Ind. Jn. of Agri. Econ.
Vol.71, No.1, Jan.-March 2016

ARTICLES

Role of Public Expenditure and Institutional Reforms in Explaining Technical Efficiency in Agriculture: An Indian Experience

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ABSTRACT

The present paper estimates technical efficiency (TE) of seven major crops — aus, aman, boro, jute, wheat, mustard, and potato─ in West Bengal, India, over the period 1980-81 to 2002-03 using stochastic frontier production function approach. The paper relies on the single-stage estimation procedure to obtain technical efficiency measures exploring the role of factors like public expenditure, credit and institutional reform, among others, to explain TE. The presence of inter-crop disparity in efficiency is evident from the study while factors like public expenditure, credit and institutional reform are found to have positive effects on technical efficiencies.

Keywords: Single-stage estimation procedure, Inter crop disparity, Technical efficiency.

JEL: Q12, Q14, Q16.

I

INTRODUCTION

Food insecurity and acute food price inflation are perhaps the biggest challenges before the Indian economy. At the same time, the traditional production function approach seems to be limited in 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, the average growth rate of total agricultural production in West Bengal fell sharply from about 5.8 per cent in 1980-81-1990-91 to about 2.5 per cent in 1991-92-2002-03. The output growth of oilseeds decelerated from about 12.2 per cent in the period 1980-81-1990-91 to only about 1.5 per cent in the period 1991-92-2002-03. The rate of foodgrains production declined from about 4.7 per cent in the first period to about 2 per cent in the second period. One alternative to intensive agricultural practices can be increase 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 minimise input use in the production of a given output vector. The efficiency measures are computed by comparing the observed performance with some

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The assistance offered by the Directorate of Agriculture, West Bengal, Bureau of Applied Economics and Statistics, (West Bengal) and the Library of Indian Statistical Institute, Kolkata for obtaining data and information is also gratefully acknowledged.

special standard which is the production frontier in case of TE. For some factors outside the producer's direct control he may fail to operate on the production frontier. These general parameters like public expenditure, credit, institutional reforms are different from the factors of production that cause movements along the frontier and can be controlled to increase (/reduce) technical efficiency (/inefficiency) in production.

II

LITERATURE REVIEW

Although a few studies on TE included the case of West Bengal (Shanmugam and Soundararajan, 2008; Ray, 1985; Kumbhakar, 1994) none of the studies focused on the factors that may have influenced technical efficiency/inefficiency in production. The general factors explaining efficiency levels can broadly be identified as public expenditure, access to credit and institutional reforms.

The role of public expenditure in one form or the other is acknowledged in the literature as an important inefficiency explaining variable for various countries (Bravo-Ureta and Pinheiro, 1993; Huang and Liu, 1994; Puig-Junoy, 2001; Coelli *et al*., 2003; Tong and Fulginiti, 2003; Headey *et al*., 2010). Credit plays an important role in explaining inefficiency (Kalirajan and Shand, 1986; Bravo-Ureta and Pinheiro, 1993; Rios and Shively, 2005; Singh, 2007; Adhikari and Bjørndal, 2009). So far as the agricultural sector is concerned any institutional reform does not come without a successful land reform programme. The increase in the share of small and marginal holdings is often viewed as an effect of a successful land reforms programme.

III

METHODOLOGY

Literature review suggests that there is a dearth of literature in analysing intercrop variation of TE for West Bengal as a whole and also in highlighting the role of factors like public expenditure, credit and land reform in explaining technical efficiency in the state. So, the present paper attempts to fill these gaps by estimating TE of major crops with the use of Stochastic Frontier Production Function approach, for the period from 1980-81 to 2002-03 and by analysing the impact of policy variables at the state level. State plan expenditure on agriculture and rural development is included as one form of public expenditure in the efficiency model in the present study. To account for changes in the technical inefficiency/efficiency due to credit, two forms of credit are taken into account-advances from land development banks and advances from scheduled commercial banks. Among the two most important sources of institutional credit to the rural sector, viz., the co-operative sector banks and the scheduled commercial banks, the former banks have larger share than the latter banks (Pandit *et al*., 2007), in terms of credit flow to the small and marginal farmers. Land development banks form an integral part of the co-operative sector. The effect of institutional reform, captured by land reform, on technical efficiency is tested by including the proportion of the small and marginal holdings in the inefficiency model.

The present analysis attempts to explain the role of the aforesaid factors on technical efficiency of various crops in West Bengal, as a case study. Seven major crops grown in West Bengal like, aman (*kharif* paddy), aus (pre-*kharif* paddy), boro (*rabi* paddy), jute, wheat, mustard and potato[1] are selected for the study. The selection of various crops has been done on the basis of their percentage shares in total area under the respective crop-category. Using this criterion, it is seen that almost 98 per cent of area under fibres comes under jute. Aman, aus, boro and wheat together contribute about 99 per cent of total area under cereals and 95 per cent of total foodgrains area. Potato covers about 71 per cent of area under miscellaneous crop category. The share of rapeseed-mustard in total area under oilseeds is 72 per cent. Aman, aus, boro and wheat account for more than 70 per cent of total foodgrains production. Almost 99 per cent fibre production is attributable to jute. Potato contributes about 82 per cent of production under miscellaneous crop category. Rapeseed-mustard accounts for about 69 per cent of oilseeds production. These seven crops account for more than 90 per cent of total agricultural production in the state. Such a disaggregated crop-specific analysis of TE is also helpful in identifying the crops that perform badly in terms of efficiency and hence need attention for improvement in efficiency of the agricultural sector as a whole.

IV

DATA AND MODEL

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) and Farrell (1957) proposed two measures of TE, viz., the input oriented measure and the output oriented measure. 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.

The present paper considers TE estimation using Stochastic Frontier Production Approach (SFPA) that followed Farrell's work and was developed independently by two almost contemporary papers - one by Meeusen and van den Broeck (1977) and another by Aigner *et al*. (1977). The Stochastic Frontier Analysis differed from the earlier analysis of deterministic production frontier by incorporating the random shocks lying outside the farm's control in addition to the inefficiency component.

Assume that the output of the farm is represented by the production function:

$$Y_i = f\,(Xi;\,\beta).\,e^{v_i} \qquad \text{….(1)}$$

where Y_i is the observed output for the i-th variable, i= 1,…,n farm.
f (Xi; β) is the production frontier,
X_i = the vector of N inputs,
β is the vector of parameters and
v_i represents a random variable seeking to capture all random factors outside the control of the farm (weather, natural disasters) that are likely to affect its maximum possible output. However, the i-th farm's observed output, Y_i, may lie below the frontier output for a variety of reasons, e.g., worker's having lower ability, poor management or inadequate monitoring effort (Ray 2004).

Such shortfalls are then attributed to the presence of technical inefficiency in the farm. Since actual output cannot exceed the frontier output, it implies—

$$Y_i = f\,(X_i;\,\beta).\,e^{v_i}.\,e^{-u_i} \qquad \text{….(2)}$$

with $u_i \geq 0$ yielding $\exp(-u_i) \leq 1$. The stochastic frontier production function assumes the relationship (2) for estimating output. The measure of TE (or as it is called in the literature, an output-oriented Farrell measure) of the i-th farm, TE_i, can be specified as the ratio between actual output to the frontier output:

$$TE_i = \frac{Y_i}{f\,(X_i\,;\,\beta).e^{v_i}} = e^{-u_i} \qquad \text{….(3)}$$

for $u_i \geq 0$. Since $e^{-u_i} \approx 1 - u_i$, the TE varies inversely with u_i and lies between 0 and 1. The maximum value 1 is attributed when $u_i = 0$, i.e., there is no inefficiency. An index of inefficiency can then be measured by the variable u_i.

The magnitude of technical efficiency across different farms can be estimated using the procedure of Battese and Coelli (1993) and Lundvall and Battese (2000). It may be added that in Equation (2) there are two error terms. One is u_i, a non- negative random variable having half-normal distribution, introduced so as to measure the magnitude of technical efficiency in production prevailing in the production of i-th farm. These random variables are assumed to be truncated at zero, i.e., $u_i \sim$ iid $N^+(0, \sigma_u^2)$. $u_i = 0$ when the farmer is efficient and thus is on the frontier and $u_i \geqq 0$ when the farmer is inefficient and below the frontier. Apart from this inefficiency component the usual error term, v_i is also there. v_i is the two-sided random disturbance term ; $v_i \sim$ iid $N(0,\sigma_v^2)$, i.e., v_i is assumed to follow a normal distribution with zero mean and constant variance, $\sigma_v^2\ \forall$ i. v_i and u_i are distributed independently of each other and of the regressors.

A farm- specific estimate of technical efficiency, following Battese and Coelli (1988) is given as

$$e^{-u_i} = E\,[\exp(-u_i)\,|\,\varepsilon_i\,] = \frac{\left[1-\Phi\left(\sigma_* - \frac{\mu_i^*}{\sigma_*}\right)\right]}{\left[1-\Phi\left(-\frac{\mu_i^*}{\sigma_*}\right)\right]} \exp\left(-\mu_i^* + \frac{\sigma_*^2}{2}\right) \qquad \text{....(4)}$$

where, $\mu_i^* = \frac{\mu\sigma_v^2 - \varepsilon_i\sigma_u^2}{\sigma_v^2+\sigma_u^2}$, $\sigma_*^2 = \frac{\sigma_u^2\sigma_v^2}{\sigma_v^2+\sigma_u^2}$ and $\Phi(\bullet)$ denotes the standard normal cumulative distribution function. For estimation purposes a specific functional form of Y (e.g. a Cobb-Douglas or a Translog) is needed.

The determinants of variations in efficiency across different farms can be found by using the single-stage estimation procedure developed through the works of Kumbhakar, Ghosh and McGuckin (1991), Reifschneider and Stevenson (1991), Huang and Liu (1994), and Battese and Coelli (1995) in which farms' efficiency is estimated and explained simultaneously. This approach assumes the inefficiency error component to have different means and a constant variance, i.e., $u_i \sim$ iid $N^+(\mu_i, \sigma_u^2)$. These mean inefficiencies are defined to be a function of the explanatory variables z_i, represented as

$$\mu_i = \delta' z_i \qquad \text{....(5)}$$

where δ' is the transpose of the vector of parameters δ. The vector z_i does not include Y_i.

The procedure is to estimate the parameters involved in the above functional relationship (5) along with the parameters of the frontier production function (2). The mean farm -specific TE in this case becomes

$$\mu_i' = \frac{(\delta' z_i)\sigma_v^2 - \varepsilon_i\sigma_u^2}{\sigma_v^2+\sigma_u^2} \qquad \text{....(6)}$$

The Maximum Likelihood estimates of the parameters of (2) and (5) are obtained using computer program FRONTIER 4.1.

Based on the above methodology, the present study attempts to measure TE for seven major crops like aus, aman, boro, jute, wheat, mustard and potato. For practical convenience the translog production function (Coelli, 1996), (FRONTIER Version 4.1) is assumed which can be represented as

$$\ln Y_i = \beta_0 + \sum_{j=1}^{l} \beta_j \ln X_{ji} + \sum_{j=1}^{l}\sum_{k=1}^{l} \beta_{jk} \ln X_{ji} \ln X_{ki} + v_i - u_i \qquad \text{....(7)}$$

($\forall$ i, i = 1,2,…, n); n is the number of crops. Henceforth, the subscript 'i' refers to observation for the i-th crop and Y_i = the observed value of output (here, yield/ acre in '000 tonnes) for the i-th crop ; X_{ji} = value of j-th input for the i-th crop; j= 1,2,…,l.

The inputs chosen are human labour (man-days) per acre (HL) and fertiliser ('000 tonnes) per acre (FR). Another included input is pesticides. But as the variable was found to have strong correlation with human labour and fertiliser (0.5 and 0.56, respectively and both are significant at 1 per cent level of significance), which could further be aggravated by the inherent nature of the translog specification, it was dropped from our analysis.

Thus the SFPF model can be represented as consisting primarily of the equations (5) and (7):

$$\ln Y_i = \beta_0 + \sum_{j=1}^{2} \beta_j \ln X_{ji} + \sum_{j=1}^{2} \sum_{k=1}^{2} \beta_{jk} \ln X_{ji} \ln X_{ki} + v_i - u_i \qquad \text{....(7a)}$$

Y_i = the observed yield per acre for the i-th crop, i = 1,2…7
X_{ji} = value of j-th input for the i-th crop; j= 1,2

Since the estimated production function is a Translog function the overall elasticity for the j-th input is given by

$$\eta_j = \beta_j + \beta_{jj} \ln X_j + \sum_{k \neq j} \beta_{jk} \ln X_k, \; k = 1,2 \qquad \text{....(7b)}$$

Apart from the levels of input use, there are some factors that lie outside the farmer's direct control and affect the inefficiency or efficiency level of the crops, too. Four such factors viz., state plan expenditure on agriculture and rural development, advances from land development banks, the proportion of area under small and marginal farmers and advances from scheduled commercial banks are selected in the final estimating equation as this combination gives the best fit on the basis of the LR-test statistic.[2] The expenditure variable and the bank credit figures are in real terms obtained by using the wholesale price index number for the primary articles as deflator. As for public expenditure data, state plan expenditure on agriculture and rural development, state plan expenditure on irrigation and flood control, expenditure on education, research and extension work in West Bengal had been included initially as separate explanatory variables. Among these, only the state plan expenditure on agriculture and rural development has turned out to be significant. The coefficients of other public expenditure variables including the expenditure on education, research and extension work in West Bengal are not statistically significant although positive. Expenditure on agriculture and rural development includes expenditures on the following heads under Agriculture and allied activities—(i) crop husbandry, (ii) animal husbandry, (iii) dairy development, (iv) fisheries, (v) forestry and plantation, (vi) food, storage and warehousing, (vii) co-operation etc. and under rural development – (i) special programmes for rural development, (ii) rural employment, iii) land reforms etc.

The mean inefficiency level expressed in (5) can thus be specified as

$$\mu_i = \delta_0 + \sum_{j}^{4} \delta_j \ln Z_{ji} + \sum_{j}^{4} \sum_{k}^{4} \delta_{jk} \ln Z_{ji} \ln Z_{ki}, \; i = 1,2\ldots7; \; j = 1,2,3,4, \; j \leq k \qquad \text{....(8)}$$

where, Z_{ji} is the value of the j-th exogenous variable for the i-th crop.
For the sake of simplicity, the constant term (δ_0), the cross –product terms and the square terms are assumed to be zero. So, equation (8) is estimated as,

$$\mu_i = \delta_1 \ln Z_{1i} + \delta_2 \ln Z_{2i} + \delta_3 \ln Z_{3i} + \delta_4 \ln Z_{4i} \;, \; i = 1,2\ldots7 \qquad \text{….(8a)}$$

where, Z_1 = state plan expenditure on agriculture and rural development,
Z_2 = advances from land development banks,
Z_3 = proportion of area under small and marginal farmers and
Z_4 = advances from scheduled commercial banks.

Public expenditure is expected to have a positive relation with efficiency and, hence, a negative relation with inefficiency. Both forms of credit are expected to augment TE (/reduce technical inefficiency). The institutional reform factor is expected to be positively associated with TE.

Data Sources

The reference period of our analysis is from 1980-81 to 2002-03. The study relies upon the Farm Management Survey reports on the Cost of Cultivation of West Bengal of various years for the yield figures and the three input data. The cost figures for the inputs are deflated by the respective Wholesale Price Indices to get the physical quantity of inputs. The data on state plan expenditure on agriculture and rural development (Rs.crores), advances from land development banks (Rs.crores), advances from scheduled commercial banks (Rs.crores) are collected from the various publications of *Economic Review of West Bengal Agriculture.* In the absence of crop-level disaggregated data on these variables the individual variables are deflated by the area under the relevant crop to get an approximate crop specific measure. The proportion of area under small and marginal farmers for different crops is calculated from data on area under different holding sizes given in the Agricultural Census, Government of West Bengal.

V

EMPIRICAL RESULTS

The maximum likelihood estimates of the parameters for the models (5a) and (6a) are presented in Table 1. The coefficient of log value of HL is statistically significant at 1 per cent level of significance. The associated elasticity is 0.433. Although the coefficient of log value of FR is negative and significant at 1 per cent level but the elasticity of output with respect to this input is positive (about 0.522).

The coefficients of δ_js show the inefficiency effects with respect to the exogenous variables like Z_1, Z_2, Z_3 and Z_4. The coefficients δ_1, δ_2 and δ_3 are significant respectively at 5 per cent, at 1 per cent and at 1 per cent levels of significance and have the expected negative signs suggesting that inefficiency level in crop production decreases with the increase in the plan expenditure on agriculture and rural development, in the advances from land development banks and in the proportion of the area under small and marginal farmers. The coefficient of Z_4 is positive and statistically significant at 1 per cent level of significance implying a significant positive relation with inefficiency. It should be noted that as mean inefficiency μ_i increases, the expected value of TE falls. Hence, the statistically significant inverse relation of Z_1, Z_2, and Z_3 with inefficiency level suggest that TE has been positively influenced by the first three variables.

Thus, increases in the state plan expenditure on agriculture and rural development and in the advances from land development banks improves the level of technical efficiency. These two factors, i.e., Z_1 and Z_2 clearly indicate that it is possible to improve technical efficiency through increases in public expenditures like expenditure on agriculture and rural development and also institutional credit from the land development banks. The positive coefficient of Z_3 shows that the increasing proportion of area under small and marginal farmers has positively affected technical efficiency. It clearly shows the favourable effect of land reform on efficiency. As against these three variables, Z_4 has negatively affected TE. As against these three variables, Z_4 has negatively affected TE. This negative relation of advances by the scheduled commercial banks with efficiency may be due to the fact that since these advances are made to the rural sector as a whole and not specific to the agricultural sector only, a major portion of these advances could be utilised to finance non-agricultural activities and thus, a lesser proportion of these advances is utilised for meeting agricultural needs. The literature also supports the diversion of agricultural credit taken from formal sources like commercial banks for the non-agricultural activities like paying-off high interest loans taken from the informal moneylenders (see Narayanan, 2015).

Further, the plots of TE for the crops and those of loan advances by the scheduled commercial banks to the rural area per acre (Z_4) suggest a heterogeneous picture. For aman TE declines for some initial years and then get stagnated. For aus, TE remains more or less stagnated. For boro TE plot shows an almost constant trend despite some fluctuations. For jute the trend for TE is slightly declining. But the plots of Z_4 for the same crops show a steady rising trend implying that in spite of the availability of credit TE of these crops fail to improve. Thus, for aman, aus, boro and jute, Z_4 definitely is not a constraining factor for the improvement in TE because for these crops TE fails to improve even if the supply of Z_4 has gone up. For wheat the trend for TE is slowly rising but Z_4 recorded an almost constant trend. For mustard despite the fall in Z_4 there was a slowly rising trend in TE. These trends again suggest that Z_4 is not the sole limiting factor behind the increase in TE for wheat and mustard. However, for potato the variable Z_4 shows negative trend while TE remains more or less constant though fluctuating. Thus, it may be possible that supply of Z_4 is a constraining factor for increase in TE. The above analysis of dissimilar trends of TE and the bank advances suggest that the lack of supply of credit does not always act as an operative constraint for the improvement in TE.

Table 1 also gives the value of γ which is the proportion of total variability of output (i.e., the deviation of the observed value from the frontier output) caused solely by the technical inefficiencies in production. A value of 0.96 for the parameter implies that inefficiency in input use is mostly responsible for output variations for the selected crops in the analysis.

TABLE 1. ESTIMATES OF PARAMETERS OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION

Variables (1)	Parameters (2)	Coefficient (3)	t-ratio (4)
Constant	β_0	-3.5953	-3.3676*
Ln HL	β_1	3.8707	6.0585*
Ln FR	β_2	-2.1796	-9.1665*
Ln (HL^2)	β_{11}	-0.6167	-6.4017*
Ln (FR^2)	β_{22}	0.2850	8.9964*
Ln (HLF)	β_{12}	0.7173	11.5735*
Ln (Z_1)	δ_1	-0.9404	-2.1651**
Ln (Z_2)	δ_2	-0.7134	-2.9318*
Ln (Z_3)	δ_3	-21.7783	-4.3995*
Ln (Z_4)	δ_4	3.1534	3.8357*
Sigma- sq	σ^2	0.5695	4.1881*
Gamma	γ	0.9617	49.5712*
Log likelihood function		-33.6532	

* and ** significant at 1and 5 per cent level of significance.

So far as the choice of the specification for the production function is concerned, two specifications are compared on the basis of a likelihood ratio test where the null hypothesis of a CD production function is tested against the alternative of a translog specification. The result of this test is presented in the first row of Table 2. The respective LR (χ^2) test statistic is statistically significant at 1 per cent level of significance. So, the null of CD function cannot be accepted. The last row of Table 2 presents the result of the test of null hypothesis of no inefficiency effect. On the basis of this test it is decided whether SFP is to be chosen over the OLS technique. As the relevant LR- statistic is statistically significant at 1 per cent level of significance, the SFP model is chosen over the OLS model.

TABLE 2. GENERALISED LIKELIHOOD RATIO TEST RESULTS FOR THE ESTIMATED STOCHASTIC FRONTIER PRODUCTION FUNCTION

Null Hypotheses (1)	Generalised likelihood ratio statistic (2)	Critical value at 1 per cent level of significance (3)
H_0: $\beta_{jk}=0$ ($j \leq k=1,2,3$) (Cobb-Douglas production function)	161.3884*	12.84
H_0: $\gamma=\delta_1=\delta_2=\delta_3=0$ (no inefficiency effect) @	132.655*	10.50

Notes: @ $\Rightarrow$ for critical values of the test involving γ the Table 1 of Kodde and Palm (1986) is consulted. * $\Rightarrow$ significant at 1 per cent level of significance.

The estimated yearly values of TE for each crop are given in Table 3. The last row gives us the annual average TE for the crops. The lowest average is recorded for mustard (0.34). Aman has the highest average TE (0.92).

TABLE 3. AVERAGE TECHNICAL EFFICIENCY ESTIMATES FOR THE CROPS

Crops / Year (1)	Aus (2)	Aman (3)	Boro (4)	Jute (5)	Wheat (6)	Mustard (7)	Potato (8)
1980-81	0.909	0.957	0.855	0.935	0.628	0.247	0.789
1981-82	0.781	0.883	0.819	0.909	0.575	0.297	0.885
1982-83	0.721	0.808	0.761	0.910	0.536	0.215	0.952
1983-84	0.719	0.903	0.757	0.908	0.617	0.284	0.923
1984-85	0.707	0.905	0.606	0.849	0.606	0.243	0.945
1985-86	0.819	0.876	0.780	0.792	0.629	0.308	0.823
1986-87	0.758	0.864	0.860	0.711	0.668	0.298	0.845
1987-88	0.729	0.902	0.851	0.776	0.684	0.282	0.492
1988-89	0.790	0.937	0.876	0.754	0.854	0.290	0.380
1989-90	0.819	0.925	0.812	0.812	0.627	0.340	0.428
1990-91	0.678	0.922	0.832	0.728	0.763	0.335	0.755
1991-92	0.387	0.922	0.690	0.806	0.791	0.270	0.528
1992-93	0.403	0.921	0.694	0.721	0.756	0.323	0.739
1993-94	0.911	0.930	0.804	0.840	0.643	0.020	0.536
1994-95	0.769	0.940	0.746	0.787	0.766	0.489	0.731
1995-96	0.903	0.914	0.727	0.775	0.684	0.423	0.381
1996-97	0.903	0.934	0.784	0.719	0.603	0.417	0.634
1997-98	0.874	0.929	0.869	0.718	0.746	0.438	0.612
1998-99	0.902	0.937	0.882	0.783	0.887	0.521	0.734
1999-2000	0.906	0.929	0.909	0.768	0.921	0.460	0.955
2000-01	0.906	0.937	0.931	0.858	0.942	0.508	0.961
2001-02	0.901	0.947	0.909	0.837	0.899	0.398	0.880
2002-03	0.900	0.943	0.886	0.806	0.890	0.383	0.835
Annual Average	0.787	0.916	0.810	0.804	0.727	0.339	0.728

It follows from the average figures that farmers have failed to utilise about 21 per cent, 8 per cent, 19 per cent, 20 per cent, 27 per cent, 66 and 27 per cent of the potential output of aus, aman, boro, jute, wheat, mustard and potato respectively. Thus, at one extreme, aman production has been the most efficient one with respect to the use of the inputs while on the other production of mustard can be augmented to a great extent through efficient use of inputs. However, the above crop-specific efficiencies cannot be averaged to provide an overall TE estimate for the state as a whole as only a few crops of the state are considered here. As for mustard, the inefficiency in production can be explained in terms of relative importance of this crop as against the major crop of West Bengal, viz., rice. Mustard is cultivated in the *rabi* season. Thus, it has to compete with boro rice, the most important cash crop of West Bengal produced in the *rabi* season. Area under boro being entirely under the high yielding variety (HYV), cultivation of this crop is not only input-intensive and costly but it also calls for higher managerial efficiency. Despite the fact that oilseeds (of which mustard is the most important one) production has gained momentum in

West Bengal from early 1980s onwards, boro production still dominates the agricultural economy in the *rabi* season and mustard gets less weights so far as allocation of resources among the crops are concerned. Also a steady decline in the per acre availability of commercial bank loans for mustard, it serves as an evidence for inadequacy of credit for this crop. Inter-crop competition for resources and inadequacy of commercial bank loans might partially explain the inefficiency of mustard.

VI

CONCLUSIONS AND POLICY IMPLICATIONS

The present study highlights an efficiency analysis focusing on seven major crops of West Bengal for the period 1980-81 to 2002-03. The stochastic frontier production function with two inputs is used for the present purpose. For estimation of inefficiency the study resorts to a single-step approach. The results highlight disparity in efficiencies among the crops selected. While at one extreme, aman production has been the most efficient one with respect to the use of the inputs while at the other production of mustard can be augmented to a great extent through efficient use of inputs.

The analysis clearly suggests that the mean inefficiency effects depend on the plan expenditure on agriculture and rural development, advances from land development banks, proportion of area under small and marginal farmers and advances from scheduled commercial banks. Increases in public expenditures like expenditure on agriculture and rural development and also in institutional credit from the land development banks can augment technical efficiency. The positive relation between efficiency and the proportion of area under small and marginal farmers emphasises that institutional changes supporting the distribution of land holding in favour of small and marginal farmers is conducive to technical efficiency changes. Although it is not possible to set any general policy guideline at the aggregate level, but for the seven selected crops, increase in public expenditure on agriculture and rural development, in credit from the land development banks and in the proportion of area under small and marginal farmers can be helpful to arrest any shortfall in production due to technical inefficiency.

Received April 2014. *Revision accepted April 2016.*

NOTES

1. Aus and jute are pre-*kharif* crops. The pre- *kharif* season refers to the period from March-April to June-July. Aman is the *kharif* crop. The *kharif* period starts with the onset of monsoon in June-July and lasts till October-November. Crops like boro, wheat, potato and mustard belong to the Rabi season which spans the period from October-November to February-March.

2. Besides the selected variables, some other variables -- like the State plan expenditure on irrigation and flood control, expenditure on education and research in West Bengal, loan advances from the Agricultural Credit Societies

in West Bengal, number of regulated sub-markets (agricultural) in West Bengal, the Gini ratio in the state, area irrigated by the government canals, total number of river lift irrigation in the State and total number of shallow tube wells in the State, the storage capacity provided by West Bengal State Warehousing Corporation and the length of roads in the state maintained by the zilla parishad (i.e., district level representation of local government) in West Bengal – were primarily included in the analysis as efficiency explaining factors. But the final estimating equation is chosen on the basis of the LR-statistic.

REFERENCES

Adhikari, C.B. and T. Bjørndal (2009), *Measuring the Extent of Technical in Nepalese Agriculture Using SDF and DEA Models*, Working No. 28/09, Institute for Research in Economics and Business Administration, Bergen.

Aigner, D.J., C.K. Lovell and P. Schmidt (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models", *Journal of Econometrics*, Vol.6, pp.21-37.

Battese, G.E. and T. J. Coelli (1988), "Prediction of Firm-Level Technical Efficiencies: With a Generalized Frontier Production Function and Panel Data," *Journal of Econometrics*, Vol. 38, pp.387-399.

Battese, G.E. and T.J. Coelli (1993), *A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects*, Working Papers in Econometrics and Applied Statistics, No. 69, Department of Econometrics, University of New England, Armidale, Australia.

Battese, G.E. and T.J. Coelli (1995), "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", *Empirical Economics*, Vol.20, No. 2, pp. 325-332.

Bravo-Ureta, B.E. and A.E. Pinheiro (1993), "Efficiency Analysis of Developing Country Agriculture: A Review of the Frontier Function Literature", *Agricultural and Resources Economics Review*, Vol. 22, No.1, pp.88-101.

Coelli, T.J. (1996), *A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation*, CEPA Working Paper 96/08, University of New England.

Coelli, T.J., S. Rahman and C. Thirtle (2003), "A Stochastic Frontier Approach to Total Factor Productivity Measurement in Bangladesh Crop Agriculture, 1961-92", Journal *of International Development*, Vol.15, No.3, pp. 321-333.

Debreu, G. (1951), "The Coefficient of Resource Utilization", *Econometrica*, Vol.19, No. 3, pp.273-292.

Farrell, M.J. (1957), "The Measurement of Productive Efficiency", *Journal of the Royal Statistical Society, Series A (General)*, Vol.120, No.3, pp.253-290.

Headey D., Md. Alauddin, D.S. P. Rao (2010), "Explaining Agricultural Productivity Growth: An International Perspective," *Agricultural Economics*, Vol.41, pp. 1–14.

Huang, C. and J. Liu (1994), "Estimation of a Non- neutral Stochastic Frontier Production Function", *Journal of Productivity Analysis*, Vol.5, No.1, pp.171–180.

Kalirajran, K., and R.T. Shand (1986), "Estimating Location-Specific and Firm-Specific Technical Efficiency: An Analysis of Malaysian Agriculture", *Journal of Economic Development*, Vol.11, pp.147–160.

Kodde, D. and Palm, F. (1986), "Wald Criteria for Jointly Testing Equality and Inequality Restrictions", *Econometrica*, Vol.54, pp.-1243-1248.

Koopmans, T.C.(1951), "An Analysis of Production as an Efficient Combination of Activities", in T.C. Koopmans (Eds.) (1951), *Activity Analysis of Production and Allocation*, Cowels Commission for Research in Economics, Monograph No. 13, Wiley, New York, U.S.A.

Kumbhakar, S.C. (1994), "Efficiency Estimation in a Profit Maximising Model using Flexible Production Function", *Agricultural Economics*, Vol.10, No.2, pp. 143-152.

Kumbhakar, S.C., S. Ghosh and J.T. McGuckin (1991), "A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in U.S. Dairy Farms", *Journal of Business and Economic Statistics*, Vol.9, No.3, pp. 279- 286.

Lundvall, K. and G. E. Battese (2000), "Farm Size, Age and Efficiency: Evidence from Kenyan Manufacturing Firms", *The Journal of Development Studies*, Vol.36, no.3, pp.146-163.

Meeusen, W. and J.van Den Broeck (1977), "Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error", *International Economic Review*, Vol.18, No.2, pp. 435-444.

Narayanan, S. (2015), *The Productivity of Agricultural Credit in India*, WP- 2015-01, Indira Gandhi Institute of Development Research, Mumbai.

Puig-Junoy, J. (2001), "Technical Inefficiency and Public Capital in U.S. States: A Stochastic Frontier Approach", *Journal of Regional Science*, Vol. 41, No.1, pp.75-96.

Ray, S.C. (1985), "Measurement and Test of Efficiency of Farms in Linear Programming Models: A Study of West Bengal Farms", *Oxford Bulletin of Economics and Statistics*, Vol. 47, pp.371-386.

Ray, S.C. (2004), *Data Envelopment Analysis: Theory and Techniques for Economics and Operations Research*, Cambridge University Press, Cambridge.

Reifschneider, D. and R. Stevenson (1991), "Systematic Departures from the Frontier: A Framework for the Analysis of Firm Inefficiency", *International Economic Review*, Vol.32, No.3, pp.715–723.

Rios, A.R. and G.E. Shively (2005), "Farm Size and Nonparametric Efficiency Measurements for Coffee Farms in Vietnam", Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island.

Shanmugam, K.R. and V. Soundararajan (2008), *Sources of Output Growth in Indian Agriculture during the Post- Reform Period*, Working Paper 26/2008, Madras School of Economics, presented at the 44th Indian Econometric Society Conference, Hyderabad.

Singh, S. (2007), "A Study on Technical Efficiency of Wheat Cultivation in Haryana", *Agricultural Economics Research Review*, Vol. 20, pp.127-136.

Tong, H. and L.E. Fulginiti (2003), "Chinese Regional Agricultural Productivity in the 1990's", Paper presented at the American Agricultural Economics Association Meetings, Long Beach, California.