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The changing scenario of technical efficiency in West Bengal agriculture: A district-wise analysis

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ABSTRACT

The present paper attempts to estimate average Technical Efficiency (TE) of major crops produced in districts of West Bengal. The TE measures are compared at three points of time—viz. 1990-91, 2000-01 and 2009-10. The methodology is to find an optimum solution to the Linear programming problem of the Data Envelopment Analysis (DEA). Most of the districts of the state are found to be efficient in agricultural production. The situation has gradually improved in 2009-10 compared to 2000-01. However, the improvement in TE for most of the districts has not been uniform at selected points of time. While the district of South 24-parganas recorded a continuous increase in average TE, Jalpaiguri lagged far behind in terms of efficiency improvement compared to other districts. Average production can be augmented in Jalpaiguri by almost 50% through efficient use of inputs.

Keywords: Technical efficiency, DEA, West Bengal, districts, agriculture

India attained self-sufficiency in food grain production with the help of intensive agricultural policy coupled with price support system during the period from mid 1960s onwards. From 1980s onwards the benefit of yield improving technology spread to new zones like the Eastern Part of the country. In states like West-Bengal farmers with modest holding were able to derive the benefits of increases in production. With this changed set-up, West-Bengal acquired an important position in the agricultural scenario of the country.

However, overtime the traditional production function approach seems to be less capable of explaining output or yield expansion in terms of increased input usage. To take the case of West-Bengal, despite a quite satisfactory performance in the field of agriculture, a year-to-year comparison of figures reveals sharp decline in the rate of growth of the index of total agricultural production,

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of total foodgrains and of Rice. Table 1 depicts that total agricultural production increased by about 63% in 1990-91 from the level of 1981-82. This rate of growth fell sharply to about 29% in 2000-01 (over 1990-91 level) and further to about 27% in 2009-10 (over 2000-01). Similarly, the rate of growth of total foodgrains output decelerated from about 57% between the years 1981-82 and 1990-91 to about 22% between the 2000-01 and 1990-91 and further to 14% in 2009-10 over 2000-01. The rate of growth of Rice production had declined from about 64% in the first decade to about 20% in the second decade and further to 15% in 2009-10 over 2000-01. This downfall clearly highlights the limitations in growth following the usual intensive agricultural practices.

At this point an alternative suggested path is to rely on improvement in technical efficiency (TE) in agricultural production. Technical efficiency refers to the ability of a production unit to obtain maximum quantity of output from a given input vector or its ability to minimize input use in the production of a given output vector. The efficiency measures are computed by comparing the observed performance with some special standard which is the production frontier in case of TE.

The objective of the present paper is to measure and analyze changes in TE in sixteen districts of West Bengal in the post-liberalization period. It seeks to find an answer to whether production can be increased through improvements in TE in the districts of West Bengal. The process of economic liberalization in India, since early 1990s, has made the agricultural sector, along with other sectors, more open to the foreign market competitions. So, to survive strong competition improvement in efficiency is required for the agricultural sector.

Among the studies on TE in West Bengal, two studies viz., Ray, (1985) and Kumbhakar (1994) are solely based on West Bengal. Ray (1985) applied a non-parametric methodology to measure efficiency of 63 farms of West Bengal in 1972-73 while Kumbhakar (1994) used a profit maximizing framework to estimate efficiency for 227 farms from West Bengal, India in the period 1980-85. Shanmugam and Soundararajan (2008) measured technical efficiency in total agricultural production for 15 major states in India over the period 1994-95 to 2003-04. Thus, perusal of literature suggests that studies on efficiency either focused partially on West Bengal [Shanmugam and Soundararajan, 2008] or addressed the period much prior to liberalization [Ray, 1985; Kumbhakar, 1994]. Further, these studies provide TE measures for the state as a whole and do not provide a district-wise disaggregated analysis of efficiency of major crops produced in the state.

The present paper addresses a disaggregated analysis with districts as the decision making units. Major crops grown in the state are rice, wheat, potato, jute and oilseeds. Instead of considering rice grown in three different season rice production figure is considered as a whole. Wheat is the second most important cereal grown in the state in terms of share in both area under and production of total cereals. Potato is the most important vegetable in terms of production and has become an important crop of the state after Rice in terms of output. Almost 98% of area under Fibres comes under Jute and it accounts for about 99% of total fibre production. Apart from these crops, total oilseeds production in the state has also registered steady increase overtime.

The aim of the study is to measure and compare changes in efficiency levels at the end points of two subsequent decades after liberalization. For this the study basically entails estimation and comparison of average TE measures calculated at three distinct points of time viz. years 1990-91, 2000-01 & 2009-10. 1990-91 is considered for being the initial year of economic liberalization. Here, average TE refers to the average for the five crops selected for the study. This average is not based on the total agricultural production of the state. The crops selected are – Rice, Wheat, Potato, Jute and the category of Oilseeds.

Methodology and Data

Technically efficient production refers to the maximum quantity of output attainable from given resource endowments. A formal definition of TE was provided by Koopman (1951) corresponding to which Debreau (1951) & Farrell (1957) proposed two measures of TE viz. the input oriented measure & the output oriented measure. Fig. 1 depicts a simple technology for producing a single output (y) from a single input (x) the curve Y =

$g(x)$ shows the production function or the graph of the technology. For any point (x^0, y^0) on this curve, y^0 is the maximum output that can be produced from input x^0.

Points P_A and P_B show the actual input-output quantities (x_A, y_A) and (x_B, y_B), respectively, of two firms A and B. Both points lie below the graph. The point P_A^* on the graph shows that Y_A^* is the maximum output that can be produced from input x_A. Thus, P_A^* shows the benchmark or reference input-output bundle for firm A. Similarly, P_B^* is the reference bundle for firm B.

Define,

$$\varphi_A^* = \frac{Y_A^*}{Y_A} = \frac{g(x_A)}{Y_A} \quad (1)$$

Then a measure of the performance of firm A is its output-oriented technical efficiency,

$$\tau_y(x_A, y_A) = \frac{1}{\varphi_A^*} \quad (2)$$

The output-oriented technical efficiency shows what proportion of the potential output from x_A has actually been realized by firm A. Similarly, the technical efficiency of firm B is measured by the ratio of Y_B and Y_B^*. As apparent from Figure 1, firm B performs better than firm A.

The present study focuses on the output Oriented measure which is also known as the Farrell (1957) measure of TE and it consists in comparing the observed output with the maximum potential output obtainable from the given inputs.

A benchmark technology reflecting the maximum producible output (e.g. production frontier in case of TE) is constructed from the given observations. The observed performance of any decision making unit is then compared with the benchmark to compute efficiency measures. The benchmark technology can be constructed either by the Stochastic Frontier Production Approach (SFPA), or by the Data Envelopment Analysis (DEA). In SFP, a stochastic production frontier is estimated based on a functional specification. Two problems are inherent with this method – one is of arbitrariness involved in the selection of functional specification and second, is of the element of stochasticity in the assumption about the form of one-sided distribution of the inefficiency term. But, in DEA no parametric specification of the production frontier is required on a-priori basis. Let $x^j = \left(x_1^j, x_,^j, \ldots x_n^j\right)$ be the bundle of n inputs used and $y^j = \left(x_1^j, y_2^j, \ldots x_n^j\right)$ the bundle of m outputs produced by firm j (j =1, 2, …, N). Suppose that k is one of the observed firms and we wish to measure the technical efficiency of firm k. The observed input output bundle of firm k is (x^k, y^k) Under the assumptions like a) all actually observed input-output combinations are feasible, b) the Production Possibility Set (PPS) is convex, c) both inputs and outputs are freely disposable, an inner approximation to the underlying PPS or benchmark technology is constructed from the feasible input-output observation. This is the free disposal convex hull constructed on the basis of observed input-output vectors and is defined as:

$$S = \Big\{(x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^j; \quad (3)$$
$$y \leq \sum_{j=1}^{N} \lambda_j y^j; \sum_{j=1}^{N} \lambda_j = 1;$$
$$\lambda_j \geq 0 \,(j = 1, 2 \ldots, N)\Big\}$$

The above PPS assumes Variable Returns to Scale (VRS) in production which is a more general assumption than CRS.

The output-oriented approach looks for the maximum feasible extent of output expansion that is possible without using any additional input. In case of multiple outputs (*i.e.*, x_0 is a vector of outputs) the task is to find out what is the maximum equi-proportionate increase possible in all outputs in the bundle.

The relevant DEA LP problem would be,

$$\max \varphi$$
$$\text{s.t.} \sum_{j=1}^{N} \lambda_j x_{ij} \leq x_{ik} \,(i = 1, 2, \ldots, n)$$
$$\sum_{j=1}^{N} \lambda_j y_{rj} \geq \varphi y_{rk} \,(r = 1, 2, \ldots, m) \quad (4)$$
$$\sum_{j=1}^{N} \lambda_j = 1; \lambda_j \geq 0 \,(j = 1, 2, \ldots, N); \varphi \text{ unrestricted.}$$

A measure of the output-oriented technical efficiency of firm k with observed input-output bundle (x^k, y^k) is,

$$\tau_k = \frac{1}{\varphi^*}$$

where, $\varphi^* = \max \varphi: (x^k, \varphi y^k) \in S$, the optimal solution of the DEA LP problem above.

The relevant LP problem is solved using EXCEL SOLVER.

Table 1: Index Number and Changes in Production of Total Agriculture, Foodgrains and Rice

Year		1981-82	1990-91	2000-01	2009-10
Total agricultural Production	Index Number	100	163	210	267
	Rate of Change (%)		63	29	27
Total Foodgrains	Index Number	100	157	192	219
	Rate of Change (%)		57	22	14
Rice	Index Number	100	164	197	227
	Rate of Change (%)		64	20	15

Table 2: Average Technical Efficiency Estimates for the Districts of West Bengal

Districts	1990-91	2000-01	2009-10
Burdwan	1	1	0.9622
Birbhum	0.7703	0.6822	0.9982
Bankura	0.9709	0.4132	1
Medinipur	1	1	1
Howrah	0.7606	0.4865	0.9919
Hooghly	1	1	1
N 24 Parganas	1	1	1
S 24 Parganas	0.5861	0.7235	0.8492
Nadia	1	1	1
Murshidabad	1	1	1
Dinajpur	1	1	1
Malda	1	0.835	1
Jalpaiguri	1	0.4192	0.5063
Darjeeling	0.6325	0.2032	1
Coochbehar	1	1	1
Purulia	0.4283	0.3621	1

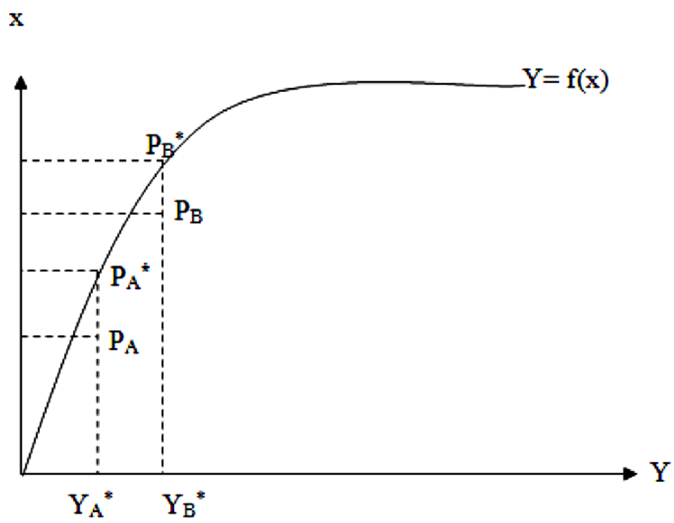

Fig. 1

Production technology includes output of the selected crops. The inputs included are— Fertiliser ('000 tonnes) (FRT), Pesticides (PST) (metric tonnes), human labour, Irrigated area ('000 hectares). The relevant data are collected from the various publications of Economic Review of West Bengal Agriculture and Farm Management Survey report, Directorate of Agriculture, Government of West Bengal.

Results and Discussion

Table 2 depicts conspicuous variation in average TE levels for sixteen districts over three selected years 1990-91, 2000-01 and 2009-10. On the basis of variation the districts can broadly be classified into four groups:

1. *Seven districts* viz., Medinipur, Hooghly, North 24-parganas, Nadia, Murshidabad, Dinajpur (South& North) and Cooch Behar can be classified as a single group on the basis of their *uniform performance* over the selected years. These districts achieved 100% average level of TE back in 1990-91 and continued to be on the frontier in 2000-01 and 2009-10, too.

2. *Six districts* viz., Birbhum, Bankura, Howrah, Malda, Darjeeling and Purulia experienced noticeable *increase in average TE in 2009-10* over the previous two years and attained 100% efficiency improvement which means these districts are on the production frontier constructed on the basis of sample data on output of the selected crops.
3. *All districts* except Burdwan *registered improvement in average TE* over the selected years. Average TE improvement was 100% in Burdwan in 1990-91 and in 2000-01 but it fell by about 4% in 2009-10.
4. Average TE improvement remained *far below 100% for two districts* -- Jalpaiguri and South 24-parganas. However, only the district of South 24-parganas recorded a continuous increase in average TE and average TE can be improved in this district by almost 15%.

The present study measures TE in agriculture for the districts of West Bengal. The analysis includes five major crops produced in the state and measures average TE on the basis of production of these crops. Major observations of the study are noted below:

1. 13 out of 16 districts in West Bengal achieved 100% mark in terms of improvement in TE in 2009-10. That is most of the districts are on or very close to the average production frontier and hence, the scope for further TE improvement is very little.
2. However, the improvement in TE varied among the districts at different selected points of time.
3. The improvement in average TE differed in terms of year-to year performance, too. While average TE declined for seven districts in 2000-01 from the level of 1990-91, noticeable improvement took place in 2009-10 for most districts, over 2000-01 level.
4. Farmers have failed to utilize about 4%, 15% and 49% of the average potential output for the districts of Burdwan, South 24-parganas and Jalpaiguri, respectively. So, it is possible to increase output without further increases in input usage in these districts by 4%, 15% and 49%, respectively.

The case of Jalpaiguri district is particularly dismal as it is farthest from the frontier. Average production can be augmented in this district almost by 50% through efficient use of inputs. Finding out factors behind lower than average TE in Jalpaiguri district is an area of further research. Information about some district specific variables in explaining TE can be helpful in this regard.

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