time series are non-stationary that is they are integrated. If a time series is integrated of order1 $[i.e., it is I(1)]$, its first difference is I (0), that is, stationary. Similarly, if a time series is I (2), its second order difference is I (0). In general, if a time series is $I(d)$, after differencing it d times we obtain an I (0) series.

Therefore, if we have to difference a time series d times to make it stationary and then apply the ARMA (p, q) model to it, we say that the original time series is ARIMA (p, d, q), that is, it is an autoregressive integrated moving average time series, where p denotes the number of autoregressive terms, d the times the series has to be differenced before it becomes stationary, and q the number of moving average terms. Thus, an ARIMA (2,1,2) tie series has to be differenced once (d=1) before it becomes stationary and the (first-difference) stationary time series can be modeled as an ARMA(2,2) process, that is, it has two AR and two MA terms. Of course, if d=0 (i.e., a series is stationary to begin with), ARIMA (p, d=0) = ARMA (p, q). Note that an ARIMA (p, 0, 0) process means a purely AR (p) stationary process; an ARIMA (0, 0, q) means purely. MA (q) stationary process. Given the values of p, d, and q, one can tell what process is being modeled. The important point to note is that to use the Box-Jenkins methodology, we must have either a stationary time series or a time series that is stationary after one or more differencing. The reason for assuming stationarity can be explained as follows. The objective of Box-Jenkins (1976) is to identify and estimate a statistical model which can be interpreted as having generated the sample data. If this estimated model is then to be used for forecasting, we must assume that the features of this model are constant through time. Thus the simple reason for requiring stationary data is that any model which is inferred from these data can itself be interpreted as stationary or stable, therefore providing valid basis for forecasting. (see Gujrati (2003)).

3.6 The Box-Jenkins (BJ) Methodology

Looking at a time series, how does one know whether if follows a purely AR process (and if so, what is the value of p) or a purely MA process (and if so, what is the value of q) or an ARMA process (and if so, what are the values of p and q). The Box-Jenkins methodology comes in handy in answering the preceding question. The method consists of four steps.

First step is identification, that is, finding out the appropriate values of p, d, and q. The correlogram and partial correlogram aid in this task. The Second step is estimation. Having identified the appropriate p and q values, the next stage is to estimate the parameters of the autoregressive and moving average terms included in the model. Sometime this calculation can be done by simple least squares but sometimes we will have to resort to nonlinear (in parameters) estimation methods. This task is now routinely handled by several statistical packages.

The third step is diagnostic checking. Having chosen a particular ARIMA model, and having estimated its parameters, we next see whether the chosen model will do the job as well. This is why Box-Jenkins ARIMA modeling is more an art than a science; considerable skill is required to choose the right ARIMA model. One simple test of the chosen model is to see if the residuals estimated from this model are white noise; if they are, we can accept the particular fit; if not, we must start over again. Thus, the BJ methodology is an iterative process.

The fourth and last step is forecasting. One of the reasons for the popularity of the ARIMA modeling is its success in forecasting. In many cases, the forecast obtained by this method are more reliable than those obtained from the traditional econometric modeling, particularly for short-term forecasts. (see Gujrati (2003)).

CHAPTER 4

DATA AND ESTIMATION

4.1 INTRODUCTION

In this chapter, we describe data sources, variable construction and estimation procedure. In section 4.2, we state the data and data sources, while in section 4.3, we explain the variable construction. In section 4.4, we describe the estimation procedure.

4.2 DATA, ASSUMPTIONS AND VARIABLE CONSTRUCTION

4.2.1 Data

Annual data have been used for output (thousand tones), area under the wheat crop (thousand hectares), total number of tractors, consumption of fertilizer (nutrient tones), labor force in agriculture sector (million persons; both male and female) for Pakistan and its four provinces. Data on average monthly rainfall are taken for the months of November, December, January, February, March and April. The period of analysis is from 1979 to 2006.

4.2.2 DATA SOURCES

Annual data on wheat output and area under the wheat crop from 1979 to 2006 have been taken from the *Agricultural Statistics of Pakistan, Ministry of Food, Agriculture and Live-stock (MINFAL), Government of Pakistan.* While annual data on district wise wheat production for each province has been taken from district wise Agricultural statistics

2005-06, *Ministry of Food, Agriculture and Live-stock (MINFAL), Government of Pakistan.*

Annual data on total number of tractors in Pakistan from 1980 to 2006, have been taken from *World Development Indicators, World Bank, Washington D.C.* Province wise number of tractors has been taken from the *Census of Agricultural Machinery (1975, 1984, 1994 and 2004)*, and from *Census of Agriculture (1980, 1990 and 2000), Agriculture Census Organization (ACO), Federal Bureau of Statistics, Government of Pakistan.*

To calculate total labor force for the wheat crop, data on total population of Pakistan and its four provinces have been taken from *Economic Survey of Pakistan, Ministry of Finance, Government of Pakistan.* Labor force participation rates and percentages of persons employed in agriculture sector of Pakistan and its four provinces have been taken from *Labor Force Survey, Federal Bureau of Statistics, Government of Pakistan.*

Data on total fertilizer consumption have been taken from *Agricultural Statistics of Pakistan, Ministry of Food, Agriculture and Live-stock (MINFAL), Government of Pakistan.* Data on percentage consumption of fertilizer for the wheat crop (percent of total fertilizer consumption on all crops) have been taken from the *Fifth and Sixth Five Year Plans* and from *Fertilizer Use Survey, National Fertilizer Development Centre, Islamabad.*

Data on monthly average rainfall are taken from *Agricultural Statistics of Pakistan, Ministry of Food, Agriculture and Live-stock (MINFAL), Government of Pakistan.*

4.3 VARIABLES CONSTRUCTION

In this section, we describe the procedure for variable construction both for dependent as well as all included explanatory variables. The procedure for variable construction for each variable is as follows.

4.3.1 WHEAT OUTPUT PER HECTARE

Wheat output per hectare for each province is found by dividing total wheat output in thousand tones in each province by total acreage in thousand hectares. That is:

$$Yi = \frac{Qi}{Ai} \qquad (4.1)$$

where Yi is wheat yield in thousand tones in each province, Qi is wheat production in thousand tones, and A_i is area under the wheat crop in thousand hectares, respectively.

4.3.2 FERTILIZER PER HECTARE

To find the consumption of fertilizer for the wheat crop, first of all, province-wise total consumption of three types of fertilizers in thousand Nutrient Tones i.e. Nitrogen, Potash and Phosphate, on all the crops has been obtained. Then, their consumption for the wheat crop for each province is calculated according to the assumptions about its use during different Five Year Plans and according to the percentage, National Fertilizer Development Centre, Islamabad (NFDC) found through different Fertilizer Use Surveys during different time periods.

So, according to 5th Five Year Plan (1975-76 to 1982-83), consumption of fertilizer for the wheat crop for each province is assumed as 48% of total fertilizer consumption. Similarly, during 6th Five Year Plan (1983 to 1988), it is assumed as 50% of total fertilizer consumption for the wheat crop. Based on Fertilizer Use Survey of 1986-87 conducted by NFDC, consumption of fertilizer for the wheat crop is 47% of total fertilizer consumption. Based on Fertilizer Use Survey of 1992-93, consumption of fertilizer for the wheat crop is 44.6% of total fertilizer consumption for the period of 1996-97 and 1997-98. Consumption of fertilizer for the wheat crop is 45.36% of total fertilizer consumption based on NFDC's Fertilizer Use Survey of 1999-00. Similarly, consumption of fertilizer is 45.36% of total fertilizer consumption on all the crops, during the period of 1998-99 to 2003-04 based on Fertilizer Use Survey of 1999-00. Finally, consumption of fertilizer is 50% of total fertilizer consumption on all the crops, during the period of 2004-05 and after-wards based on Fertilizer Use Survey of January 2005.

4.3.3 WEIGHTED AVERAGE AND WEIGHTED STANDARD DEVIATION OF RAINFALL

We have used weighted average of rainfall and weighted standard deviation of rainfall as independent variables for each province. Wheat output in each province in any particular year: say in 2006, depends on the rainfall in the months of November and December of previous year (November and December 2005) and rainfall in the months of January to April of that particular year (January, February, March and April 2006). The procedure for calculating weighted average and weighted standard deviation of rainfall is as follows.

4.3.3.1 WEIGHTED AVERAGE OF RAINFALL

Initially, average monthly rainfall in millimeters for the months of November, December, January, February, March and April (total rainfall in a particular month divided by number of days in a month), for the available stations in each province has been taken. We have calculated weighted average of rainfall for the months of November, December, January, February, March and April and have used sum of weighted average of rainfall of the months of November, December, January, February and March as an explanatory variable. Weighted average of April has been used as a separate explanatory variable. Weighted average of rainfall is calculated with the following formula:

$$\text{Weighted Average of Rainfall in each month} = \sum_{i=1}^{N} \frac{R_i W_i}{Wi} \tag{4.2}$$

where N is number districts in each province, Ri and W_i is the rainfall in millimeters and wheat output in thousand tone of $_i$th district, respectively.

So while finding weighted average of rainfall in each month for each province, wheat output of each district in thousand tones (W_i) is multiplied with its own rainfall in millimeters or rainfall of nearest station (R_i) and then divided with its wheat output (W_i). Then all these terms for all the districts in each province are summed up to get the weighted average of rainfall in a particular month for each province. Thus, the district with more wheat output gets more weights and vice versa. The detail of wheat growing districts, stations having rainfall data, the stations that are used as a proxy, in each province are as follows.

According to District wise Agricultural Statistics of Pakistan 2005-06, wheat growing districts in the province of Punjab are Attock, Rawalpindi, Islamabad, Jhelum, Chakwal, Sargodha, Khushab, Mianwali, Bhakar, Toba Tek Singh, Faisalabad, Jhang, Gujrat, Mandi B. Din, Sialkot, Norowal, Gujranwala, Hafizabad, Sheikhpura, Lahore, Kasur, Okara, Sahiwal, Pakpatan, Multan, Lodhran, Khanewal, Vehari, Muzzafar Garh, Layyah, D.G. Khan, Rajanpur, Bahawalpur, Rahim Yar Khan and Bahawalnagar. The stations for which average monthly rainfall data is available are Rawalpindi, Jhelum, Sialkot, Lahore, Sargodha, Faisalabad, Multan and Bahawalpur.

For the wheat growing districts for which data on rainfall for that particular district are not available, the rainfall of nearest station (nearest in distance) having data on rainfall has been used as a proxy. It is not necessary that only the nearest station in that particular province is used as a proxy rather sometimes, if some district has nearest station in any other province, the data of that station has also been used as a proxy. The district that has their such location that one part of that district is nearest to one station and other part is nearer to another station, average of both stations has been used a proxy.

In the province of Punjab, data on average rainfall of Rawalpindi station has been used as a proxy for Attock and Chakwal; Sargodha for Khushab; D.I. Khan for Mianwali and Bhakar; Faisalabad for Toba Tek Singh, Jhang, Okara, Sahiwal and Pakpatan; Multan for Khanewal, Vehari, Muzzafar Garh, Layya and D. G. Khan; Bahawalpur for Lodhran, Bahawalnagar, Rajanpur and Rahim Yar Khan districts.

According to District wise Agricultural Statistics of Pakistan 2005-06, wheat growing districts in the province of Sindh are Khairpur, Ghotki, Sukkar, N. Feroze, Nawabshah, Jacobabad, Shikarpur, Larkana, Sanghar, Tharparkar, Mirpur Khas, Dadu, Hyderabad, Baddin, Thatta, and Karachi. The stations for which average monthly rainfall data is available are Jacobabad, Nawabshah, Hyderabad and Rohri.

In the province of Sindh, following stations that had available data on rainfall have been used as a proxy for the stations for whom data on rainfall are not available. Data on average rainfall of Rohri station have been used as a proxy for Khairpur, Ghotki, Sukkar, Shikarpur and Larkana; Nawabshah for N. Feroze, Sanghar and Dadu; Hyderabad for Mirpur Khas, Badin, Tharparkar and Thatta.

According to District wise Agricultural Statistics of Pakistan 2005-06 wheat growing districts in the province of N.W.F.P. are Peshawar, Charsada, Noshero, Mardan, Sawabi, Kohat, Hangu, Karak, Mansehra, Battgram, Abbotabad, Haripur, Kihistan, Malakand, Swat, Bunir, Shangla, Lower Dir, Upper Dir, Chitral, D.I. Khan, Tank, Bannun, Lakki Marwat, Mohman Agency, Khyber Agency, Kurrum Agency, Orakzai Agency, Bajour Agency, North Waziristan, South Waziristan, F. R. Peshawar, F. R. Kohat, F. R. Bannun and F. R. D. I. Khan. The stations for which average monthly rainfall data are available are Peshawar and Kohat. In the province of N.W.F.P, data on average rainfall of Peshawar station has been used as a proxy for the Charsada, Noshera, Mardan, Malakand, Shanglah, Swat, Bunir, Dir Lower, Dir Upper, Mohmand Agency, Bajour Agency, North Waziristan agency area and F.R. Peshawar; Kohat for Hangu, Karak, Bannu, Lakki

Marwat, Kurrum Agency and F.R. Bannu; Islamabad for Swabi, Mansehra, Battgram, Abbotabad, Haripur and Kohistan districts; Sargodha for D.I. Khan and F.R. D.I. Khan; Zhob that is the district of Baluchistan province for the Tank district and North Waziristan agency area, respectively. Average of Kohat and Peshawar stations has been used as a proxy for the Khyber and Orakzai Agency areas. Average of Peshawar and Kohat has been used for the Khyber agency as some of its areas are near to Peshawar and others are near to Kohat.

According to District wise *Agricultural Statistics of Pakistan 2005-06* wheat growing districts in the province of Baluchistan are Quetta, Pishin, Killa Abdullah, Chagai, Loralai, Musa Khail, Barkhan, Zhob, Killa Saifullah, Sibi, Ziarat, Kohlu, Dera Bughti, Nasirabad, Jaffarabad, Bolan, Jhal Magsi, Kalat, Mustang, Khuzdar, Awaran, Kharan, Lasbela, Turbat, Panjgoor and Gawadar. The stations for which average monthly rainfall data (average of maximum and minimum) are available are Quetta, Sibi, Zhob and Kalat. In the province of Baluchistan, data on average rainfall of Quetta station has been used as a proxy for Pishin, Killa Abdullah, Ziarat and Mastung; Zhob for the Musa Khail, Barkhan, Killa Saifullah districts; Kalat for the Chagi, Khuzdar, Awaran, Kharan, Lasbela, Turbat, Panjgoor and Gawadar districts; Jacobabad that is the district of the Sindh Province, for Dera Bughti, Jaffarabad, Naseerabad and Jhal Magsi districts.

4.3.3.2 WEIGHTED STANDARD DEVIATION OF RAINFALL

Weighted standard deviation for the months of November, December, January, February and March has been calculated for each province. First of all we have calculated weighted standard deviation of rainfall for these months mentioned above and then summed up to use it as an explanatory variable. Weighted standard deviation of rainfall for each month for each province has been calculated with the help of following formula.

$$\text{Weighted Standard Deviation of Rainfall} = \sqrt{\sum_{i}^{N} \frac{Wi(Xi - \overline{X})^2}{Wi}} \tag{4.3}$$

where W_i is the wheat production of $_i$th district in each province; X_i is the average rainfall of ith district and $\overline{X}$ is the mean of Weighted Average of Rainfall of each month.

4.3.4 TRACTORS PER HECTARE

Data on total number of tractors in Pakistan from 1980 to 2004 has been obtained from Word Development Indicators 2006. From Census of Agriculture Machinery and Census of Agriculture, conducted by Agriculture Census Organization (ACO), Federal Bureau of Statistics, we know the share of agricultural tractors in total tractors for each province. However, share of non-agricultural tractors in total tractors is very low. For example, according to Census of Agriculture Machinery 1975, in Pakistan non-agricultural tractors were only 1.55% of total numbers of tractors. So, all the tractors are assumed as agricultural tractors. Moreover, as wheat is the major crop of Rabi season, so we assume that all the tractors are assume being involved in activities related to wheat production. Census of Agriculture Machinery was conducted in the year 1975, 1984, 1994 and 2004 while Census of Agriculture was conducted in the year 1980, 1990, and 2000.

The number of agricultural tractors for the years that lie between these census years, have been obtained by finding the change from one census year to the other and then by manipulation. For example, according to Census of Agriculture Machinery 1984, total numbers of agricultural tractors in the province of Punjab were 127589 that are 81.1 % of total tractors in Pakistan and according to Census of Agriculture 1990, total numbers of agricultural tractors were 172359.4 that are 64.86 % of total tractors in Pakistan. For the years that lie between 1984 and 1990, numbers of agricultural tractors have been found by exponential interpolation of the share from 1984 to 1990. For example, the numbers of agricultural tractors for the year 1985 have been found with the help of following formula. 81.1*(64.86/81.1) ^ (1/6) and for 1986 the formula becomes 81.1*(64.86/81.1) ^2/6 and so on, where '*' and '^' indicate multiplication and power operation, respectively.

4.3.5 LABOR FORCE

Labor force for the production of Wheat crop has been calculated as follows.

First of all, figures on total population of Pakistan have been obtained from various issues of Economic Survey of Pakistan. Exact population figures for Pakistan and its four provinces were only available in the census years. These censuses were conducted in 1972, 1981 and 1998. Figures on Pakistan population for the years that lie between different censuses years, are obtained by exponential interpolation. From the population censuses conducted, we also know the population of each province. Thus, we can know how much population in percentage terms each province had in the census year.

The population figures for the years that lie between these census years have been obtained by finding the change in population in percentage terms from one census year to the other and then by manipulating for population percentages for the years that lie between the two censuses years. For example, in the census year of 1972 and 1981, total population of Pakistan was 65.31 million and 84.25 million, respectively. The population of Punjab province in 1972 was 37.61 million that is 57.58 percent of total population of Pakistan and in 1981 total population of Punjab province was 47.29 million that is 56.13 percent of Pakistan population. Similarly, population of the Sindh province in 1972 and 1981 was 14.15 and 19.02 million, respectively that is 21.67 and 22.58 percent, respectively. Population of NWFP province in 1972 and 1981 was 8.38 and 11.06 million, respectively that is 12.84 and 13.12 percent of Pakistan population, respectively. Population of Baluchistan province in 1972 and 1981 was 2.42 and 4.33 million, respectively that is 3.71 and 5.14 percent of Pakistan population, respectively. The manipulation for the population percentages for example, for Punjab province, for the 1973 is made with the following formula: 57.58*(56.13/57.58) ^ (1/9).

From the Labor Force Survey conducted by Federal Bureau of Statistics in different years, we know the total labor force participation rates (combined for males and females) for each province of Pakistan i.e. how much population of each province of Pakistan in percentage terms was working as labor. We also know from Labor Force Survey, the percentage of employed persons for each province for the agriculture sector. Federal Bureau of Statistics conducted these Labor Force Surveys in the following years: 1974, 1978, 1982, 1984, 1985, 1986, 1987, 1990, 1991, 1992, 1993, 1996, 1997, 1999, 2001, 2003 and 2005. First of all, total labor force has been found by using the participating rates for each province and then by using the percentage of employed persons in agriculture sector.

From, Agricultural Statistics of Pakistan published by Ministry of Food, Agriculture and Livestock (MINFAL), we know total cropped area as well as wheat area. As wheat is the main crop of Rabi season, so it is assumed that almost all the labor force in agriculture sector remains engaged in growing and looking after the wheat crop. Labor force for growing wheat crop has been obtained by finding the percentage of wheat area in total cropped area, and then by using this percentage, labor force for the wheat crop has been found. For example, in the year 2005-06, total cropped area (net area sown plus area sown more than once) for the Punjab, Sindh, NWFP and Baluchistan provinces, was 16410, 3465, 1940 and 901 thousand hectares while wheat area in 2005-06 for the Punjab, Sindh, NWFP and Baluchistan provinces, was 6483.4, 933.2, 721.3 and 310 thousand hectares that is 39.5, 26.93, 37.18 and 34.06 percent, respectively. On the other side, total labor force for the Punjab, Sindh, NWFP and Baluchistan provinces, was 13305.41, 4276.57, 2601.91 and 1330.18 thousands, respectively. By using the percentage that was obtained by total wheat area as a percentage of total cropped area, labor force engaged in growing and looking after the wheat crop in the Punjab, Sindh, NWFP and Baluchistan provinces in 2005-06,comes out to be 0.395*13305.41= 5256.81, 0.2693*4226.57=1151.77, 0.3718*2601.91=967.4 and 34.06*133.18=453.13 thousands, respectively. For 2006, the labor force participation rate and percentage of persons employed in agriculture are taken as that of 2005.

4.4 ESTIMATION PROCEDURE

4.4.1 ESTIMATION OF COBB-DOUGLAS PRODUCTION FUNCTION

We use the data from 1979 to 2006 for wheat output and acreage and from 1980 to 2006 for all other variables. The reason for one year back data for wheat output and acreage is that lag output per hectare is used as an explanatory variable. Equation (3.3) that represents Cobb-Douglas production function for each province of Pakistan i.e. Baluchistan, NWFP, Punjab and Sindh has been estimated by applying Iterative Generalized Least Squares (IGLS). As described in chapter 3, the dependent as well as all the included explanatory variables have been taken in Log terms. The procedure for estimation Cobb-Douglas Production Function with IGLS is as follows.

Log wheat output per hectare has been regressed on log labor force per hectare; tractors per hectare; fertilizer per hectare; sum of the weighted average of rainfall in the months of November, December, January February and March; weighted average of rainfall in the month of April; sum of the weighted standard deviation of rainfall in the months of November, December, January, February and March; , and lag output per hectare.

Thus the coefficients obtained by this estimation technique are elasitcities of dependent variable (Wheat Output per Hectare) with respect to each included explanatory variable, for each province except the intercept terms that indicate the variations in the level of output per hectare due to the differences in the climate, nature of soil, variation in the distribution of rainfall and the temperature etc in the four province of Pakistan. Initially, there are thirty two coefficients in total for all the four provinces (eight for each province). Wald Coefficient Test is then applied to find common coefficients. Using this test, we equate the coefficients of one particular variable, say fertilizer across provinces to each other and check whether null hypothesis is accepted or rejected on the basis of the probability values. As there are four provinces, so initially, there are four elasticities estimates of output with respect to this particular variable (one for each province). After applying the test and noting the probability values, we see whether the null hypothesis is rejected and what is the respective probability value. The coefficient of that variable is taken as common for which the null hypothesis is accepted and that has maximum probability value among the variables. For example, after noting the probability values and checking about null hypothesis rejection or acceptation, we note that null hypotheses for labor force per hectare and for some other variables are rejected but labor force per hectare variable has higher probability value than the other variables. So we write one coefficient, say C (1), (the common coefficient) in pace of four different coefficients, say C(1), C(2), C(3), and C(4) and re-estimate the model. We again apply Wald test and note the probability values for the remaining variables. Again, the coefficient of that particular variable is taken as common among the remaining ones for which null hypothesis is accepted with the maximum probability value. We keep on re-estimating the model, after taking the coefficients as common, one at a time until null hypotheses for all the remaining variables is rejected.

4.4.2 DETERMINING THE ORDER OF INTEGRATION OF THE SERIES

Like all the stochastic models, an ARIMA model is also applied to stationary series. The reason is that any attempt to estimate the model with a non-stationary series will produce biased estimates of the parameters of these models. Furthermore, since the estimates of the autocorrelation coefficients are downward biased, there is a great risk of making the false conclusion that the series is stationary with strong autocorrelation. Analysis of the stationary properties of a series is also called determining the order of integration.

A series is said to be stationary if its mean, variance and auto-covariances are constant over time, though the auto-covariances may vary with the lag length at which the current and past errors are related. An integrated process is a time series process that can be derived as a finite ordered integral of some stationary series. Or put in more simple terms and assuming discrete times, a series is called integrated process if it can be reduced to a stationary series after applying a finite number of differencing. Furthermore a series is called integrated process of order d if it can be reduced to a stationary series after differencing d times. It is trivial to note, for example, that all stationary series are integrated of order 0. The concept of integrated process is crucial for time series analysis because a non-integrated process is crucial for time series analysis because a non-integrate process is of little use for the estimation of stochastic models.

The order of integration can be determined by applying unit root tests. The most popular unit root test is called Dickey and Fuller (1979, 1981) test. To understand the test considers a simple stochastic process.

$$Y_t = \rho Y_{t-1} + \varepsilon_t \qquad (4.4)$$

where ε_t is a white noise process. If $\rho = 1$, the process is degenerates to a pure random walk, which is non-stationary, though integrated of order 1. In case $\rho > 1$, the process is non-integrated and hence it cannot be reduced to stationary process. Only in case $\rho < 1$ the series can be shown to be stationary. Since in the first two cases, the root of the equation lies outside the unit circle, the process is called the unit root process. Thus the first step of the test is to formulate the null hypothesis that a unit root exists, that is $\rho \geq 1$ against the alternative that unit root does not exist, that is $\rho < 1$. it is now well known that under the null hypothesis, the parameter ρ is downward biased and , therefore the conventional test based on t-stat can produce misleading conclusion. DF test is one-tailed t-test with appropriate adjustment in the critical t-values to adjust for the downward bias.

DF test is usually applied with three alternative specifications including (4.4). The second specification adds a drift parameter in 4.1 while the third one includes deterministic trend in addition to drift. The idea is to determine if the series becomes stationary after allowance for deterministic drift and/ or transformation of equation (4.4) and its counterpart for the other two transformations. The three specifications are

$$\Delta Y_t = \gamma Y_{t-1} + \varepsilon t \qquad (4.5)$$

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \varepsilon t \qquad (4.6)$$

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \beta_t + \varepsilon t \qquad (4.7)$$

where $\gamma = \rho - 1$

An augmented version of the test called Augmented Dickey-Fuller (ADF) test is based on a more general stochastic process, involving higher order lags. The corresponding three specifications considered are

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{j=2}^{p} \theta_j Y_{t-j} + \varepsilon_t \tag{4.8}$$

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \sum_{j=2}^{p} \theta_j Y_{t-j} + \varepsilon_t \tag{4.9}$$

$$\Delta Y_t = \alpha + \gamma Y_{t-1} \beta_t + \sum_{j=2}^{p} \theta Y_{t-j} + \varepsilon_t \tag{4.10}$$

For all the specifications (4.5) to (4.10) the null and alternative hypotheses are:

$H_0 : \gamma \geq 0$

$H_A : \gamma < 0$

The test is available in all the standard time series packages. The critical t-values are also supplied with the test results.

The typical first order round of the test is based on the original series. If the series turns out to be stationary, the task is complete. Otherwise, the test is applied on the first difference of the series. If the first difference is also non-stationary, the test is applied to the second difference and so on. Since most of the time series in economics and finance have stationary exponential growth in most cases, the first difference of natural log turns out to be stationary.

4.4.3 PROCEDURE FOR ARIMA MODELS ESTIMATION

4.4.3.1 DIAGNOSTICS, ESTIMATION AND FORECASTING

As described in chapter 3, the procedure for ARIMA models estimation involves four tasks. These tasks are: Identification, Estimation, Diagnostic checking and Forecasting.

The most appropriate route to the determination of ARIMA is based on Box and Jenkins (1976). The procedure, as explained in Green (2003) and Gujrati (2003), is based on a careful study of correlograms for the partial autocorrelation function (PACF), the autocorrelation function (ACF), and the resulting correlograms. In addition to the study of correlograms, various performance criteria such as Akaike Information Criterion (AIC) and Schwartz Bayesian Criteria (SBC) are also used to make choices when more than one specifications look equally good (See Green (2003) and Gujrati (2003)).

First step is to draw correlograms for the stationary series and make a tentative decision about the autoregressive and moving average terms on the basis of the shapes of ACF and PACF. The next step is to estimate the resulting ARIMA model and draw correlograms for the regression residuals. If some autocorrelation is still present, the ARIMA specification needs to be adjusted for re-estimation in the light of additional information. This step-wise procedure is continued until the regression residuals approximate white noise. To confirm that the residuals are white noise, Q-statistics is applied on the cumulative autocorrelation coefficients for sufficiently lengthy lags (see Gujrati (2003)) for Q-statistics). The diagnostic-estimation procedure is continued until Q-statistics for all meaningful lag lengths turns out to be insignificant.

The last step is to forecast the independent variables including acreage for the period 2005-06 and then for the period 2007-15. At first, we estimate ARIMA equations using the data from 1980 to 2004 and make forecasts for 2005-06. On the basis of these predicted coefficients along with the coefficients obtained from GLS estimation technique, forecast for wheat output per hectare is made for the years 2005 and 2006.

After finding a way for forecasting and assessing its quality, the full sample (1979 to 2006) is used to forecast wheat output for the period of 2007-15.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 INTROCUTION

In this chapter, we present the results and discussion that we find about wheat output for Pakistan and its four provinces. In section 5.2, we present the results of elasticities of wheat output with respect to each included explanatory variable. Specification of ARIMA models is presented in section 5.3. Forecast errors are reported in section 5.4. In section 5.5, we present future forecasts of wheat output for Pakistan and its four provinces for the period of 2007 to 2015. Actual wheat output as well predicted wheat output and its growth rate is shown in section 5.6 for the period of 2000 to 2015 out of which actual output is for the period of 2000 to 2004 and predicted output is for the period of 2007 to 2015. Wheat forecasts were made for the above mentioned period after finding a way for forecasting and assessing its quality through calculations of wheat forecast errors for the period of 2005-06.

5.2 RESULTS OF ELASTICITIES OF WHEAT OUTPUT

Table 5.1 shows elasticities of dependent variable (wheat output per hectare) with respect to independent variables. The results show that the values of intercept for the four provinces of Pakistan: Baluchistan, NWFP, Punjab and Sindh, are 1.4512, 1.3202, 1.4976 and 1.7504, respectively. These intercept values show why there are variations in the level of output per hectare in four provinces of Pakistan. The reason for these variations is the differences in the climate, nature of soil, variation in the distribution of rainfall and the temperature, etc in the four provinces. It is also apparent from the table that a one percent increase in labor force per hectare leads to 0.1095 percent increase in wheat output per hectare in all the four provinces of Pakistan. The results show that there is positive relationship between number of tractors in four provinces and wheat output per hectare. A one percent increase in the total number of tractors leads to 0.077 % increase in the wheat output per hectare.

Table 5.1 Elasticities of Wheat Output With Respect to Inputs

Variable	Baluchistan	NWFP	Punjab	Sindh
Intercept	1.4512 (2.66)*	1.3202 (2.47)**	1.4977 (2.62)*	1.7504 (3.15)*
Labor Force Per Hectare	0.1095 (2.41)**	0.1095 (2.41)**	0.1095 (2.41)**	0.1095 (2.41)**
Tractors Per Hectare	0.0776 (1.89)***	0.0776 (1.89)***	0.0776 (1.89)***	0.0776 (1.89)***
Fertilizer Use Per Hectare	0.0161 (0.39)	0.0161 (0.39)	0.0161 (0.39)	0.0161 (0.39)
Mean Rainfall in Nov. to Jan. & Mar.	0.0437 (4.32)*	0.0437 (4.32)*	0.0437 (4.32)*	0.0437 (4.32)*
Mean Rainfall in April	-0.2280 (-2.49)**	-0.2280 (-2.49)**	-0.2280 (-2.49)**	-0.2280 (-2.49)**
SD Rainfall in Nov. to Mar.	-0.0134 (-1.04)	-0.0134 (-1.04)	-0.0134 (-1.04)	-0.0134 (-1.04)
Lag Output Per Hectare	0.7405 (8.36)*	0.3709 (2.53)**	0.6664 (6.60)*	0.4936 (4.06)*
R-Squared	0.90			
Adjusted R-Squared	0.89			
Durban Watson	2.37			

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Similarly, a one percent increase in the application of fertilizer per hectare (sum of three types of fertilizer i.e. nitrogen, phosphate and potash) leads to 0.016 percent increase in wheat output per hectare in all the four provinces of Pakistan. However, this relationship is not statistically significant. A possible reason for this may be that farmers do not use fertilizer in time or they may not have a proper knowledge about the exact time of its application i.e. they may not know at what stage and in how much quantity, a particular type of fertilizer should be applied for a good crop. The results further show that one percent increase in rainfall (sum of average monthly rainfall in millimeters in five months: November, December, January, February and March) leads to an increase of 0.044 percent in wheat out put per hectare. While a one percent average monthly rainfall in the month of April during which harvesting as well as threshing take place, leads to a 0.23 percent decrease in wheat output per hectare.

The results also show that a one percent increase in the level of deviations, as measured by standard deviation in the rainfall in a particular district in the months of November, December, January, February and March leads to 0.013 % reduction in the wheat output per hectare in the four provinces. However, this relationship is not statistically significant. This means that it is the level of rainfall rather that its fluctuations that is more important in determining wheat output per hectare.

Finally, the results show that wheat output per hectare depends significantly on the output level in the previous time period (Lag output). There may be different reasons for this. Firstly, if the farmers enjoy good harvest this year, their income level increases and now they are in a position to spend more on the next crop as the income from one crop is used for the expenditures on the next one or two crops. If this is true, then due to investment on the wheat crop next year, the farmers are expected to enjoy a good wheat harvest next year. Secondly, it is possible that farmers spent more time in looking after the crop in the form of better irrigation by private sources and in the forms of application of pesticides for the control of weeds, etc. as they expect to receive high support price for their crop.

It is also apparent from the results that except the intercepts and lag output per hectare, all the other coefficients are common for all the four provinces. These show that all these variables have the same role in production of wheat in all the four provinces. The value of R-squared is 0.90 showing that 90 percent variation in the dependent variable is explained by included explanatory variables. The value of Durban Watson statistics is 2.37, which falls within acceptable limits.

5.3 RESULTS OF ARIMA MODELS

Following the procedure explained in chapter 4, first of all we determine the order of integration of stock prices. The application of ADF tests indicates that the dependent variable and included explanatory variables are non-stationary. Furthermore, the first differences of all the variables are stationary. In other words, all the variables are integrated of order one.

The future values of various inputs are obtained by estimating a separate Auto Regressive Integrated Moving Average (ARIMA) model for each input. Dynamic forecasts for the required forecasting period are then made using this model. This exercise is performed for each input and for each province separately once by using the time series data from 1979 to 2004 to get the future values of various inputs for the period of 2005-06 and then for the period 1979 to 2006 to make forecasts for the period of 2007-15. The reason for estimating the ARIMA model for various inputs for the smaller time periods is that we estimate the ARIMA model for various inputs using the data from 1979 to 2004 for the evaluation of the ability of the model in forecasting wheat output. These forecasts are then compared with actual values of wheat output realized to assess the quality of forecasts. After finding a way for forecasting and assessing its quality, the full sample (1979 to 2006) is used to forecast wheat output for the period of 2007-15.

The results of the parameter estimates of ARIMA model equations are shown in Tables 5.2 (a, b, c, and d) for the period of 1979 to 2004 and Tables 5.3 (a, b, c, and d) for the period of 1979 to 2006. We can see that out of 152 parameters, 114 are statistically significant. Further scrutiny establishes the fact that eighty parameters are significant at 1%, twenty-three parameters are significant at 5%, and eleven are significant at 10% level of significance. Thus the statistical performance of all the estimated models appears quite impressive.

The presence of autoregressive trends as shown by the ARIMA equation results imply that in about half of the cases (26 of 56) there exists a strong autoregressive process of order one, that is AR (1) process. This means that the turbulences experienced throughout the time period under consideration is significantly related to the occurrences in the previous period. The AR (1) process has been justified on the basis of geometric decline in the autocorrelation function (ACF). This means that the shocks in output per hectare experienced during a period have a rigid relationship with futures output. This effect declines in severity with the passage of time. We can also see that in the province of Sindh, AR (2) is present in the Weighted Standard Deviation of rainfall in the months of November to March in both periods i.e. in 1979-2004 and 1979-2006 periods.

The moving average (MA) or temporary disturbance terms are also present in most of the cases. The order of MA process determines the nature of one-off relationship between the current and past fluctuations in wheat output. For example, with MA (1) process a shock occurring in one period will have an effect on the wheat output per hectare in the next consecutive period. This shock is, however, eliminated from the system within one period. The results show that in 20 out of 56 cases experience an MA (1) process while in 14 out of 56 cases an MA (2) process exists.

The results also show that the dummy variable used in the acreage ARIMA equation for the province of Sindh and that represent some shock, is significant at one 1% level of significance. In 2000, wheat output in the province of Sindh declined from 1144.2 thousand tones to 810 thousand tones in 2001. So use of the dummy variable is justified.

The results show that intercepts of the estimated ARIMA equations are significant in 32 out of fifty six cases. Since intercept measures systematic component, it follows from a non-zero intercept that the average growth rate of a particular independent variable is not zero. Out of fifty-six intercepts estimates, ten have a negative sign and one (weighted standard deviation of rainfall in November to March, in the province of NWFP) is statistically significant implying that the average growth rate of a this independent variable is negative and significant. On the other hand, the estimates of the forty-six out of fifty-six intercepts are positive and thirty-one are statistically significant indicating that the average growth rate of these independent variables is positive and significant.

Table 5.2a Estimates of ARIMA Models for 1979-2004 (Baluchistan)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0292 (1.39)	-0.5368 (-3.05)*			2.11
Labor Force Per Hectare	0.0303 (1.68)***	-0.7509 (-5.20)*			1.87
Tractors Per Hectare	0.0623 (5.62)*				1.04
Fertilizer Use Per Hectare	0.0600 (14.70)*		-0.7367 (-5.60)*		2.14
Mean Rainfall in Nov. to Mar.	-0.0053 (-0.09)			-0.5480 (-2.92)*	2.07
Mean Rainfall in April	0.0009 (0.14)	-0.5517 (3.00)*			2.26
SD Rainfall in Nov. to Mar.	0.0012 (0.03)		-0.3267 (-1.58)	-0.5570 (-2.55)*	1.90

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.2b Estimates of ARIMA Models for 1979-2004 (NWFP)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0024 (0.29)		-0.0004 (-0.002)		1.99
Labor Force Per Hectare	0.0291 (2.55)**	-0.7939 (-5.29)*			1.95
Tractors Per Hectare	0.0525 (4.54)*				0.92
Fertilizer Use Per Hectare	0.0448 (13.26)*			-0.9791 (-9.05)*	2.50
Mean Rainfall in Nov. to Mar.	-0.0149 (-0.72)	-0.7566 (-5.10)*		-0.9072 (-11.03)*	1.83
Mean Rainfall in April	0.0041 (1.81)***		-0.9897 (-2673)*		1.70
SD Rainfall in Nov. to Mar.	-0.0010 (-0.07)		-0.9659 (-14.03)*		1.85

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.2c Estimates of ARIMA Models for 1979-2004 (Punjab)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0091 (6.04)*	-0.7886 (-5.76)*		0.9075 (-4.68)*	1.62
Labor Force Per Hectare	0.0268 (20.97)*	0.3250 (1.45)	-0.9509 (-17.28)*		1.97
Tractors Per Hectare	0.0659 (2.01)***	0.6320 (2.53)**			1.24
Fertilizer Use Per Hectare	0.0485 (2.75)**				2.40
Mean Rainfall in Nov. to Mar.	-0.0001 (-0.009)			-0.9791 (-8.07)*	1.83
Mean Rainfall in April	0.0065 (2.87)*		-0.9460 (-10.03)*		1.71
SD Rainfall in Nov. to Mar.	0.0134 (0.727)	-0.6349 (-3.67)*		-0.9392 (-11.40)*	2.01

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.2d Estimates of ARIMA Models for 1979-2004 (Sindh)

Variable	Intercept	AR (1)	AR (2)	MA (1)	MA (2)	Dummy	D.W
Acreage	0.0125 (2.12)**					-0.3571 (-11.87)*	1.78
Labor Force Per Hectare	0.0172 (1.69)***	-0.5928 (-3.29)*					1.60
Tractors Per Hectare	0.0483 (4.13)*						0.90
Fertilizer Use Per Hectare	0.0340 (13.55)*			-0.9324 -(14.99)*			1.27
Mean Rainfall in Nov. to Mar.	0.0040 (0.11)	-0.5046 (-2.62)**			-0.9537 (-23.87)*		2.02
Mean Rainfall in April	0.0013 (0.16)	-0.4767 (-2.499)**					2.23
SD Rainfall in Nov. to Mar.	-0.0007 (-0.07)	-0.4948 (-2.52)*	-0.6500 (-3.45)*	-0.9894 (-2164)*			1.76

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.3a Estimates of ARIMA Models for 1979-2006 (Balochistan)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0294 (1.25)	-0.5317 (-3.10)*			2.06
Labor Force Per Hectare	0.0296 (1.75)***	-0.7273 (-5.52)*			1.94
Tractors Per Hectare	0.0621 (6.10)*				1.63
Fertilizer Use Per Hectare	0.0599 (15.75)*		-0.7316 (-5.77)*		2.15
Mean Rainfall in Nov. to Mar.	-0.0182 (-0.28)			-0.4849 (-2.18)**	2.05
Mean Rainfall in April	0.0002 (0.03)	-0.5590 (-3.21)*			2.26
SD Rainfall in Nov. to Mar.	0.0147 (-0.37)		-0.6930 (-4.27)*		1.72

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.3b Estimates of ARIMA Models for 1979-2006 (NWFP)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0012 (0.16)				1.97
Labor Force Per Hectare	0.0256 (2.22)**	-0.7281 (-4.96)*			1.97
Tractors Per Hectare	0.0514 (4.83)*				1.47
Fertilizer Use Per Hectare	0.0447 (10.63)*			-0.9192 (-31.99)*	2.34
Mean Rainfall in Nov. to Mar.	-0.0101 (-0.53)	-0.8326 (-5.75)*		-0.8817 (-14.07)*	1.80
Mean Rainfall in April	0.0039 (1.68)***		-0.9538 (-12.05)*		1.70
SD Rainfall in Nov. to Mar.	-0.0820 (-2.58)**		-1.4956 (-4.97)*		1.73

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.3c Estimates of ARIMA Models for 1979-2006 (Punjab)

Variable	Intercept	AR (1)	MA (1)	MA (2)	D.W
Acreage	0.0092 (19.54)*	-0.8638 (-11.06)*		0.9796 (-4732)*	1.79
Labor Force Per Hectare	0.0256 (9.60)*	0.4346 (2.29)**	-1.76 (-4.78)*		2.44
Tractors Per Hectare	0.0522 (3.11)*	0.3302 (1.64)			2.13
Fertilizer Use Per Hectare	0.0533 (3.12)*				2.29
Mean Rainfall in Nov. to Mar.	-0.0033 (0.15)	0.2901 (1.55)	-0.9618 (-20.67)*		1.72
Mean Rainfall in April	0.0057 (0.57)		-0.9895 (-6.90)*		1.86
SD Rainfall in Nov. to Mar.	0.0043 (0.28)			-0.9377 (-23.27)*	1.88

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

Table 5.3d Estimates of ARIMA Models for 1979-2006 (Sindh)

Variable	Intercept	AR (1)	AR (2)	MA (1)	MA (2)	Dummy	D.W
Acreage	0.0138 (2.46)**					-0.3584 (-12.03)*	1.73
Labor Force Per Hectare	0.0171 (1.47)	-0.9321 (-7.64)*		0.5993 (2.28)**			1.97
Tractors Per Hectare	0.0470 (4.37)*						1.43
Fertilizer Use Per Hectare	0.0364 (10.54)*	0.3001 (1.32)		-0.9510 -(21.55)*			1.82
Mean Rainfall in Nov. to Mar.	0.0313 (0.65)	-0.4258 (-2.05)**			-0.8732 (-6.74)*		1.87
Mean Rainfall in April	0.0026 (2.06)***			-0.9895 (-4492)*			1.86
SD Rainfall in Nov. to Mar.	-0.0065 (0.42)	-0.4138 (-2.09)**	-0.7015 (-3.56)*	-0.91 (-6.56)*			1.59

*Note: t-values and p-values are in parentheses under the coefficients. * Significant at 1% level of significance. ** Significant at 5% level of significance. *** Significant at 10% level of significance.*

5.4 RESULTS OF FORECAST ERROR FOR PAKISTAN AND ITS FOUR PROVINCES

Table 5.4 (a, b, c, d, and e) shows results of predicted output, actual output, forecast error (the difference of actual and predicted output) and percent forecast error for Pakistan and its four provinces for 2005, 2006 and combined forecast error (average of 2005 and 2006 error) for 2005-06.

Table 5.4a Wheat Forecast and Forecast Error (2005-06) for Baluchistan

Years	Actual Output	Predicted Output	Forecast Error	Percent Forecast Error
2005	738.01	637.60	-100.41	-15.75
2006	715.01	649.90	-65.11	-10.02
2005-06	1453.02	1287.50	-165.52	-12.68

Table 5.4b Wheat Forecast and Forecast Error (2005-06) for NWFP

Years	Actual Output	Predicted Output	Forecast Error	Percent Forecast Error
2005	1070.84	1091.10	20.26	1.86
2006	1093.82	1100.60	6.78	0.62
2005-06	2164.66	2191.70	27.04	1.23

Table 5.4c Wheat Forecast and Forecast Error (2005-06) for Punjab

Years	Actual Output	Predicted Output	Forecast Error	Percent Forecast Error
2005	16730.01	17375.00	644.99	3.71
2006	17065.47	16776.00	-289.47	-1.73
2005-06	33795.48	34151.00	355.52	1.04

Table 5.4d Wheat Forecast and Forecast Error (2005-06) for Sindh

Years	Actual Output	Predicted Output	Forecast Error	Percent Forecast Error
2005	2243.21	2508.60	265.39	10.58
2006	2455.52	2750.30	294.78	10.72
2005-06	4698.73	5258.90	560.17	10.65

Table 5.4e Wheat Forecast and Forecast Error (2005-06) for Pakistan

Years	Actual Output	Predicted Output	Forecast Error	Percent Forecast Error
2005	21612.3	20782.07	-830.23	3.84
2006	21276.8	21329.82	53.02	-0.25
2005-06	42889.1	42111.89	-777.21	1.81

As is apparent from the results presented in Tables 5.4 (a, b, c, and d) forecast as well as percent forecast errors are positive for NWFP and Sindh provinces while negative for Baluchistan province for the years 2005 and 2006. Combined forecast error for the year 2005-06 is also positive for NWFP and Sindh provinces and negative for the Baluchistan province. Forecast error is negative in year 2006 and positive in year 2006 for Punjab province and for Pakistan. Combined forecast error for the period of 2005-06 is also positive for the Punjab province and for Pakistan. As forecast error is the difference between actual and predicted wheat output, a positive forecast error means that actual is greater than the predicted wheat output and wheat output is underestimated and vice versa.

5.5 WHEAT FORECASTS FOR PAKISTAN AND ITS FOUR PROVINCES FOR THE PERIOD OF 2007-15

After finding a way and basis for future forecasting and assessing its quality, forecasts for wheat output are made for Pakistan and its four provinces for the period of 2007 to 2015 and are reported in table 5.5.

As is apparent from the table that predicted wheat output has positive trend over the period of 2007 to 2015 for Pakistan and its four provinces.

Table 5.5 Wheat Forecasts for Pakistan and its four Provinces for the Period of 2007-15

Years / Province	2007	2008	2009	2010	2011	2012	2013	2014	2015
Baluchistan	734.3	764.8	833.1	874.4	927.9	971.8	1020.1	1065.2	1112.4
NWFP	1080.2	1094.9	1098.4	1117.1	1125.6	1143.7	1154.6	1171.9	1184.1
Punjab	16436.1	16432.9	16511.8	16731.9	16977	17305.8	17638.3	18025.7	18410.2
Sindh	2716.4	2707.1	2688.8	2747.1	2825.5	2855.1	2912.5	2992.2	3078.1
Pakistan	20967	20999.7	21132.1	21470.3	21856	22276.4	22725.4	23255	23784.9

5.6 GROWTH RATE OF TOTAL WHEAT OUTPUT FOR PAKISTAN AND ITS FOUR PROVINCES

Actual as well as predicted wheat output and its growth rate for the Pakistan and its four provinces for the period of 2000 to 2015 have been reported in table 5.6 and shown graphically in figure 5.1. Actual wheat output is reported for the period of 2000 to 2004. While using the ARIMA modeling, forecast has been made for the period of 2005-06 to find a forecasting way. After successfully finding a basis for forecasting and assessing its quality, future forecasts have been made for Pakistan and its four provinces for the period of 2007 to 2015, using the same techniques followed for 2005 and 2006. Then growth rate of wheat output is found for the whole period i.e. 2000 to 2015 for Pakistan and its four provinces and is shown in Table 5.6 and Figure 5.1 (a, b, c, d, and e).

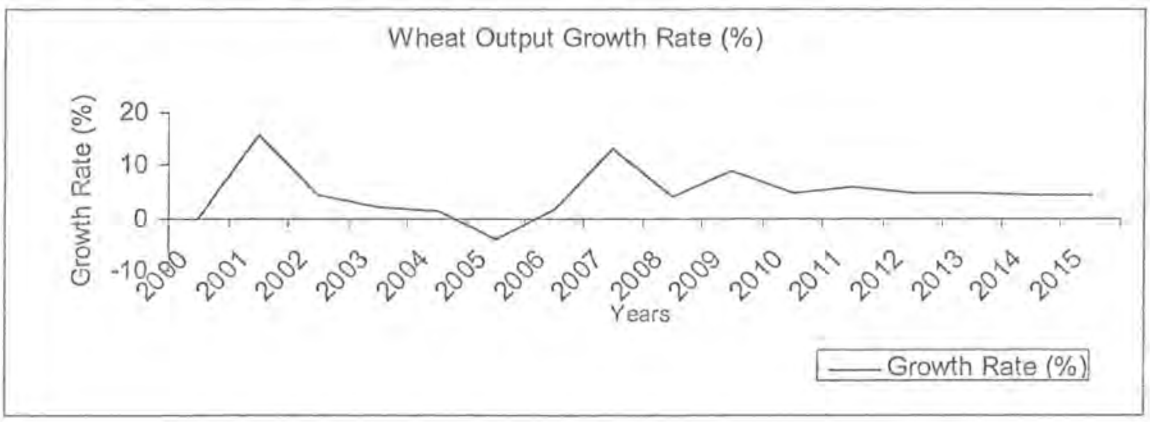
As is apparent from Table 5.6 and Figure 5.1a, growth rate of wheat output is positive ranging from 1.3 % in 2004 to 16 % in 2001 for the province of the Baluchistan for the whole period except in year 2005 when it is negative (-3.9 %). Figure 5.1b shows that wheat output growth rate is positive for the province of NWFP ranging from 0.3 % in 2009 to 19.5 % in 2003 and negative in years 2001, 2004, and 2007.

Table 5.6 Growth rate of Total Wheat output for the period of 2000-15(Actual as well as Predicted)

Years	Balochistan	Growth (%)	NWFP	Growth (%)	Punjab	Growth (%)	Sindh	Growth (%)	Pakistan	Growth (%)
2000	529.5	------	1067.8	------	16480.0	------	3001.3	------	21078.6	------
2001	614.2	16.0	764.0	-28.5	15419.0	-6.4	2226.5	-25.8	19023.7	-9.7
2002	640.6	4.3	890.5	16.6	14594.4	-5.3	2101.0	-5.6	18226.5	-4.2
2003	654.7	2.2	1064.4	19.5	15355.0	5.2	2109.2	0.4	19183.3	5.2
2004	663.4	1.3	1025.2	-3.7	15639.0	1.8	2172.2	3.0	19499.8	1.6
2005	637.6	-3.9	1091.1	6.4	17375.6	11.1	2508.6	15.5	20782.2	6.6
2006	649.9	1.9	1100.6	0.9	16776.0	-3.4	2750.3	9.6	21329.8	2.6
2007	734.3	13.0	1080.2	-1.9	16436.1	-2.0	2716.4	-1.2	20967.0	-1.7
2008	764.8	4.2	1094.9	1.4	16432.9	0.0	2707.1	-0.3	20999.7	0.2
2009	833.1	8.9	1098.4	0.3	16511.8	0.5	2688.8	-0.7	21132.1	0.6
2010	874.4	5.0	1117.1	1.7	16731.9	1.3	2747.1	2.2	21470.3	1.6
2011	927.9	6.1	1125.6	0.8	16977.0	1.5	2825.5	2.9	21856.0	1.8
2012	971.8	4.7	1143.7	1.6	17305.8	1.9	2855.1	1.0	22276.4	1.9
2013	1020.1	5.0	1154.6	1.0	17638.3	1.9	2912.5	2.0	22725.4	2.0
2014	1065.2	4.4	1171.9	1.5	18025.7	2.2	2992.2	2.7	23255.0	2.3
2015	1112.4	4.4	1184.1	1.0	18410.2	2.1	3078.1	2.9	23784.9	2.3

Similarly, growth rate of wheat output is negative in years 2001, 2002, 2006 and 2007 and positive for the remaining period, as is apparent from the Figure 5.1c growth rate of wheat output is also negative for the province of Sindh in 2001, 2002, 2007, 2008 and

Figure 5.1a Growth Rate of Wheat Output (Baluchistan)



2009 and is positive for remaining period as is apparent from the Figure 5.1d. As far as Pakistan is concerned, wheat output growth rate is positive and increasing over the time for it, except for the three years i.e. 2001, 2002 and 2007 when growth rate is negative.

Figure 5.1b Growth Rate of Wheat Output (NWFP)

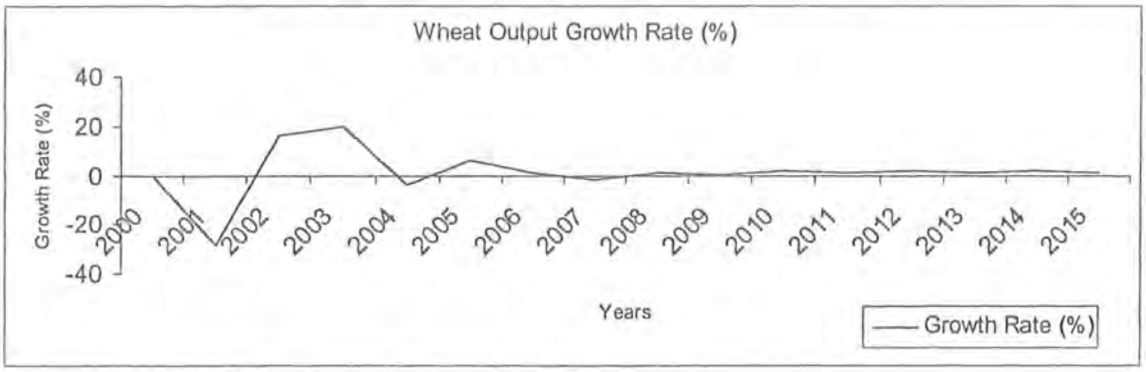


Figure 5.1c Growth Rate of Wheat Output (Punjab)

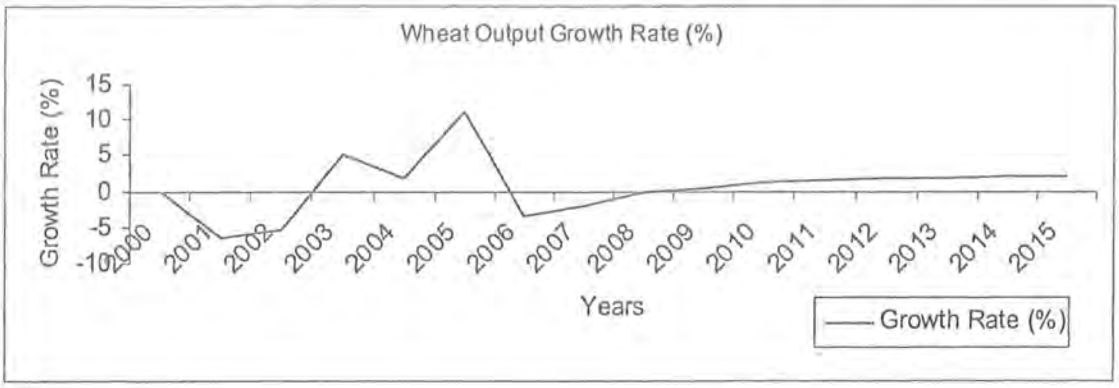


Figure 5.1d Growth Rate of Wheat Output (Sindh)

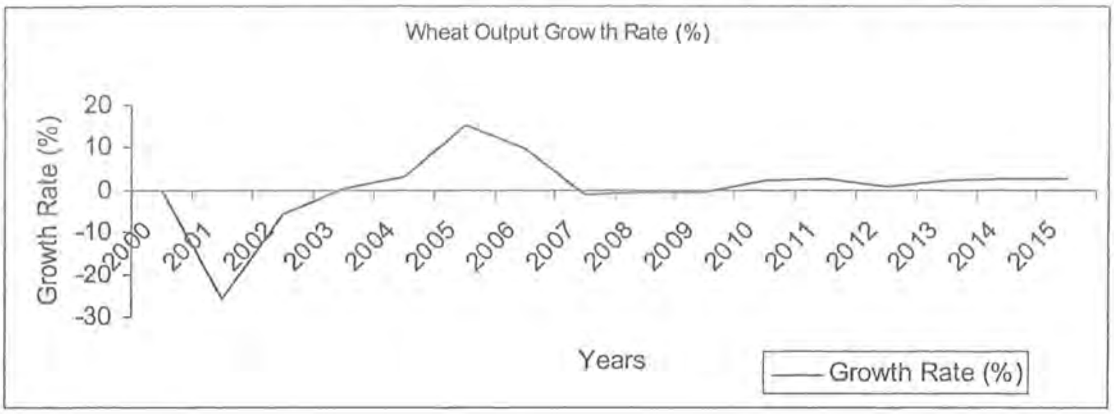
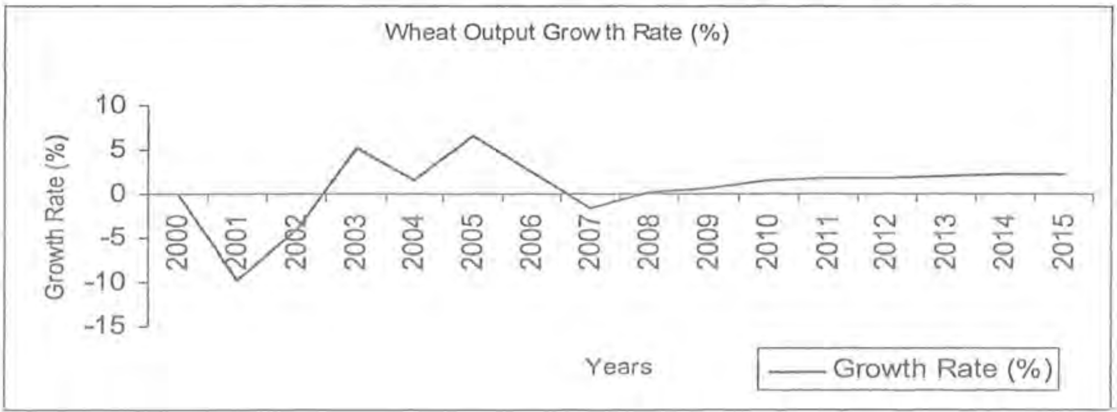


Figure 5.1e Growth Rate of Wheat Output (Pakistan)



CHAPTER 6

CONCLUSION

We conclude that Lag output per hectare is the most important factor in determining the current output per hectare, in all the four provinces of Pakistan. Moreover, the ranking of the lag output per hectare in the determination of the current output per hectare, first, second, third and fourth for Baluchistan, Punjab, Sindh and NWFP, respectively. Second and third important variables in ranking in the determining the current outputs per hectare are labor force per hectare and tractors per hectare, respectively in all the four provinces of Pakistan. Sum of the rainfall in the months of November, December, January, February and March is the fourth important variable in ranking in the determination of output per hectare. Among these four variables in ranking, three variables (Lag output per hectare, labor force per hectare and number of tractors per hectare) are the control variables in the sense that if in one year output level is high due to different factors like better agricultural policy, better support price policy that is about equal to market price, better marketing facilities etc, out put level will increase next year also as farmers' decision about the allocation of area for the wheat crop depends on last year's wheat crop experience i.e. experience about the price input prices like the fertilizer price, and marketing facilities. While the fourth one (sum of the rainfall in the months of November, December, January, February and March) is not the control variable. So we can conclude that wheat output level can be increased by providing the farmers subsidies in the prices of inputs, keeping the support price equal to the market price and that is equal to the world market price so that farmers may be induced to allocate more area under the wheat crop, providing them better marketing facilities etc.

Wheat forecasts have been made for Pakistan and its four provinces using the ARIMA forecasting models for the period of 2005 and 2006. Wheat forecasts errors are positive for the provinces of NWFP, Punjab and Sindh, and negative for the province of Baluchistan, in 2005. While in 2006, forecast errors are positive for the provinces of NWFP and Sindh, and negative for the provinces of Baluchistan and Punjab. It implies that in 2005, wheat output is underestimated for NWFP, Punjab and Sindh provinces and for overall Pakistan, and overestimated for the Baluchistan province. While in 2006, wheat output is underestimated for the Baluchistan and Punjab provinces and for overall Pakistan, and overestimated for the NWFP and Sindh provinces. As for as overall Pakistan is concerned, wheat output is underestimated and overestimated in 2005 and 2006, respectively. Combined forecast error for overall Pakistan, for the years of 2005 and 2006, is 1.81 which implies that on average, wheat output is underestimated for the years of 2005 and 2006.

Wheat forecasts have positive growth rate that are made for the period of 2007 to 2015, after finding a base and way for wheat forecasting for the period of 2005 and 2006. Moreover, this growth rate has an increasing trend most of the time, not only for overall Pakistan but for its four provinces also except for the years 2007, 2008 and 2009. In 2007, growth rate of total wheat output is negative for the provinces of NWFP and Punjab and for overall Pakistan while it is negative for the province of Sindh in 2008 and 2009.

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