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ESTIMATION OF TOTAL FACTOR PRODUCTIVITY GROWTH IN AGRICULTURE SECTOR IN PUNJAB, PAKISTAN: 1970-2005

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Productivity growth is of central importance to economic growth. In the study of Total Factor Productivity (TFP), Input and output growth indices have been estimated for Punjab's agriculture for the period 1970 to 2005. The indices were calculated using the most commonly employed index number approach namely Tornqvist Theil approximation to divisia index. The Tornqvist-Theil index provides consistent aggregation of inputs and outputs under the assumptions of competitive behavior, constant returns to scale, Hicks-neutral technical change, and input-output separability. The results showed that annual average growth rate of input, output and TFP indices remained 1.46, 3.49 and 2.0 for the study period. The study also estimated that TFP contributed 57 percent of the output growth in Punjab's agriculture during the study period.
Keywords: Productivity, TFP, Index number, Tornqvist Theil Index

INTRODUCTION

Agriculture is the mainstay of the economy of Pakistan. Moreover, it is the main source of livelihood for majority of the country's population. It accounts for 21.8 percent of GDP and employs 44.7 percent of the total work force. As such, national economic welfare depends on agriculture which has been considered by the Government as the engine of national economic growth and poverty reduction (Government of Pakistan, 2009). Punjab's economy is also mainly base on agriculture sector. Its share in the GDP of the province is 20.3 percent. It employs almost half of the labor force in the province. It adds over half of the national agricultural value added. (Government of Punjab, 2007)

In face of increasing population growth especially in developing countries, there exists limited possibilities of further extension of cultivated land. The situation is further aggravated by conversion of fertile land to residential and industrial areas **(**Chang and Zepeda, 2001), increasing resource degradation (Murgai *et al*. 2000) and wide gap between potential and national average yields (Government of Punjab, 2007). Under these circumstances, agricultural production can only be increased through increased productivity (TFP).

In the past, major emphasis was on partial factor productivity, but due to misleading measure of productivity, Total Factor Productivity (TFP) was devised. TFP is the ratio of an index of agricultural output to an index of agricultural inputs. The index of agricultural output is a value-weighted sum of all agricultural production components. The index of agricultural inputs is the value-weighted sum of conventional agricultural inputs. These generally include land, labour, physical capital, livestock and chemical fertilizers and pesticides (Ahearn *et at*. 1998).

The most comprehensive measure of aggregate productivity is Total Factor Productivity. Numerous studies in the empirical literature had estimated total factor productivity by employing different approaches [for example, Sarel and Robinson (1997); Fernandez-Cornejo and Shumway (1997); Jin *et al.* (2001); Gerdin (2002); Coelli and Rao (2003); Hall and Scobie (2006); Fulginiti *et al*. (2004) and Mukherjee and Kuroda (2003)].

However, due to data limitations, this area of research could not be explored extensively in Punjab. Few studies have been conducted in Pakistan on TFP. Wizarat (1981) computed TFP for the period of 1953-54 to 1979 for Pakistan agriculture. She concluded that the growth of the value added index, aggregate input index and TFP index remained 3.4, 2.3 and 1.1 respectively. However, the study suffers from serious methodological and data limitations because an arithmetic index which has been derived from a linear production function assumes perfect substitutability between inputs, the use of value-added output index excludes the role of intermediate and purchased inputs and she used capital input variable as stock, whereas used as service flow has been used frequently in literature (Ali, 2004).

Rosegrant and Evenson (1993) estimated total factor productivity growth for the period 1956-1985 in the crop sector. They also concluded that maximum growth has been observed during green revolution at a

rate of 1.86 percent per annum which declined very sharply subsequently. Khan (1997) computed TFP for the agriculture sector for the period 1960-1996. The results showed that TFP grew at an average annual rate of 0.8 percent. Ali and Byerlee (2000) estimated TFP for the period of 1966 to 1994 using T-T index. They concluded that aggregated total factor productivity increased at 1.51 percent per annum.

Sabir and Ahmad (2003) calculated economic growth rates during the pre-reform period (1972-73 to 1987-88) and reform period (1987-88 to 2001-02). They concluded that average annual growth rate in agriculture during the study period (1972-73 to 2002-03) remained 2.0 percent. Ali (2004) calculated the total factor productivity using Tornqvist-Theil index methodology for the period of 1960-96. The results showed that total factor productivity had grown at an average annual rate of 2.3 percent for the entire period. It accounted for 58 percent of the total output growth. Ahmad and Bukhari (2007) concluded that the contribution of input availability is not significant except during the period of 1973-77. After that, it is TFP that accelerated growth in agriculture sector. They revealed that during 1988-92, TFP contributed 86.9 percent to agriculture growth.

Since the resources are changing due to many factors including government policies, so there is a need to estimate total factor productivity growth in the agriculture sector in Punjab in order to analyze the effect of policy changes as well as to provide the policy options to the policy makers for appropriate allocation of scarce resources.

MATERIALS AND METHOD

Two major approaches have been used frequently in literature namely (a) Econometric approach and (b) Growth accounting (index number) (Antle and Capalbo, l988). Under the Growth accounting there are further two commonly used measures i.e. (i) Arithmetic Index (AI) and (ii) Tornqvist-Theil Index (TTI). We selected the second due to its advantages over growth accounting. For example, T_T index uses a time varying weighting scheme and it has come to be viewed as superior to other indices, Tornqvist-Theil index is a superlative index which is exact for the linear homogeneous translog production function (Diewert, 1976), a further advantage of the Tornqvist-Theil index is that it accounts for changes in quality of inputs because current factor prices are used in constructing the weights, quality improvements in inputs are incorporated, to the extent that these are reflected in higher wage and rental rates (Capalbo and Vo, 1988).

The Tornqvist-Theil (T-T) approximation to the Divisia index for TFP estimation is implied in this empirical work. The most frequently used formulation of Antle and Capalbo (1988) and Thirtle and Bottomley (1992) is applied as:

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

Where R_{it} is the share of output i in total revenue, Q_{it}, is output i, S_{jt}, is the share of input j in total input cost, and X_{jt}, is input j, all in period t. In this specification, revenue shares for the output index and cost shares for the input index are updated every time period as compared to the use of fixed weights in the arithmetic and geometric indices. This avoids the underestimation/overestimation, implicit in a fixed-weight estimation procedure.

The TFP index is computed with aggregate output and input index. The gross output index includes both major and minor crops and livestock products. The major crops includes Wheat, Rice, Maize, Sugarcane, Cotton, While minor crops consist of Bajra, Tobacco, Gram, Mung, Mash and Masoor Jawar, Barley, Groundnuts, Rape seed , Potato, Onion, Garlic. Among fruits, data on production of Citrus, Guava and Mango were collected. The output series for livestock sub-sector accounts for data on milk, beef and mutton. Similarly inputs include land, labor, capital (tractors, diesel and electricity tube wells and draught animals) and purchased inputs such as fertilizer and pesticide consumption in agriculture. The input index also includes fodder, wheat straw and concentrates being used for livestock production. The output data on all crops except livestock products were collected from various issues of Agricultural Statistics of Pakistan, Punjab Development Statistics and 50 Years of Pakistan in Statistics. Data on livestock products were not readily available at Punjab level, therefore, it has to be estimated based on the data available at Pakistan level.

Farm gate prices for all crops and livestock categories were not readily available, therefore, farm gate prices were estimated from whole sale prices obtained from different official sources including various issues of Year Book of Statistics, Agricultural Statistics of Pakistan, Reports of Punjab Economic Research Institute (PERI), Economic Survey of Pakistan etc. by assuming 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 (FBS), when required (Fifty Years of Pakistan in Statistics, FBS publication). Data on inputs quantities and their prices were collected or estimated from various sources in addition to above, includes Pakistan Labor Force Surveys, Pakistan Livestock and Agriculture Machinery Surveys. Extrapolation or Interpolation has also been made where found necessary. The stock of capital items has been estimated through perpetual inventory method.

RESULTS AND DISCUSSION

The importance of productivity has widely been recognized in the empirical literature. And its importance will further increase due to limited possibility of further extension of cultivated area, increasing population and expected increase in income. The output and input indices are based on the output and input aggregators as defined in the equation 1. The estimated output, input and TFP indices obtained from Tornqvist-Theil indexing procedure are set at 100 for the year 1970-71 and are presented in Table 1 and their growth rates are reported in the Table 2. The graphical presentation is given in Figure 1.

Table 2 shows that the highest average annual growth in total factor productivity occurred during the decade of 1980s. The overall average annual growth rate of TFP in Punjab remained 2.0 percent. The results of this study are also consistent with Ali (2004) and Khan (1994) who estimated annual average growth of TFP 2.2 and 2.1 percent respectively. Sabir and Ahmad (2003) also estimated 2.0 percent growth in TFP of agriculture sector during the period of 1972-73 to 2001-2002. The contribution of TFP towards output growth has also been estimated by dividing the TFP Index to Output Index followed by multiplying by 100 and it remained 57 percent during the whole study period. This result is also consistent with Ali (2004) who estimated 58 percent contribution of TFP in output growth. The output and input growth was calculated as 3.49 and 1.46 percent respectively. Again the results of this study are not much different from Ali (2004) who estimated output, input growth as 4.0 and 1.7 percent respectively.

The results indicate that productivity growth was a significant factor in the performance of the agriculture sector in Punjab over 36 years. As pointed out by Byerlee (1994) “over the long –run evidence form a number of countries suggests that an overall rate of agricultural productivity growth of 1.5 to 2.0 percent can be expected (as measured by TFP index).” This a priori expectation is met by the TFP growth rate results of 2.0 percent per year during the entire period in this study. Moreover, the estimates of the study also fall within the general range of TFP growth rates calculated in previous studies for other developing countries.

Table 1. Indices of agricultural output, input, and TFP in Punjab: 1970-2005

Year	Output Index	Input Index	TFP Index
1970	100	100	100
1971	108.17	102.25	105.8
1972	106.46	102.81	103.55
1973	108.62	103.65	104.79
1974	110.28	104.44	105.59
1975	113.79	106.63	106.71
1976	114.92	109.22	105.22
1977	116.48	110.34	105.57
1978	124.44	112.09	111.02
1979	131.89	116.48	113.23
1980	134.10	118.38	113.28
1981	145.48	116.44	124.94
1982	146.65	121.24	120.96
1983	138.24	119.59	115.59
1984	155.08	121.67	127.46
1985	169.13	125.14	135.15
1986	168.27	123.79	135.93
1987	174.14	126.23	137.95
1988	187.44	128.04	146.4
1989	193.27	131.22	147.28
1990	200.36	131.82	152.00
1991	215.61	133.32	161.73
1992	213.77	137.70	155.25
1993	215.58	143.96	149.74
1994	235.21	140.42	167.50
1995	258.41	139.26	185.56
1996	237.14	152.95	155.05
1997	260.06	157.99	164.61
1998	264.72	157.87	167.69
1999	288.08	161.22	178.69
2000	273.62	160.90	170.05
2001	296.60	157.55	188.25
2002	300.07	157.36	190.70
2003	311.80	162.74	191.59
2004	343.19	168.42	203.77
2005	344.08	168.32	204.42

Source: Author’s own calculation

Table 2. Average growth rates of agricultural output, input and TFP indices, 1970–2005

Period	Output Index	Input Index	TFP Index	TFP contribution in output growth (%)
Decade Wise Average Growth Rates				
1970-80	2.97	1.70	1.25	42
1981-90	3.25	1.25	1.98	61
1990-2000	2.87	1.83	1.03	36
Total Period				
1970-2005	**3.49**	**1.46**	**2.0**	**57**

Source: Author's own calculation

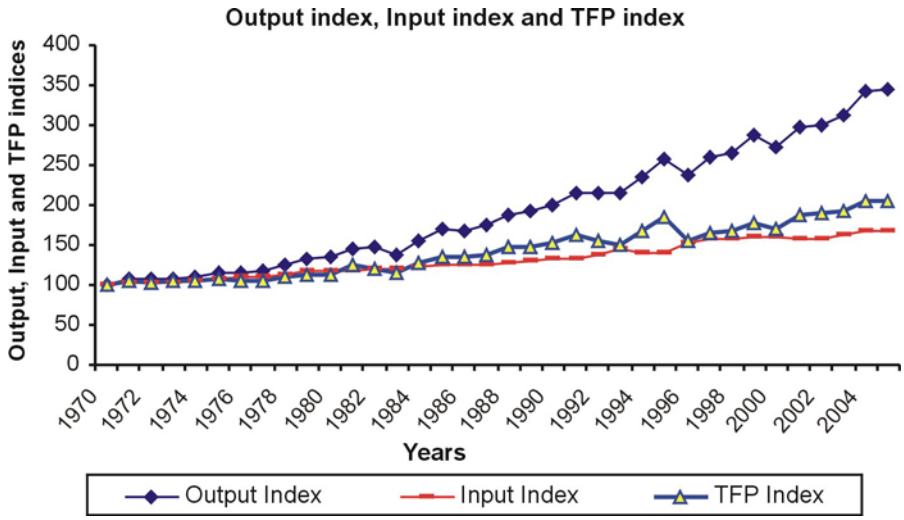

Figure 1. Output, Input and TFP Indices of Punjab's Agriculture (1970–2005)

CONCLUSIONS

The results reveal that overall average annual growth rate of TFP in Punjab remained 2.0. The contribution of TFP towards output growth stood 57 percent during the study period ranging from 1970 to 2005. The results indicate that productivity growth has been a significant factor in the performance of the agriculture sector in Punjab over 36 years.

The study also concluded that the trends of TFP in Punjab agriculture sector remained almost increasing except for the years of 1993, 1996 and 2000. The main reasons were widespread attack of cotton leaf curl virus (CLCV), fall in growth rates of major crops and adverse weather conditions respectively.

Cotton and Wheat are the two important major crops which contribute maximum to agricultural growth. Any fluctuation in the production of these crops not only effects the agricultural growth of the province but also the overall economic development of the whole country as the province of Punjab is the largest contributor in agricultural production of the country (Pakistan). Therefore, policies should be devised to increase the productivity of these two important major crops on sustainable basis. Besides that policies should also be formulated for promoting crop diversification in order to minimize the effects of adverse shocks to the economy due to reduction in the production of major crops. As has been defined that TFP is the combination of both technical change and technical efficiency moreover, Technical change is a long term phenomena, while technical efficiency is a rather short term process. Thus our first priority should be to increase the technical efficiency of major crops in particular and minor crops in general through educating the farmers in better field management practices. Here the extension department can play its role to accomplish this job through different techniques. Therefore, it is necessary that extension workers should be facilitated so that they could approach the small farmers as well, who constitute the maximum part of the farming community. However, our focus should not be diverted from technological change as it constituted maximum part of TFP and is a major tool for rapid increase in agricultural productivity to fulfill the increasing demand of food and fiber of the province.

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