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Estimation of Total Factor Productivity Growth of Major Grain Crops in Pakistan: 1972-2013

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Abstract

The present study has conducted to estimate the total factor productivity (TFP) growth of major grain crops in Pakistan for the period of 1972-2013 by using Tornqvist-Theil index methodology. Time series data of outputs and inputs was collected from different official published sources for the period of 1972-2013. The output index consist of wheat, rice and maize produces while, input index was constructed by using most of the conventional inputs. The results showed that TFP growth rate of major grain crops on an average was 1.90 percent per year during the study period (1972-2013). This study also estimated TFP growth during different time horizons. The results showed that TFP (4.65 percent) and output (6.69 percent) growth rate was highest during the decade of 90s and lowest during the last decade of the study period (-1.21 percent and 1.01 percent, respectively). The registered TFP growth rate was 2.60 percent and 1.56 percent during the decade of 70s and 80s, respectively. This study observed that weather conditions, different institutional and macro level factor are the major factor that affect the rate of TFP growth during the different study periods. It is recommended that in order to increase TFP growth rate huge public investments required in the area of extension, market, infrastructure and research.

Keywords: *TFP Growth, Tornqvist-Theil Index, Grain Crops, Output Index, Institutional.*

Introduction

Pakistan agriculture sector has been experiencing a transition due to the introduction of new farm technologies. In spite of this fact, the overall factor productivity of this sector remained low. The average annual growth rate of agriculture in Pakistan shows an unstable trend with highest positive agriculture growth rate of 15 percent in the year 1954-55 and the lowest negative agriculture growth rate of 9 percent in the year 1952-53. The significant growth in major crops is contributed by wheat, rice, cotton and sugarcane. This fluctuation in the growth rate of agriculture clearly throws its effects on the overall economy of the country (GOP, 2016). The growth in agriculture significantly contributes to the performance of the overall economy.

Most important grain crops in Pakistan are wheat, rice, and maize. These crops also consider as the staple food for most of the population. Wheat, rice, maize, millets, barley and sorghum are major grain crops that is cultivated in Pakistan. Average cultivated area under these grain crops is 13.32 million hectares per year during 2007-2015 and average production is 33.57 million tons (GOP, 2016). The present study concentrate on three major grain crops (wheat, rice, and maize) due to their great importance because these three crops accounted for 94 percent of the area under grain crops and have highest contribution in the annual production (98 percent) of all grain crops.

Pakistan is the largest producer of wheat that is accounted for 68.25 percent of the total production of grains and is cultivated on an average more than nine million hectares each year. Its average annual production was 24.87 million tons during the period of 2007-15. Rice is the second most important grain crop in Pakistan after wheat and average cultivated area under rice is 2.79 million hectare (21 percent of total grain crops area), while its average annual production was 6.50 million tons during the time period of 2007-15. Pakistan is the fifth world largest rice exporter (2.9 million tons) after Thailand, India, Vietnam, and the United States. Similarly, maize is the third most important grain crop in Pakistan after wheat and rice because its area has expanded to more than 1 million hectares, while its production has increased to an average 3.7 million tons during 2007-15. Hybrid maize seed revolutionized maize production in some irrigated districts of Punjab that is planted in the spring with yields averaging 8-9 tons per hectare. Due to this reason, maize contribution to food grains output has risen from 6.6 percent to 10.5 percent and maize share in the value addition by major grain crops also has been increased from 3.15 percent to 5.09 percent (GOP, 2016).

The most essential and prerequisites for economic development of the country is reducing poverty, hunger and food insecurity because both are mutually interact and reinforce each other in the process of development (Ali, 2008). The alarm bell on food security, mainly for the developing country has raised due to unexpected increase in the prices of food items during the first decade of 21st century. It is prerequisites for Pakistan to adopt a wide-ranging approach to increase efficiency of all foods rather than only focusing upon attaining just wheat based food security in order to make it food-secure and consistent growth in agricultural.

As in many other developing countries, Pakistan agriculture especially grain sector faces significant challenges in current century. Pakistan current population is more than 180 million, while growing at about 2.03 percent per year and is projected to be 4th largest country in the world by the year 2050 (GOP, 2010). With this continual population growth, diminishing supply of per capita available land, restrictions to more cultivated land expansion, reducing returns to more input growth and relatively high income elasticity of food in developing countries like Pakistan, there is growing need for food supply increases that could only originate from efficiency and productivity growth rather than increase in inputs (Ali, 2005). The main objective of Pakistan food security policy just like all other world nations is to ensure adequate food supply

at affordable prices. Although, availability of daily average calories is considerably lesser than other countries. The current requirement for grain crops in Pakistan is higher than its production. If population grows at an assumed rate of 1.82 percent per year, the country will remain a net importer of grain crops. The farmers are facing cost price squeeze. Thus, major grain crops are losing comparative advantage in the international market. Therefore, emphasis on grain crops productivity is imperative to secure the food security of small and marginal farmer (Ahmad and Farooq, 2010).

The total factor productivity (TFP) approach considered an appropriate tool to examine and understand the growth in major grain crops productivity and to separate out the effect of inputs and other factors like technology, infrastructure, and farmers' knowledge on grains productivity growth. Productivity growth is decompose into technical change and technical efficiency (Kalirajan et al., 1996). The upward shift in the frontier causes improvement in TFP as productivity increase with the same set of resources. This increase in productivity is due to the favorable policies such as timely availability of genuine inputs, effective implementation of on-farm water management program, proper seed development and its distribution, effective implementation of price support, favorable terms of trade and crop procurement. Similarly, the policies that promote the human capital, improve infrastructural development, ensure macroeconomic stability, facilitate openness of agricultural economy, increase credit resources and materialize the agricultural research and extension activities to its full potential increase productivity (Quddus et al., 2006).

Literature Review

Few studies had conducted in Pakistan, India and Bangladesh, which estimated TFP of individual crops and of agriculture sector. Baset *et al.* (2009) estimated TFP growth of modern variety of potato in Bangladesh was 1.5 percent per year. Pingali and Heisey (1999), Rosegrant and Evenson (1995), Hong *et al.* (2010) and Ali (2005) used gross output index. Ali (2008) also used gross output index. Similarly, it has used all the purchased inputs in constructing the input index. Ali and Byrelee (2000) addressed critical issues of long-term productivity of Pakistan's irrigated agriculture. They used data of only 16 irrigated districts of Punjab.

They estimated TFP of different agro-ecological zones, separately. The present study estimated TFP of major grain crops by using national level data. Some other studies like Khan (2006) identified macro determinants of TFP for the economy as a whole but the present study specifically did this job for major grain crops. Sabir and Ahmad (2003) estimated TFP of different sectors and confined it only to structural adjustment reforms program. Munir *et al.* (2012) calculated growth rate of agriculture productivity in Punjab by using Tornqvist-Theil index. Rice-wheat cropping zones have highest productivity growth as compared to other cropping zones per year.

Research Objective

The present study will fill this gap by estimating the TFP of individual grain crops in covering the recent period for which the required data was available. The present study differs from the previous ones noted above as it gave emphasis only on the major grain crops. The study in hand added to the existing estimates of productivity growth of major grain crops of Pakistan by establishing a consistent series of TFP index, output index and input index for the period 1972 to 2013. The major contribution of the present study in the estimation of total factor productivity of these crops is that it used major grain crops to construct output index. Thus, this provide the latest estimates and trends in total factor productivity growth of major grain crops (wheat, rice and maize) during different time period and also suggest some policy measures to improve and sustain productivity growth in the major grain crops.

Methodology

The present study estimate the productivity growth of grain crops in Pakistan for the period of 1972-2013. The Tornqvist-Theil (T-T) methodology to the Divisia index for TFP estimation employed in the present empirical work. This approximation used by (Chamber, 1988; Nadeem et al., 2010; Ali, 2008) and is expressed in the form of logarithm. Tornqvist-Theil total factor productivity index given as follow:

$$\ln\left(TFP_t / TFP_{t-1}\right) = \frac{1}{2}\sum_i \left(R_{it} + R_{it-1}\right)\ln\left(Y_{it} / Y_{it-1}\right) - \frac{1}{2}\sum_i \left(S_{jt} + S_{jt-1}\right)\ln\left(X_{jt} / X_{jt-1}\right)$$

Where,

R_{it} = shows the share of i-th output in total revenue
Y_{it} = shows the i-th output
S_{jt} = shows the j-th input share in total cost of input and
X_{jt} = shows j-th input in period t
The base year is 1972 and value of TFP index is equal to 100.

Data Description

Time series data was collected from different official published sources on output production and on the use inputs for the production of these major grain crops for the period of 1972-2013. The different official published sources are economic surveys of Pakistan, Agricultural Statistics of Pakistan, Agricultural Prices Institute, Islamabad, Labor Statistics Yearbook and Surveys of Labor Force and Federal Bureau of Statistics.

Output Index

The output series consist of consists of wheat, rice and maize, that aggregated into divisia output index for the estimation of total factor productivity growth of major grain crops. The production data of these crops included in the analysis collected from different official documents. The time series data on output was transfer in uniformed unit (thousand tones) for all categories for the purpose of analysis. The data of output prices for these grain crops from 1972-2013 were collected from different official published sources (Economic Surveys of Pakistan and Agricultural Statistics of Pakistan). The data for these years were on the producer/farm gate prices. The farm gate prices data of these outputs for early years were not easily available. Hence, the farm gate prices of early year had estimated from wholesale prices. It is presume that wholesale prices were 20 percent higher than farm gate prices. The producer prices were available for these output categories for a portion of the study period and these prices had taken directly without any further calculation (Ali, 2008). Similarly the identical unit of prices for these crops output series was formulated i.e. million rupees per thousand tones.

Input Index

The input index of grain crops constructed by using different categories of inputs such as pesticide use, fertilizer off take in terms of nitrogen, phosphorus and potash, land, labor and capital in term of tractor, drought animals and tubewells. The data series for input collected from different official published sources. Land as an input measure was use in the present study in the form of the cultivated area under major grain crops and their rent value is measure in Rs. /ha. The annual time series data on cultivated land of major grain crops was collected from different official published sources (Economic Surveys of Pakistan and

Agricultural Statistics of Pakistan). The data on rental prices of land was collected from different farm management surveys conducted by the government agencies and from various annual issues of support price policy of major crops conducted by Agricultural Prices Institute (API), Islamabad. The data on land input in the present study used in thousand hectares of the cultivated area under these crops and the land rent value taken in million rupees per thousand hectares. The labor also use as an input and an average of 250 working days in a year was used in previous study (Nadeem et al., 2012). More or less the same working days was use in the studies conducted at the locations, where similar agricultural conditions prevail. The data on daily wage rates was obtain from different official published sources (Labor Statistics Yearbook, Surveys of Labor Force and Federal Bureau of Statistics) and the original data was in rupees per day. Capital stock formation consist of number of tractors, tubewells (diesel and electric) and working animals. The capital stock estimated by using the perpetual inventory method and net annual addition and depreciation rate (10 percent) of stock also included (Ali, 2008). Time series data of tubewells installation cost, draught animal values and tractor prices were collected from different official published sources with 20 percent service flow per year (Ali, 2008), while for draught animal is 15 percent of the annual price. The amount of fertilizer used in this study is in the form of fertilizer off take (000N/ton) (nitrogen, phosphates and potassium) and data was collected Economic Surveys of Pakistan. The price data reported in Economic Surveys of Pakistan consisted of price in rupees per 50 Kg bag. The price of 50 Kg bag converted first into the price per tone of the relevant fertilizer and then into price/nutrient tone of the relevant nutrient from the given information of the percentage nutrients content of each marketed compound. These prices then transformed into million rupees per 000N/T (Nadeem et al., 2010).

In Pakistan 4 percent pesticide used in rice crop and 7 percent used in cereal crops of total pesticides consumption in Pakistan (GOP, 2016). The pesticide consumption in major grain crops is 10 percent on an average. The data on the import quantity of pesticides along with its value collected from different issues of Economic surveys of Pakistan.

Results and Discussion

Total Factor Productivity (TFP) Growth rate of Major Grain Crops in Pakistan: 1972-2013

This study use the Tornqvist-Theil index method to estimate the output, input and TFP index of major grain crops in Pakistan for the period of 1972-2013. To calculate the TFP index of major grain crops TFPIP version 1.0 software, developed by Tim Coelli (1996) was use. These estimated indices of grain crops are set at 100 for the base year, while the base year is 1972 and then these indices has been used to calculate the growth rates of major grain crops for the study period. The major concentration of this study is to estimate the movements in productivity growth rates in the study period and during different decades in Pakistan.

The average annual growth rates, calculated from these indices are presented in Table 1. The results clearly depicts the more volatility in the growth rates of all the series in the later part of the study period i.e. during 1995s and afterwards. The output, input and TFP growth rates showed somewhat consistent growth pattern during the early part of the study period. Table 1 showed that total factor productivity growth rate of major grain crops on an average was 1.90 percent per year during the study period (1972-2013). By viewing the results, it could be reported that total factor productivity growth was an important force in the growth performance of Pakistan's major grain crops during the last forty-two years. The results revealed that total factor productivity growth contributed 45 percent to major grain crops output growth in Pakistan. Output and input growth rate was on an average 4.2 percent and 3.48 percent during the study period. In 1987 and 1990 maximum annual TFP growth rate were 12.72 percent and 10 percent, respectively with negative input growth rate.

Supporting evidences for the results of this study can be gain from the study of Khan (1995) for Pakistan's agriculture with average estimated total factor productivity growth rate of 1.87 percent for the period 1980-1993 that was consistent with the finding of the present study. Ali (2008) estimated TFP growth rate of agriculture in Pakistan was 2.14 percent that was close to the estimated total factor productivity growth rate of major grain crops (1.90 percent). The results of the present study of TFP growth rate (1.90 percent) are in line with the estimated results obtained in most of the previous studies. However, some studies showed less total factor productivity growth rates. It may be due to different computational method and their early period of study in which the technological change (an important part of total factor productivity growth) was not growing as fast as it is today in developing countries.

Table 1: Annual Growth Rates (%) (Output, Input and TFP) of Major Grain Crops in Pakistan: 1972-2013

Year	Output	Input	TFP	Year	Output	Input	TFP
1973	12.27	-1.32	13.89	**1994**	0.90	9.51	-7.64
1974	-2.26	0.22	-2.44	**1995**	5.29	0.40	4.83
1975	-2.03	4.08	-5.83	**1996**	3.93	-1.32	5.26
1976	12.16	-2.48	15.04	**1997**	0.65	5.12	-4.38
1977	3.63	6.02	-2.31	**1998**	18.84	-3.01	22.88
1978	-1.26	4.72	-5.51	**1999**	13.31	9.95	2.66
1979	14.79	2.38	11.67	**2000**	11.11	-11.04	24.87
1980	5.25	5.61	0.00	**2001**	7.14	19.31	-9.96
1981	3.53	2.46	0.75	**2002**	3.73	-2.29	5.99
1982	1.01	0.48	0.74	**2003**	-11.57	9.44	-19.13
1983	7.81	3.52	4.41	**2004**	0.29	2.70	-2.15
1984	-9.63	2.28	-11.97	**2005**	4.35	2.11	2.20
1985	4.93	-0.19	5.60	**2006**	3.47	2.06	1.08
1986	10.75	2.04	8.33	**2007**	0.24	-1.32	1.60
1987	-6.36	-0.12	-6.29	**2008**	0.43	5.43	-4.71
1988	1.87	8.18	-5.97	**2009**	1.33	8.50	-6.59
1989	4.88	-6.66	12.70	**2010**	2.63	-1.35	4.12
1990	2.64	7.44	-4.93	**2011**	0.77	-3.85	4.52
1991	3.33	0.09	3.70	**2012**	8.14	1.42	7.03
1992	4.83	-4.76	10.00	**Average**	4.20	3.48	1.90
1993	2.01	-0.10	1.95				

Source: Author's own calculation

Table 2: Decades Wise Growth Rates (%) (Output, Input & TFP) of Major Grain Crops in Pakistan: 1972-2013

Time Horizon	Output	Input	TFP
Decade Wise Average Growth Rates			
1973-1980	4.71	2.22	2.60
1981-1990	2.51	1.18	1.56
1991-2000	6.69	2.65	4.65
2001-2012	1.01	2.51	-1.21

Source: Author's own calculation

The growth rates of output input and TFP in different time horizons (decade wise) presented in Table 2.

Total Factor Productivity (TFP) Growth Rate of Major Grain Crops: 1973-1980

Table 2 shows the decade wise growth rate of output, input and TFP for different time horizons. The results of table 2 shows that during first decade (1973-1980) of the study period the growth rates of TFP was 2.60 percent, while output and input was 4.71 percent, 2.22 percent and 2.60 percent, respectively. During this (70s), output growth rate was positive but it was due to higher growth in input as compared to TFP growth. The main reasons for this maximum growth in output were the increasing trend in labor force and cultivated area, four to eight times increase in the consumption of fertilizer and pesticides and doubling of the numbers of tubewells, tractors and draught animals during the period of 1973-1980. The low growth rate of TFP during 70s was also observed by Ali (2005), Ali (2008), Wizarat (1981) and Khan (1997), that was 0.93 percent, 0.96 percent, 0.57 percent and -0.1 percent, respectively.

Total Factor Productivity (TFP) Growth Rate of Major Grain Crops: 1981 to 1990

Table 2 also shows the output, input and TFP growth rates of major grain crops for the period of 1981-1990. The results showed that the growth rates of output, input and TFP were 2.51 percent, 1.18 percent, 1.56 percent, respectively and was low as compared to the decade of 70s. These results are in line with the previous studies Ali AND Byerlee (2000) and Ali (2008). The estimated growth rates for the decade of the 80s were positive for output, input as well as for total factor productivity of major grain crops. The growth rate in input use of major grain crops was low as compared to output growth and total factor productivity growth rates of these major grain crops. In this decade, government also announces favorable schemes to encourage farmers such as increase in the prices of wheat and rice before the time of sowing due to which total revenue from these crops increased. The large subsidy on major agriculture inputs i.e. fertilizers, tubewells installation and pesticides was the main reason of maximum input growth during this decade. Favorable climate, timely availability of inputs at subsidize rates to the farmers were the main factors of positive TFP growth rate during this decade (Ali, 2008).

Total Factor Productivity (TFP) Growth Rate of Major Grain Crops: 1991 to 2000

Table 2, shows that this decade (90s) had highest growth rates as compared to 70s and 80 decades. Sabir and Ahmad (2003) described the average annual growth rates of 1.2 percent in all factor inputs during the period 1988-2001. Thus, the results of the present study (growth rate of 2.65 percent in factor inputs) are in line with the results of this study. The 6.69 percent growth rate in output during the decade of the 90s though very high as compared to the growth rate of the previous decade. It means that total factor productivity contributed more in output growth in the decade of the 90s than the decade of the 70s and 80s. Different factors were responsible for high output growth in the 90s, as government favorable policies(export policy due to which rice and wheat played a leading role in foreign exchange incomes, removal of subsidy and increase in support prices) related to these crops. These results also in line with (Ali, 2005). During this time period favorable weather conditions was also play a significant role in the growth rate of output.

Total Factor Productivity (TFP) Growth Rate of Major Grain Crops: 2001 to 2012

Table 2 also shows the average annual growth rates of output, input and total factor productivity of these crops for the last decade (2000-2012) of the present study and were estimated 1.01 percent, 2.51 percent and -1.21 percent, respectively. The average annual growth in output and total factor productivity was very low and negative during these 12 years and the average annual growth in input use was high during the same time span as compared with the decade of 1990s. The results of the present study for these years are

not much different from the findings of this study. The differences in the findings were due to different output and factor inputs used in the construction of output and input indices. During this decade, high oil prices, food inflation, unavailability of important inputs required for these crops and more importantly unfavorable government policies related to these crops were the main reasons of low output, input and negative TFP growth rate during this decade.

Conclusions and Recommendations

Total Factor Productivity (TFP) of major grain crops showed fluctuating trend during the given period. The study showed the input intensification and limits to further expansion in cultivated land. On the other hand, demand for food is increasing day by day. Thus, the need of the time is that input use should be optimize and emphasis should given to improve the total factor productivity of major grain crops with the help of technology breakthrough and by efficient allocation of resource. The government should deliver continuous support to major grain crops on regular basis for sustainable TFP growth of major grain crops, in term of new technologies and favorable macroeconomic policies. This is particularly important for a country like Pakistan that is facing input scarcity, so optimum use of resources should be ensure through capacity building of the farming community. This will help Pakistan to save its precious resources keeping their resource availability intact.

Government should allocate more budgets to agriculture sector under different programs in order to enhance the productivity of major grain crops. When more resources are allocated to this sector then ultimately more resources are allocated to major grain crops in order to enhance the productivity of these major grain crops and more research and investment are made in this sector due to their utmost importance in Pakistan.

This study also recommended that credit should be provide to farmers in the shape of kind rather than cash to reduce the chances of its misutilization. Credit for mechanization in agriculture should be increase in order to capture its long-run impact on productivity. The field officers responsible for monitoring the activities of farmers should also be train and motivate to ensure proper utilization of resources. This will help in fetching fair returns from the utilization of credit thus leading to improvement in total factor productivity of major grain crops.

Government should take step to provide improved or quality seed of major grain crops by forcing seed certified firms to contract and provide seed to small farmers. Hence, this step increased the productivity of major grain crops of small farmers in Pakistan and small farmers easily adopt new technology. Impure seed distribution was common in Pakistan agricultural marketing system. Government should take step to check these markets regularly in order to enhance the availability of improved seed distribution at proper time in markets.

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