TOTAL FACTOR PRODUCTIVITY (TFP) GROWTH OF AGRICULTURE IN PAKISTAN: TRENDS IN DIFFERENT TIME HORIZONS

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The present study estimated total factor productivity (TFP) growth of agriculture sector of Pakistan for the period 1971-2006 by employing Tornqvist-Theil (T-T) index number methodology. Most of the conventional inputs were used in constructing the input index. The output index includes major crops, minor crops, important fruits and vegetables and four categories of livestock products. The study estimated TFP growth rates for different decades. The results showed that TFP growth rate was lowest during the decade of 70s (0.96 percent) and highest during the last six years of the study period (2.86 percent). The decade of 80s and 90s registered TFP growth rate of 2.24 percent and 2.46 percent, respectively. The results also explained that TFP growth contributed about 33 percent to total agricultural output growth during the decade of 70s and this contribution increased up to 83 percent during the last six years of the study period. The contribution of TFP growth to total agricultural output growth was 53 and 81 percent during the decades of 80s and 90s, respectively. The study observed that macro level government policies, institutional factors and weather conditions are the major key factors that influenced TFP growth.

Keywords: Tornqvist-Theil, TFP, input index, output index, agriculture, Pakistan

INTRODUCTION

Agricultural production can be increased from the increase in the use of inputs and from increase/improvement in the productivity (Rosegrant and Evenson, 1993; Collins and Bosworth, 1997). Under the first component of agricultural growth, land, labor, water, fertilizer and pesticide consumption are the basic physical inputs being employed in the agricultural production process in Pakistan. Growth rate in the use of these critical inputs is now slow as they have gained the potential level of their use (GOP, 2007). The second component of agricultural growth is the increase in productivity. Total factor productivity measures the amount of increase in total output not accounted for by increases in total inputs. The growth in TFP is the growth in total output less the growth in total inputs (Rosegrant and Evenson, 1992). Total Factor Productivity measures are sometimes used to compare productivity in different locations but mainly to compare productivity gains overtimes. The year to year specific TFP values may fluctuate; hence TFP Growth (TFPG) is best considered in terms of productivity trends over a period of time (Qum *et al.*, 1999). It is clear that growth in agricultural productivity can be viewed as essential condition or even pre-condition for growth in the rest of the economy.

Scarcity of resources has been recognized as a limiting factor in the process of economic growth. It is relevant to mention here that output expansion based on increased use of resources may be feasible but it cannot be sustainable. Therefore, productivity of resources becomes a critical factor in economic growth (Mongia and Sathaye, 1998). One of the path-breaking discoveries in economic history is that a large part of the increase in output cannot be explained by the traditional factors of production (Abramovitz, 1956; Solow, 1957).

Few studies have been conducted in Pakistan, which estimated TFP of agriculture sector and also of the economy as a whole. The pioneer study in this area is of Wizarat (1981) and the very recent study is of Ahmad and Bukhari (2007). The results of most of the studies revealed that the contribution of total factor productivity growth to agricultural output growth is more than 50 percent. The present study adds to the existing estimates of productivity growth of agriculture in Pakistan by establishing a steady series of TFP growth for the period 1971 to 2006. In Pakistan, due to problems in data availability, there have been only few studies so far as stated above and all of them except, Khan (1997) and Ali (2004) used the data on crop production, excluding livestock. As the livestock sub-sector contributes about 50 percent to agricultural growth, therefore, this sub-sector has also been included in the estimation of TFP of agriculture sector. The present study also contributed in this research area by including output data of some fruits, vegetables and of poultry meat for the first time, in constructing output index. The input data on wheat straw and concentrates were also included for the first time in constructing input index. There is no any official agency in Pakistan who maintain total factor productivity index for agriculture sector and there is

also no effective mechanism for monitoring changes in the efficiency of resource use and assessing the sustainability of various policy approaches. Thus, the study provides the latest estimates and trends in TFP growth during different time horizons which will shape up the policy options for sustainable productivity growth of agriculture.

The remainder of this paper is organized as follows. Section 2 provides methodological framework employed in the present study. Description of data and variable specification is explained in section 3. Section 4 presents the results of the study. Section 5 provides the conclusions and policy recommendations.

MATERIAL AND METHODS

Econometric approach, efficiency frontier approach and growth accounting / index number approach are the three major approaches being used in the literature to estimate total factor productivity (Sharma, 2004).

Arithmetic index is the simplest one among the index numbers, which is used to compute the input and output aggregates required for TFP estimation. As research progressed in this area, the Tornqvist-Theil (T-T) index number methodology has come to be viewed as an index that is exact for the linear homogeneous translog production function. The T-T index imposes no restrictions on the substitution possibilities between inputs as it entails fewer restrictions between the data and the TFP measure (Alston *et al.,* 1995). A practical advantage of the T-T Divisia Index is that it accounts for changes in the quality of inputs as it uses current factor prices in constructing the weights. This index number methodology provides consistent aggregation of output and input under the assumptions of competitive behavior, constant return to scale, Hicks-neutral technical change and output-input separability.

The present study measured the productivity change in Pakistan's agriculture as the difference between the rate of output change and the input rates of change, for the period 1971 to 2006. The formulation of (T-T) approximation to divisia index of (Chamber, 1988; Capalbo and Antle, 1988; Thirtle and Bottomley, 1992) is frequently used and applied in the present study. Expressed in logarithmic form, the Tornqvist-Thiel TFP index is given by as follow:

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

where R_{it} is the share of i-th output in total revenue, Y_{it} is output i, S_{jt} is the share of input j in total input cost, and X_{jt} is input j, all these in period t. In this specification, revenue shares for the output index and cost shares for the input index are updated every year. Specifying the index equal to 100 in the base year and accumulating the measures based on equation (1) provides the TFP index.

Data description

Annual time series data were collected for output produced and inputs used in the agricultural production process, for the period 1971 to 2006.

Data regarding output categories

Output series included in the TFP estimation of agriculture in the present study consisted of crop and livestock sub-sectors, as these two sub-sectors accounts for a lion's share (97 percent) of agricultural output. Fishing and forestry were not included in the analysis because of their insignificant share in the GDP. Output series for crop and livestock sub-sector included thirty three major and minor crops, fruits and vegetables and livestock products. Output series for livestock sub-sector included data on milk, beef and mutton. As poultry sector is also emerging as a major contributor to meet production, thus data on poultry meet were also included for the output series. The data on production of different categories of crop sub-sector were collected from various issues of Agricultural Statistics of Pakistan. Output data for milk, beef, mutton and poultry meat were collected from various issues of Economic Surveys of Pakistan (GOP, 2005).

The output price data for most of the crop and livestock categories from 1991-2006 were collected from the website of Food and Agriculture Organization (FAO). The price data regarding these output categories from 1971-1990 were collected from various issues of Agricultural Statistics of Pakistan. The price data for milk, beef, mutton and poultry meat were collected from various issues of Economic Surveys of Pakistan. As farm gate prices of output for most of the crop and livestock categories for some period of study were not easily available, thus, these were estimated from whole sale prices. It is assumed that farm gate prices were uniformly 20 percent lower than the whole sale prices. The same procedure is also being used by Federal Bureau of Statistics while calculating the farm gate prices from whole sale prices.

Data regarding input categories

Land, labor and capital (separately for tractors, diesel tube wells, electric tube wells and draught animals), fertilizer off-take (separately for nitrogen, phosphorus and potash), pesticide consumption, fodder, wheat

straw and concentrates are the input categories used in the construction of agricultural input index.

The annual time series of the cultivated land and labor input were collected from various issues of Economic Surveys of Pakistan. The service flow from land is measured in terms of annual rental value i.e. the value in rupees per hectare. Labor input is calculated by multiplying the number of agricultural laborers by the average annual workdays i.e. 250. The previous studies like Khan (1997), Evenson et. al, (1999) and Ali (2005) used 265, 244 and 250 annual workdays, respectively in their studies of TFP estimation of agriculture. Daily wage rates data have been obtained from various issues of Yearbook of Labor Statistics, and Labor Force Surveys, Federal Bureau of Statistics.

Measurement of capital stock in agriculture of Pakistan is at an elementary stage. In Pakistan various studies used different items for capital stock formation in agriculture. Wizarat (1981) used a composite index of capital that included land rent, capital cost of private and public tube wells, number of tractors and livestock. Ali (2005) has used tractors, tube wells and work animals in the main capital inputs into Pakistan's agriculture. In the present study, we included the number of tractors, number of tube wells (diesel and electric), and the number of draught animals in the capital stock formation. The perpetual inventory method was used to calculate the stock of tractors, tube wells and draught animals after taking into account the depreciation of the stock and net annual addition. The depreciation rate is assumed to be 10 percent, considering that a ten year life span is quite reasonable. The production data of these items were collected from various issues of Agricultural Statistics of Pakistan. The data on average price of tractors, average cost of tube wells installation and the value of draught animals were collected from various official sources and also from field information. The annual service flow for tractors and tube wells is assumed to be 20 percent of the value of the stock of these items. This includes the 10 percent rate of depreciation. For draught animals, the service flow was assumed 15 percent of the annual price series. The same figures have also been used by Khan (1997) and Ali (2005).

The pesticide consumption data was calculated from the value of import data by dividing the respective quantity. The imported quantities are determined on the basis of anticipated usage. Thus, quantities imported serve as a proxy for quantities actually consumed. Fodder and wheat straw productions are the important inputs used in the livestock sub-sector. The present study used the wheat straw data in the estimation of TFP for the first time. The oil seed cake (concentrate) is an essential input for livestock rearing. As the data on concentrates is not readily available in any official documents, so, it has been calculated from the data on cotton production.

RESULTS AND DISCUSSION

Output, input and total factor productivity (TFP) index of Pakistan's agriculture has been estimated for the period 1971 to 2006 by using Tornqvist-Theil (T-T) indexing methodology. The output and input indices are based on the output and input aggregators as defined in the equation (1). TFPIP version 1.0, a TFP index program, developed by Tim Coelli (1996) is used for calculation of TFP index. The estimated output, input and TFP indices are set at 100 for the base year i.e. 1971. The output, input and TFP growth rates of Pakistan's agriculture are calculated using the estimated indices. The study concentrates on the trends in TFP growth rates during different time horizons (decades) and the results are presented in Table 1.

Table 1. Decade wise average growth rates of agricultural output, input and TFP: 1971-2006

Period	Output Index	Input Index	TFP Index
1971-1980	2.88	1.90 (67)	0.96 (33)
1981-1990	4.23	1.94 (47)	2.24 (53)
1991-2000	3.02	1.32 (19)	2.46 (81)
2001-2006	3.46	0.59 (17)	2.86 (83)

The numbers in parenthesis in the third and last column are the percent contribution of inputs and productivity growth to agricultural output growth, respectively.

TFP growth of Pakistan's agriculture: 1970-71 to 1979-80

The results shows that the estimated TFP growth rates during 1970s was 0.96 percent and the growth rates in the aggregated input was 1.9 percent during the same period. While, the output growth rates between 1971-80 is observed to be 2.88 percent. The results explained the positive growth in agricultural output during the decade of 1970s, but it was more due to growth in input use than the TFP growth. The results reveal the contribution of only 33 percent of TFP growth to the agricultural output growth and the contribution of input growth was 67 percent during the decade of 70s. This can best be explained from the increasing trend in the use of inputs in the agricultural production process. Cultivated area increased from 16.6 million hectares in 1971 to 19.33 million hectares in 1980. Labor force also showed an increasing trend

from 10.58 million in 1971 to 13 million in 1980. The consumption of fertilizer and pesticide increased four to eight times during this decade. The numbers of tube wells, tractors and draught animals also increased more than double during this decade (GOP, 1982).

There were at least three sources of this poor performance in productivity growth of agriculture. First, the government undertook major institutional and structural reforms effecting agriculture adversely. Second, the external environment also affected agriculture adversely. The inflation reached a peak of 30 percent in 1974. Finally, crop output suffered due to drought conditions in 1970-72 and in 1974. There was also an unfavorable weather in the shape of heavy rains and accompanying floods in 1973-74. Due to these entire government disincentive policies, and bad weather conditions, productivity growth in agriculture could not sustained during the decade of 1970s and the major contribution in output growth devoted to increased usage of inputs.

Wizarat (1981) and Khan (1997) found slow productivity growth of only 0.57 percent and -0.1 percent, respectively in their studies during the decade of 1970s. Ali (2005) also observed lowest growth rates of TFP of 0.93 percent during 1971-75 and also lowest of 1.2 percent during the decade of 1970s.

TFP growth of Pakistan's agriculture: 1980-81 to 1989-90

The contribution of TFP growth to agricultural output growth is found to be 53 percent during the decade of 1980s. It shows an improvement in TFP growth rate of 2.24 percent from 0.96 percent of the previous decade. The results showed that the remaining 47 percent share in the output growth is attributed to the input growth. The disaggregated results for the decade of 80s clearly revealed the improvement in TFP growth rates which is highlighted from its contribution to output growth from 33 percent in 70s to 53 percent during the decade of 1980s. The result also showed a tremendous increase in the output growth rates from 2.88 percent to 4.23 percent. Ali (2005) estimated TFP growth of 2.24 percent for the period 1981-90 and 58 percent contribution of TFP growth to agricultural output growth. The results of the present study for the decade of 80s are in line with the results of the study of Ali (2005).

As we see that the estimated growth rates for the decade of 1980s are positive for output, input as well as for TFP growth. But the growth rate in input use was low as compared to output and TFP growth rates. The substantial increase in the contribution of TFP to output growth can best be explained by viewing the policies and other developments affected the agricultural growth during the decade of 1980s.

In 1980, a new policy framework for agriculture was announced. It aimed at expanding the role of market forces within the agriculture sector by increasing the domestic agricultural prices to bring them at par with world prices. The procurement/support prices of major crops were reviewed periodically and raised on the recommendations of agricultural prices commission (APCOM) (GOP, 1980). The government also opted of deregulation policy. The other evidences showed that during 5th Five-year plan (1979-83) and 6th Five-year plan (1984-88) periods, the agriculture sector grew at an average growth rate of 4.4 percent and 3.5 percent respectively. The production index for fiber crop (cotton) almost doubled with per hectare yield rising from 312 Kg/hectare to 615 Kg/hectare from 177-78 to 1990-91. That productivity response to cotton was largely due to technical change embodied in the improved varieties of cotton seed and increased efficiency in other complementary inputs. The results of high investments in seventies were visible in eighties with the average agricultural growth rate of 5.4 percent during this decade.

The livestock sub-sector grew at an average annual rate of 5 percent during 1980s. This achievement was remarkable with comparison of no growth in the period of 1970s. While analyzing the decade of 1980s, and viewing the role of productivity growth, we see that food grain production also increased tremendously during 1978-88. The contribution of TFP growth to agricultural output growth was also favored due to favorable weather, adequate availability of key inputs which increased the efficiency of their use, combined with policy changes for stability in the crop price structure.

TFP growth of Pakistan's agriculture: 1990-91 to 1999-2000

The TFP growth contributed about 81 percent to agricultural output growth during the decade of 1990s. The Table reveals the growth rates of 3.02 percent, 1.32 percent and 2.46 percent in output, aggregated factor inputs and TFP of agriculture during the period 1991 to 2000, respectively.

The growth rates in factor inputs in agriculture were not high compared to other sectors during the reform period that includes the years of 1990s (Sabir and Ahmad, 2003). Agriculture sector showed a declining trend in growth of factor inputs during macroeconomic reform period. On the other hand growth in output in agriculture was high (3.9 percent) in reform period. Thus the growth of TFP played a substantial part in explaining the pattern of growth in agriculture during

the decade of 90s. The study of Sabir and Ahmad (2003) also showed the growth in TFP during the period 1988-2001 of 2.6 percent and it contributed about 68 percent towards economic growth, supporting the findings of the present study for this sub-period. One of the explanations regarding this phenomenon is that during the decade of 90s, the government abolished fertilizer subsidy and as a result of high prices, efficiency increased in fertilizer consumption, which lead to increase in TFP. The improvement in agricultural incentives, reflected in the upward trends in terms of trade and support prices of major crops, have been the significant factors in evoking the high productivity growth during this period.

Different factors were responsible for low output growth (3.02 percent) during 90s, as attack of (CLCV) cotton leaf curl virus on important major crop of cotton, floods in the early nineties and drought conditions in the late nineties. The major contributor to this growth is the livestock sector which administered a high growth rate of 11.2 percent in 1995-96 (GOP, 1997). To some extent the discrimination against agriculture has been gradually declined due to reforms in trade policy and adjustments in nominal and real exchange rates. This improving incentive regime for the farmers has been a significant factor in the sustained productivity response of agriculture during the decade of 90s.

TFP growth of Pakistan's agriculture: 2000-01 to 2005-06

The average annual growth rates of output, input and TFP of agriculture sector for the last six years of the present study were estimated to be 3.46 percent, 0.59 percent and 2.86 percent, respectively. The average annual growth in output and TFP was high during these six years and the average annual growth in input use was low during the same time span compared with the decade of 1990s. TFP was emerged as a major contributor by contributing about 83 percent to agricultural output growth in the first six years of the 21st century. The results of the study of Ahmad and Bukhari (2007) showed average TFP growth of 2.8 percent for the period 2003-06.

As we see that the growth rate in the production of major crops which accounted for by 37 percent of agricultural value added, was well off during the first six years of the 21st century. The wheat production increased from 19 million tones in the year 2000-01 to 21.3 million tones in the year 2005-06. Similarly, rice, cotton and maize production touched the figures of 5.5, 2.2 and 3.1 million tones from 4.8, 1.8 and 1.6 million tones, respectively during the same time period. On the other hand, the growth in input use was not high during these six years. The increase in the cultivated area was only from 2.2 to 2.3 million hectare, and the labor force showed an increase from 1.80 to 1.86 million. The growth in fertilizer and pesticide consumption also moderate in the same time span. Fodder consumption remained stagnant during this period. The year 2004-05 was good for agriculture, in which unprecedented rise in cotton crop and a near bumper wheat crop on account of widespread and timely winter rainfall as well as increase in it's support price, agriculture surpassed it's target of 4 percent for this year by a wide margin and registered an impressive growth of 7.5 percent. Some contribution to agriculture growth also came from rice production, which grew by 2.7 percent in 2004-05. This entire picture clearly depicted the good performance in the growth rate of agricultural TFP and its contribution to agricultural output growth.

CONCLUSIONS AND RECOMMENDATIONS

The present study concluded that average annual TFP growth rate of Pakistan's agriculture was highest (2.86 percent) during the last six years of the present study and lowest (0.96 percent) during the decade of 70s. The decade of 80s and 90s registered average TFP growth rate of 2.24 and 2.46 percent, respectively. The contribution of TFP growth to agricultural output growth was 33, 53, 81 and 83 percent during the decade of 70s, 80s, 90s and for the last six years of the study period, respectively. The results explained that the contribution of input was not significant except for the decade of 70s and it was the TFP that derived growth in agriculture sector.

The study viewed the historical background of Pakistan's agriculture during the different decades in order to find out the possible reasons and explanations which were responsible for the changes in productivity growth rates of agriculture. On the basis of analysis of estimated TFP results, government interventions and developments in agriculture sector, the policy recommendations have been made to improve TFP growth rate.

The study observed that the change in the rate of TFP growth during the different study periods was due to changes in different macroeconomic factors, institutional factors and weather conditions. The results highly recommend the huge public investments in infrastructure, markets, research and extension in order to increase TFP growth rate. The results of these investments done during 70s showed their results in the decade of 80s. The results also recommended that public sector interventions should be eliminated in marketing and distribution activities. The government should also keep the level of inflation rate at low pace

as it reduces the productivity of agriculture. Due to limits in the expansion of cultivated area, intensification in input use, increase in population and rise per capita income and to meet the challenges of food security, the study recommended the increase in productivity growth rather emphasizing the increase in the use of inputs. The TFP growth can be sustained by increasing the efficiency of resource use and technological breakthrough in agriculture sector without compromising the quality of inputs. This can be achieved by investment in agricultural development projects, macroeconomic stability, education and training, infrastructure development, institutional reforms and also luck i.e. favorable weather. The key message of this study is that the focus of the future research should be on increasing/sustaining the productivity of agriculture in order to meet the challenges of food security.

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