Does Efficiency Matters in Explaining Total Factor Productivity Growth of Rice Production in India?

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Abstract

The present paper estimates Total-Factor-Productivity-Growth (TFPG) of Indian agriculture for Rice over the period 1970-71 to 2013-14 considering the major producing states of these crops by using non-parametric method of Data-Envelopment-Analysis (DEA). After estimating the TFPG the major factors influencing TFPG is explained. The result reveals that although the green revolution policies may push the TFPG in a higher level but the effect of green revolution policy may fade out over time. The analysis also reveals that in order to encourage total factor productivity growth, any policy changes that will lead to increase in the government irrigation, availability of agricultural loan, rural-literacy, government expenditure on agricultural research and extension should be emphasized. Although there exists non-linear relationship (i) between TFPG and the growth of HYV uses, the marginal effect of HYV uses is positive implying that an increase in growth of HYV uses will push up TFPG and (ii) between TFPG and the inequality-in-operational-land-holding but the marginal effect of the inequality-in-operational-land-holding is positive suggesting that learge holding of land has positive effect on TFPG.

Key Words:*Total Factor Productivity Growth, Indian Agricultural Sector, Data Envelopment Analysis (DEA).*

1. Introduction

The productivity growth in agriculture is very important because it is not only the necessary condition but is also the sufficient condition for the advancement of the sector as well as the economy. It has been widely acknowledged in the economic literature that economic growth no matter how impressive is will not be sustainable without improvement in total factor productivity growth.

Since last six decades productivity growth in agriculture has been one of the focused areas of intense research. Both development economists and agricultural economists have tried to estimate the TFPG and also tried to find out the sources of productivity growth over time. Productivity growth in the agricultural sector is considered essential if agricultural sector output is to grow at a sufficiently rapid rate to meet the demands for food and raw materials arising out of steady population growth. There are not many studies on TFPG in agricultural sector in respect of developing countries. Most of these studies found a declining TFPG in the developing countries which may be unexpected and paradoxical results. Some of the studies relating to the estimation of agricultural TFPG in developing countries are as follows: Kawagoe et al. (1985), Kawagoe and Hayami (1985), Lau and Yotopoulos (1989), Fulginiti

and Perrin (1993), Trueblood (1996) and Arnade (1998), Trueblood and Coggins (2003), Alauddin, Headey and Rao (2005), Coelli and Rao (2005), Restuccia et al. (2008), Belloumi and Matoussi (2009) and many others. However, resent studies like Shahabinejad and Akbari (2010) found that during 1993 – 2007 total factor productivity has experienced a positive evolution in D-8 countries.

In case of India the measurement of TFPG in agriculture involves a number of studieslike Kumar and Rosegrant (1994), Fan, Hazell and Thorat (1998),Murgai (1999),Forstner et al (2002), Nin et al (2003),Bhushan (2005), Kumar and Mittal (2006), Bosworth and Collins (2008), Chand, Kumar and Kumar(2011)etc.

While considering TFPG analysis for Indian agriculture most of the earlier study adopts either growth accounting or econometric techniques. Crop specific studies on the total factor productivity growth rate of output are extremely important because this can highlight the crop specific problem relating to the total factor productivity growth. Thus it can be taken as a guideline for framing appropriate policies towards the crops. In the literature such type of crop specific studies are in fact lacking.

Given this background, the objectives of the present paper are first of all to find out the TFPG of Indian agricultural sector by using non-parametric method of Data Envelopment Analysis (DEA). This study tried to find out TFPG for rice of the Indian agricultural sector. Under rice major producing states are considered as the multiple decision making units (DMUs). After finding out the extent of TFPG, the second objective tries to explain the factors behind the variation in TFPG with special focus on the efficiency changes.

Rest of the paper is as follows:

Section 2 discusses the methodology and data source. In subsection 2.1 the methodology for measuring non-parametric method of Data Envelopment Analysis (DEA) is discussed. In subsection 2.2 methodology for finding out determinants explaining variation in TFPG by using panel regression approach has been discussed. Data Sources are discussed in 2.3. Section 3 presents the results of estimation elaborately and some concluding remarks are made in Section 4.

2. Methodology and Data Source

2.1 Methodology of measuring non-parametric method of Data Envelopment Analysis (DEA)

Analysis of productivity change can use either a parametric method or the non-parametric index number approach. Theoretically productivity of a firm is measured by the quantity of output produced per unit of input. In the single input, single output case it is simply the average productivity of the input - measured as a ratio of the firm's output and input quantities - is easy to compute. In most situations, however, we encounter multiple inputs and outputs, in which case some economically meaningful aggregation of inputs and outputs is necessary. That is when multiple inputs and/or multiple outputs are involved, one must replace the simple ratios of the output and input quantities by ratio of quantity indices of output and input (see Ray (2004, p. 279-295) for details).

In this paper we adopt the non-parametric (primal) approach to measure total factor

productivity change. In the non-parametric approach, productivity index is used to measure productivity change.

2.2 Determinants of TFPG: The use of Simultaneous Panel Regression

In order to explain the variation in TFPG following explanatory variables are considered:

- **HYV Uses (HYV)**
- **Government irrigation (GI) or Private irrigation (PI)**
- **Rainfall (RF)**
- **Government expenditure on agricultural education, research, and extension (E)**
- **Rural literacy (RL)**
- **Agricultural Loan (AL)**
- **Distribution of Operational Land Holding (G)**
- **Efficiency of Previous Period**
- **Per Capita Net State Domestic Product**

The parameters are thus estimated by GMM by considering fixed effect under a seemingly unrelated regression (SUR) framework each regression was adjusted for contemporaneous correlation (across units) and cross section heteroscedasticity. While estimating the panel model the thesis test for fixed effect or random effect model using. Hausman test and found fixed effect to be the best fitted model.

2.3 The Data Sources

In this paper we have considered the input and output data for estimating the productivity growth. The input and outputs are as follows:

Output: Production of each Crop

Inputs:

I. Seed (Kg.)
II. Fertilizer (Kg. Nutrients)
III. Manure (Qtl.)
IV. AREA ('000 Hectares)
V. Human Labour (Man Hrs.)

All the data has been collected from the different issues of the Statistical abstract, Agriculture at a Glance, Agriculture in Brief, Handbook of Statistics on Indian Economy, *www.indianstat.com* (an online commercial data service), Cost of Cultivation data published by the Government of India.

This paper considers eleven major rice producing states in India. Rice crop is chosen because India is the major producer and exporter of rice in the world. Under rice major producing states are as follows:

- ✓ Rice- Andhra Pradesh, Assam, Bihar, Haryana, Karnataka, Madhya Pradesh, Orissa, Punjab, Tamil Nadu, Uttar Pradesh, West Bengal

Data Period: 1970-71 to 2013-14

3. Results of estimation

All the results are presented in Tables 1 to 3.

3.1 Results of Average Annual Rate of Changes of TFPG

The TFPG for each of the years, each of the crops and each of the states are estimated. The results are then summarized to generate the information regarding the average annual rate of changes of TFPG for rice. Such estimation results for Rice are presented in Table 1.

Table 1 Average Annual Rates of Total Factor Productivity Changes in Rice

	ALL YEAR	1970-79	1980-89	1990-99	2000-2013
AP	0.75	2.41	1.30	2.16	-2.87
AS	-0.484	4.342	-0.0000000051	-0.097	-6.183
BI	2.33	2.05	3.59	4.50	-0.83
HA	3.672	7.757	3.646	8.075	-4.788
KA	2.042	6.728	5.486	-1.463	-2.582
MP	1.942	1.882	1.464	1.407	3.014
OR	2.420	3.696	1.107	1.971	2.907
PU	2.835	6.557	4.650	3.083	-2.951
TN	1.009	5.617	0.912	-0.490	-2.003
UP	1.021	5.243	0.855	0.227	-2.243
WB	1.089	1.521	4.611	1.274	-3.052
OVER ALL	1.94	4.35	2.87	1.88	-1.96

From Table 1 in case of **Rice** it can be concluded that overall average annual rate of change of TFPG in case of rice is 1.94% for the period 1970-71 to 2013-14. Now if one consider the state wise results the average annual rate of change of TFPG is negative only in case of AS (-0.48%) for the period 1970-71 to 2013-14. This rate of changes of TFPG is highest in case of HA (3.67%) followed by PU (2.83%), OR (2.42%), BI (2.33%), KA (2.04%), MP (1.94%), WB (1.08%), UP (1.21%), TN (1.009%) and AP (0.75%). The decadal average annual rates of change of TFPG are also estimated. For decadal analysis the overall period 1970-71 to 2013-14 is broken down into four sub periods 1970-79, 1980-89, 1990-99 and 2000-2013.The result of decadal average annual rate of change of TFPG implies that this change is highest for the period 1970-79 (4.35%). This change may be due to the successful implementation of green revolution policies in that decade. The overall average annual rate of change of TFPG declined from 4.35% in 1970-79 to 2.87% in 1980-89 to 1.88% in 1990-99. In the period 2000-2013 the average annual rate of change of TFPG is negative (-1.96%). This may occur because nine among the eleven major rice producing states experienced a negative average annual

rate of changes of TFPG for the period 2000-2013. The overall decline in average annual rate of changes of TFPG may be visualized from its decline for 10 states out of 11 for the period 1970-79 to 1980-89 and 7 states out of 11 for the period 1980-89 to 1990-99 along with corresponding decline associated with the period 2000-2013.

3.2 Results of Determinants of TFPG

The present paper explains the factors influencing TFPG for each of the crop Rice. From the determinants analysis it can be concluded that previous period's efficiency has non-linear positive and significant effect on the TFPG.

Table 2: Estimated Results of Productivity Equation in case of Rice

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RF	0.000162*	3.59E-05	4.51253	0
HYV	3.245422*	0.367631	8.82793	0
HYV*HYV	-1.291833*	0.298353	-4.32988	0
GI	1.520065*	0.302225	5.02958	0
E	0.081624*	0.016684	4.89235	0
RL	0.235646*	0.009183	25.66111	0
G	-4.555683*	0.438276	-10.39455	0
G*G	5.214744*	0.418173	12.47030	0
AL	4.415827*	1.689448	2.61377	0.0093
EFF(-1)	7.849652*	0.212109	37.00763	0
PNSDPA	0.4630184*	0.118623	3.90329	0.0001
RL(-1)*EFF(-1)	0.259766*	0.009778	26.56637	0
AL*PNSDP	2392.603*	634.8462	3.76879	0.0002
E(-1)*EFF(-1)	0.089353*	0.016683	5.35593	0
Adjusted R-squared	0.789875			

*significant at 1%, **significant at 5%, ***significant at 10%

Table 3: Marginal Effects of the Explanatory Variables from the Productivity Equation in case of Rice

RF	0.000162	**RL**	0.474199
HYV	1.730798	**AL**	8.379519
G	1.650514	**GI**	1.520065
EFF (-1)	19.62134	**E**	0.16368
		PNSDPA	0.463018

From the results (Table 2 and Table 3) of the marginal effect it is also be concluded that previous period's efficiency has the highest impact on the TFPG. Considering the other factors influencing TFPG in case of rice, it can be concluded that the TFPG of rice is non-linearly and significantly related with HYV uses, Government expenditure on Agricultural research and extension, agricultural loan, per capita state domestic product from agriculture and rural literacy. Though there is non-linear relationship found but the marginal effect of these variables is positive implying that an increase in these variables will encourage TFPG of rice. It is found that there exists an inverted U shaped relationship between HYV uses and TFPG implying that too much HYV uses is bad for TFPG of rice. Also there exists an interaction term between previous period's efficiency and Government expenditure on Agricultural research and extension implying that the innovation may increase the efficiency and both jointly can increase the TFPG of rice production in Indian agriculture. There exists another interaction term between previous period's rural literacy and efficiency and the implication is the same as just mentioned. Again there exists another significant positive effect of the interaction term between agricultural loan and per capita state domestic product from agriculture the implication is that availability of loan may push up the TFPG. Again there exists significant and positive relation between TFPG and per capita state domestic product from agriculture. Further, there exists a "U" relation between inequality in the distribution of operational land holding and the productivity of rice, suggesting that an increase in inequality in distribution of operational land holding may adversely affect the TFPG in first stage but beyond some point it has positive effect on TFPG.

4. Conclusion

The present paper estimates Total-Factor-Productivity-Growth (TFPG) of Indian agriculture for Rice over the period 1970-71 to 2013-14 considering the major producing states of these crops by using non-parametric method of Data-Envelopment-Analysis (DEA). After estimating the TFPG the major factors influencing TFPG is explained. The result reveals that although the green revolution policies may push the TFPG in a higher level but the effect of green revolution policy may fade out over time. The analysis also reveals that in order to encourage total factor productivity growth, any policy changes that will lead to increase in the government irrigation, availability of agricultural loan, rural-literacy, government expenditure on agricultural research and extension should be emphasized. Although there exists non-linear relationship (i) between TFPG and the growth of HYV uses, the marginal effect of HYV uses is positive implying that an increase in growth of HYV uses will push up TFPG and (ii) between TFPG and the inequality-in-operational-land-holding but the marginal effect of the inequality-in-operational-land-holding is positive suggesting that learge holding of land has positive

effect on TFPG.

Thus this result reveals that although the green revolution policies may push the TFPG in a higher level but the effect of green revolution policy may fade out over time. The analysis also reveals that in order to encourage TFPG , any policy changes that will lead to increase in the government irrigation, availability of agricultural loan, rural literacy, government expenditure on agricultural research and extension, increase in efficiency should be emphasized.

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