Forecasting Wheat Production of Pakistan

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Abstract

This study analyzes future prospects of wheat production in Pakistan. For forecasting purpose we need future values of inputs used in wheat production and the parameters that link inputs to wheat output. The parameters are obtained by estimating Cobb-Douglas production function for wheat for each province of Pakistan. The future values of various inputs are obtained by estimating a separate ARIMA model for each input for each province and then making dynamic forecasts for the required forecasting period using the time series data from 1979-2006. Input forecasts and parameters of wheat production function are then used to generate wheat forecasts. Forecasting performance of the model is evaluated by finding wheat forecast errors and percent errors for 2005-06 by conducting the entire analysis and making forecasts for 2005-06, using the data from 1979-2004. The results of the study show that first, second, third, and fourth important inputs in ranking in wheat production per hectare are lag output per hectare, labor force per hectare, number of tractors per hectare, and sum of the rainfall in the months of November to March, respectively in all the four provinces. The results also show that the coefficients of labor force per hectare, tractors per hectare, per hectare fertilizer use, sum of the rainfall in the months of November to March, rainfall in the month of April and sum of the standard deviations of rainfall in the months of November to March are common for all the four provinces implying that all these variables have the same role in wheat production in all the four provinces. Forecasting performance of the model based on out-of-sample forecasts for 2005-06 period is highly satisfactory with 1.81 % mean absolute error. The future forecasts for the period of 2007-15 show steady growth of 1.6 %.

1. Introduction

Wheat is the main staple food for Pakistani people. During the past years some factors like the water shortage, increase in the prices of the inputs, extraordinary drought conditions etc. have affected the wheat crop, though in recent past Pakistan experienced good wheat crops. Due to the favorable conditions, it became possible to pile up healthy strategic stocks.

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 of the economy. Wheat cultivation has been suffering from various problems, such as shortage of irrigation water, low yields, traditional methods of farming, increase in the input prices, shortage of good quality key inputs and less use of modern technology in this sector. Pakistan has experienced ups and downs in wheat production. The negative relationship was observed between the flour prices and the wheat production. However, surplus of wheat production was observed only in few years. In such periods of times

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farmers suffered heavy losses due to inadequate marketing facilities in the country. Moreover, future prospects of the crops like prices, productions etc. are also not known by the farmers while allocating area for the crops. Same is the case of wheat crop. There is a dire need to forecast production as well wheat yield in Pakistan.

In different studies, Azhar et al (1972, 1974), Iqbal et al (2005) forecasted the wheat production in Pakistan. 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 for irrigated and barani districts. Azhar et al (1974) again made wheat production forecasts for 1973-74. For comparison, they also included a forecast for 1972-73. They used data at the disaggregated district level. The results showed that the prediction exceeded the final wheat estimate during 1972-73.

Another study was done 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.

Thus 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 updated 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.

The present study determines future prospects of wheat in Pakistan as well as in its four provinces using the past trends. The study makes wheat forecasts for Pakistan and for its four provinces for the period of 2005 and 2006 and compares them with actual production in this period. Thus the difference between the actual and predicted production is the wheat forecast error. A positive forecast error means that wheat production has been underestimated and vice versa.

The study tries to find a basis for future wheat forecasting and after finding a basis for forecasting, and makes forecasts for the period of 2007 to 2015. The study sees what will be the trend in wheat production in Pakistan as well as in its four provinces in the coming few years. Thus the study provides updated wheat forecast estimates for Pakistan as well as its four provinces.

The organization of the paper is as follows. In section 2, the methodology is presented. Data and estimation procedure are described in section 3. Results are presented in section 4. Finally, section 5 concludes the study.

2. METHODOLOGY

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. These elasticities can be found by estimating a production function with an appropriate functional form. To know about what inputs are crucial in the production of wheat output, the study estimates Cobb-Douglas production.

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.

The study proposes the following specification of production function.

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

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

The coefficients that are obtained from estimating Cobb-Douglas production function 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 the study needs 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 for each province. 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.

3. DATA AND ESTIMATION

3.1 Data

The study uses province level data for the period o1979 to 2006. Data on wheat output and area under the wheat crop are taken from the *Agricultural Statistics of Pakistan and* Area Production (By Districts), Ministry of Food, Agriculture and Live-stock (MINFAL), Government of Pakistan.

The data on total number of tractors in Pakistan from 1980 to 2006, have been taken from *World Development Indicators*, World Bank, Washington D.C. *Census of Agricultural Machinery (*1975, 1984, 1994 and 2004*)*, and *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, 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.

3.2 VARIABLES CONSTRUCTION

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.

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 nitrogen, potash and phosphate, on all the crops is 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.

Weighted Average of Rainfall

Initially, average monthly rainfall in millimeters for the months of November, December, January, February, March and April, for the available stations in each province has been taken. The 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:

Weighted Average of Rainfall in each month: $\overline{X} = \dfrac{\sum RiWi}{\sum Ri}$

where Ri and W_i are the rainfall in millimeters and wheat output in thousand tone in the district, respectively. Thus, the districts with more wheat output get 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 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 have also been used as 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.

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 rainfall data available 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.

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.

Finally, 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.

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 weighted standard deviations of rainfall for these are calculated months and then summed the resulting figures 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.

Weighted Standard Deviation of Rainfall: $S^2 = \sqrt{\frac{\sum Wi\left(Xi - \overline{X}\right)^2}{\sum Wi}}$

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, the share of agricultural tractors in total tractors for each province can be known. However, the 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 it is assumed that all the tractors are 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 exponential interpolation.

Labor Force per Hectare

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*. 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, the population of each province can also be known. Thus, the percentage of population in each province in the census year can be known. 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 interpolating for population percentages for the years that lie between the two censuses years.

From *the Labor Force Survey* conducted by Federal Bureau of Statistics in different years, the study knows the total labor force participation rates for each province of Pakistan. From *Labor Force Survey*, the percentage of employed persons for each province for the agriculture sector can be known. Federal Bureau of Statistics conducted these surveys in the years: 1974, 1978, 1982, 1984, 1985, 1986, 1987, 1990, 1991, 1992, 1993, 1996, 1997, 1999, 2001, 2003 and 2005. 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), the study knows 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.

3.3 ESTIMATION PROCEDURE

Equation is initially estimated for each province separately, yielding a total of 32 parameter estimates. Wald coefficient test is then applied to find common coefficients across provinces. The coefficient of that variable is taken as common for which the null hypothesis of equal coefficients is accepted and that has maximum probability value among the variables. The study again applies Wald test and notes the probability values for the remaining null hypotheses. 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. This procedure is continued until null hypotheses for all the remaining variables are rejected.

The study then estimates ARIMA equations for all the independent variables using the data from 1980 to 2004 and makes forecasts for 2005-06. On the basis of these predicted inputs along with the estimated coefficients of the production function, forecasts for wheat output per hectare are 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.

4. RESULTS

4.1 RESULTS OF ELASTICITIES OF WHEAT OUTPUT

Table 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 1.45, 1.32, 1.50 and 1.75, respectively. These intercept values show 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 0.11 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 0.078 % increase in the wheat output per hectare.

Table 1: Elasticities of Wheat Output With Respect to Inputs

Variable	Baluchistan	NWFP	Punjab	Sindh
Intercept	1.45 (2.66)*	1.32 (2.47)**	1.50 (2.62)*	1.75 (3.15)*
Labor Force Per Hectare	0.11 (2.41)**	0.11 (2.41)**	0.11 (2.41)**	0.11 (2.41)**
Tractors Per Hectare	0.078 (1.89)***	0.078 (1.89)***	0.078 (1.89)***	0.078 (1.89)***
Fertilizer Use Per Hectare	0.016 (0.39)	0.016 (0.39)	0.016 (0.39)	0.016 (0.39)
Mean Rainfall in Nov. to Jan. & Mar.	0.044 (4.32)*	0.044 (4.32)*	0.044 (4.32)*	0.044 (4.32)*
Mean Rainfall in April	-0.23 (-2.49)**	-0.230 (-2.49)**	-0.23 (-2.49)**	-0.23 (-2.49)**
SD Rainfall in Nov. to Mar.	-0.013 (-1.04)	-0.013 (-1.04)	-0.013 (-1.04)	-0.013 (-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 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 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: November to March period leads to an increase of 0.044 percent in wheat output 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 wheat output per hectare. 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 year. 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 etc. as they expect to receive high support price for their crop.

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

4.2 RESULTS OF ARIMA MODELS

First of all we determine the order of integration of all the variables. 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 2 (a, b, c, and d) for the period of 1979 to 2004 and Tables 3 (a, b, c, and d) for the period of 1979 to 2006. The study 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 implies 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. The study 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 for both the 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 represents 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.

It is also apparent from the results 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 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 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 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 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 3a: Estimates of ARIMA Models for 1979-2006 (Baluchistan)

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)	-0.560 (-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 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 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 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.*

4.3 RESULTS OF FORECAST ERRORS FOR PAKISTAN AND ITS FOUR PROVINCES

Table 4 (a, b, c, d, and e) shows results of predicted output, actual output, forecast error (the difference of actual and predicted output) in thousand tones 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. As is apparent from the results presented in the Tables 4 (a, b, c, d and e), forecast as well as percent forecast errors are positive for Baluchistan province, while negative for NWFP and Sindh provinces for the years 2005 and 2006. Combined forecast error for the year 2005-06 is also positive for Baluchistan province and negative for NWFP and Sindh provinces. Forecast error is negative in year 2005 and positive in year 2006 for Punjab province. Combined forecast error for the period 2005-06 for the Punjab provinces negative. As far as overall Pakistan is concerned, Forecast error is positive in year 2005 and negative in year 2006. Combined forecast error for the period 2005-06 for overall Pakistan is positive. As forecast error is the difference between actual and predicted wheat output, a positive forecast error means that actual wheat output is greater than its predicted value therefore wheat output is underestimated and vice versa. In any case the overall forecast error for Pakistan is small, therefore the model proposed and estimated in this paper has satisfactory performance.

Table 4a: Wheat Forecast and Forecast Errors in Thousand Tones (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 4b: Wheat Forecast and Forecast Errors in Thousand Tones (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 4c: Wheat Forecast and Forecast Errors in Thousand Tones (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 4d: Wheat Forecast and Forecast Errors in Thousand Tones (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 4e: Wheat Forecast and Forecast Errors in Thousand Tones (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

4.4 WHEAT FORECASTS 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. The predicted wheat output has positive trend over the period of 2007 to 2015 for Pakistan and its four provinces.

Table 5: Wheat Forecasts in Thousand Tones 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	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

Growth rate of actual as well as predicted wheat output for the Pakistan and its four provinces for the period of 2001 to 2015 are reported in table 6. The table shows actual annual growth rates for the period 2001 to 2006 and predicted growth rates for the period 2007 to 2015. As is apparent from the table 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 %). 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.

Similarly, growth rate of wheat output is negative in years 2001, 2002, 2006 & 2007 and positive for the remaining period for the province of Punjab. Wheat output is also negative for the province of Sindh in 2001, 2002, 2007, 2008 & 2009 and is positive for remaining period. As far as Pakistan is concerned, wheat output growth rate is positive except for the three years i.e. 2001, 2002 and 2007 when growth rate is negative.

Table 6: Growth rate of Total Wheat output for the period of 2000-15(Actual as well as Predicted)

Years	Baluchistan	NWFP	Punjab	Sindh	Pakistan
2001	16.0	-28.5	-6.4	-25.8	-9.7
2002	4.3	16.6	-5.3	-5.6	-4.2
2003	2.2	19.5	5.2	0.4	5.2
2004	1.3	-3.7	1.8	3.0	1.6
2005	-3.9	6.4	11.1	15.5	6.6
2006	1.9	0.9	-3.4	9.6	2.6
2007	13.0	-1.9	-2.0	-1.2	-1.7
2008	4.2	1.4	0.0	-0.3	0.2
2009	8.9	0.3	0.5	-0.7	0.6
2010	5.0	1.7	1.3	2.2	1.6
2011	6.1	0.8	1.5	2.9	1.8
2012	4.7	1.6	1.9	1.0	1.9
2013	5.0	1.0	1.9	2.0	2.0
2014	4.4	1.5	2.2	2.7	2.3
2015	4.4	1.0	2.1	2.9	2.3

5. CONCLUSION

The study concludes that lagged output per hectare is the most important factor in determining the current output per hectare in all the four provinces of Pakistan. The other two important variables in determining the current outputs are labor force per hectare and tractors per hectare. Sum of the rainfall in the months of November, December, January, February and March is another important variable in the determination of output.

Wheat forecasts have been made for Pakistan and its four provinces using the ARIMA forecasting models for all the inputs 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 slightly 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. 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.

The forecasts show that in the next eight years what output will on average grow at a rate of 1.6%, which is slightly less than the expected growth rage of population. So Pakistan is likely to see a slight shortfall in supply of wheat, which can be overcome by taking appropriate steps like better credit facilities to farmers to encourage them to adopt more advanced production activities.

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