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Factors affecting the technical efficiency of Boro rice production in Bangladesh a Cobb-Douglas stochastic frontier analysis

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Abstract

A Cob-Douglas stochastic frontier production function was estimated to determine the technical efficiency of Boro rice production in Bangladesh. Technical inefficiency effect model was also estimated simultaneously with stochastic frontiers to identify factors, which influence efficiency.

The coefficients of fertilizer, irrigation and human labour were found to be significantly positive in the stochastic frontier function, which meant with increase of fertilizer, irrigation and human labour the production of Boro rice will be increased. The coefficient of extension contact was negative and significant in the inefficiency effect model in Phulpur upazlla. This indicates that inefficiency decreases with the increase in extension contact. The mean technical efficiency was 92 percent. There appeared 8 percent inefficiency, which means that the farmers increase their production 8 percent without changing the input.

Keywords: Stochastic, Frontier function and Technical efficiency

Introduction

Agriculture has been playing a vital role in socio-economic progress and sustainable development through upliftment of rural economy, ensuring food security by attaining autarky in food grains production, poverty alleviation and so on. It contributes 21.91 percent to the country's GDP. Agricultural sector in Bangladesh is largely dominated by paddy production. About 75.77 percent of the total cropped area is devoted to rice cultivation (Statistical Yearbook of Bangladesh, 2004).

In normal years, the production of rice usually is about 25 million tons or so. If there is a bumper crop, it may exceed 27 million tons. Nevertheless, food problem is one of the major problems of our country. Bangladesh still has a chronic shortage of grain especially in rice. Of course, the food grains rate, now-a-days runs ahead the population growth rate. During the last decade (1990/91 to 1995/96) production of paddy increases at the rate of 2.83 percent annually (Nantu, 1998).

We should increase our productive efficiency. Efficiency of a production unit may be defined as how effectively it uses various resources for the purpose of profit maximization, given the best production technology available.

Schultz (1964) advanced the celebrated hypothesis that farm families in developing countries were "efficient but poor", and thus that "there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture". This hypothesis is an enduring view in the literature on development economics. It has led policy makers to believe that; improvement could not be achieved since the farmers adhere to their existing outdated production technologies.

Empirical studies suggests that farmers in developing countries fail to exploit fully the potential of a technology making inefficient decision due to various reason of which management capacity is an important one. For example, Ali and Flinn (1989) concluded that the profit of rice farmers in Pakistan's Punjab could be increased by 28% through improved efficiency, which is positively related with education and timelines of input use. Belbase and Grabowski (1985) have estimated average technical efficiency for Nepalese agriculture amounting to 84% for rice production suggesting there is a potential of 26% increase in the farm output. Reviews made by Battese (1992), and Bravo-Ureta and Pinheiro (1993) summarizes various studies found in the literature. Thus, the "poor but efficient hypothesis" may have overlooked important potential for increasing agricultural productivity.

In Bangladesh, where resources are scarce and opportunities for new technologies are lacking efficiency (or inefficiency) studies will be able to show that it is possible to raise productivity by improving efficiency without new investment or developing new technology. It is generally assumed that in our country farmers are inefficient in producing rice crops and there are significant efficiency differences among regions and farmers groups. After the measurement of efficiency differences, proper measures can be taken to reduce them. In the productive efficiency area, we are familiar with three types of efficiency namely, technical, allocative and economic efficiencies. In this study technical efficiency of boro rice production for the farmers of the study area has been estimated, which refers to the ability of a firm to obtain maximal output from a given set of inputs under certain production technology. After the measurement of efficiency and identifying the influencing factors for growing Boro rice by the farmers of the study area various policy, like price policy, input supply policy, extension policy and distribution policies can be adopted with a view to augmenting total output.
The objectives of this paper, therefore, are:

i) to measure the productivity of Boro rice production in the study area.
ii) to estimate and compare productive (technical) efficiency of Boro rice farmers in the study area.
iii) to identify the socio-economic factors affecting the level of technical efficiency of Boro rice farmers in the study area.
iv) to suggest some policies to increase productivity and efficiency of rice production

Materials and Methods

For this study, primary data were used. To collect the primary data from the farmers of the study area, stratified sampling technique was adopted. A preliminary survey was conducted in the study areas in order to have potential idea about relevant information. At first a sampling frame of farmers was constructed with the help of village leaders and some other relevant people. Afterwards stratified random sampling method was used to select the boro rice farmers for the study. The sample was composed of small (below 1.00 hectare), medium (1.00 - 3.00 hectare), and large (above 3.00 hectare) farms (BBS, 2004). A total of 120 Boro rice farmers were interviewed in this study, of which 30 were small, 18 were medium, and 12 were large farmers from Mymensingh sadar upazila and the rest 60 farmers constituting above farm groups were taken from Phulpur upazila of Mymensingh district. The data were collected during the leisure time of respondents and it was started on January 2006 and completed by March 2006.The data were collected from rice farmers using a direct interview method through pre-tested questionnaires. The questionnaire included 200 questions covering different aspects of rice farmers, such as, age, education, farming experience of farmers, land distribution, production of rice, price of rice, production of other crops produced by farmer, purchasing price of seed or seedling and selling price of rice etc.

In order to estimate the level of technical efficiency in a manner consistent with the theory of production function we have specified a Cobb-Douglas type stochastic frontier production function. Cobb-Douglas form of production function has some well-known properties that justify its wide application in economic literature (Henderson and Quandt 1971). The explicit Cobb-Douglas Stochastic frontier production function for Boro rice is given below:

$$\ln Y_i = \ln \beta_0 + \sum_{i=1}^{9} \beta_i \ln X_i + \beta_{10} EDU + \beta_{11} EXT + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, Y = Output per farm

X_1 = Area under rice crops (hectare)
X_2 = Human labour (man-days)
X_3 = Seed (kg)
X_4 = Fertiliser (kg)
X_5 = Manure (kg)
X_6 = Tractor cost (Tk.)
X_7 = Irrigation cost (Tk.)
X_8 = Age of farm operator (year)
X_9 = Experience of farmer (year).
EDU = Education of farmers (year of schooling)
EXT = Extension service (Dummy variable which receives values "1" if farm had contact with extension agents and receives "0" otherwise).

V_i are assumed to be independently and identically distributed random errors, having N (O, $\sigma^2 v$)-distribution and U_i are non-negative one-sided random variables, called technical inefficiency effects, associated with the technical inefficiency of production of the farmers involved. It is assumed that the inefficiency effects are independently distributed with a half normal distribution $\{U \sim |N(0, \sigma^2_u)|\}$.

The model for the technical inefficiency effects in the stochastic frontier of equation (1) is defined by

$$U_i = \delta_0 + \delta_1 AGE_i + \delta_2 EXPERIENCE_i + \delta_3 EDU_i + \delta_4 CONTACT_i + \delta_5 FARMSZi + W_i \ldots\ldots. \quad (2)$$

Where,

AGE represents age of farm operator (in years)
EXPERIENCE is the experience of the farm operator (in years).
EDU is defined as earlier
CONTACT represents extension contact by the extension agents to the farmers
FARMSZ represents Farm size; and

the W_i are unobservable random variables, which are assumed to be independently distributed with a positive half normal distribution.

The β and δ coefficients are unknown parameters to be estimated, together with the variance parameters which are expressed in terms of

$$\sigma^2 = \sigma^2_u + \sigma^2_v \text{ and} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\gamma = \sigma^2_u/\sigma^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where the γ-parameter has value between zero and one. The parameters of the stochastic frontier production function model are estimated by the method of maximum likelihood, using the computer programme, FRONTIER Version 4.1c.developed by Coelli (1996a).

It is important to note that the above model for the inefficiency effects (equation 2) can only be estimated if the inefficiency effects are stochastic and have a particular distribution specification. Hence there is interest in testing the null hypothesis that the inefficiency effects are not present, $H_0 = \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$; the inefficiency effects are not stochastic, $H_0 : \gamma = 0$; and the coefficients of the variables in the model for the inefficiency effects are zero, $H_0 : \delta_1 = \delta_2 = ...= \delta_5 = 0$. These and other null hypotheses of interest will be tested using the generalised likelihood-ratio test and t-test. The generalised likelihood-ratio test requires the estimation of the model under both the null and alternative hypotheses. Under the null hypothesis, $H_0 = \gamma = 0$, the model is equivalent to the traditional average response function, without the technical inefficiency effect, U. The test statistic is calculated as

$$LR = -2\{\ln [L(H_0)/L(H_1)\}] = -2\{\ln[\ln(H_0)] - \ln[L(H_1)]\} \text{ .... } (5)$$

where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypotheses, H_0 and H_1, respectively.

If H_0 is true, this test statistic is usually assumed to be asymptotically distributed as a chi-square random variable with degrees of freedom equal to the number of restrictions involved. However, difficulties arise in testing H_0: $\gamma = 0$ because $\gamma = 0$ lies on the boundary of the parameter space for γ. In this case, if H_0: $\gamma = 0$ is true, the generalised likelihood-ratio statistic LR, has asymptotic distribution which is a mixture of chi-square distributions, namely $\frac{1}{2} \chi_0^2 + \frac{1}{2} \chi_1^2$ (Coelli 1995a).

The technical efficiency of a farmer at a given period of time is defined as the ratio of the observed output to the frontier output, which could be produced by a fully efficient firm, in which the inefficiency effect is zero. Given the specifications of the stochastic frontier model (equation 1) - (equation 2), the technical efficiency of the i-th farmer can be shown to be equal to $TE_i = \exp. (-U_i)$

$$= \exp.\{-E(U_i/\varepsilon_i)\}.$$
$$= 1 - E (U_i/\varepsilon_i) \text{ .... } (6)$$

Thus the technical efficiency of a farmer is between zero and one and is inversely related to the inefficiency effect. The efficiencies are predicted using the predictor that is based on the conditional expectation of exp $(-U_i)$ given composed error $\varepsilon_i = (V_i-U_i)$.

The mean technical efficiency or the mathematical expectation of the farm-specific technical efficiencies can be calculated for given distributional assumptions for the technical inefficiency effects. The mean technical efficiency can be defined by

$$\text{Mean T.E.} = E [\exp. \{-E (U_i/\varepsilon_i)\}] = E \{1-E (U_i/\varepsilon_i)\}] \text{ .... } (7)$$

Because the individual technical efficiencies of sample farms can be predicted, an alternative estimator for the mean technical efficiency is the arithmetic average of the predictors for the individual technical efficiencies of the sample farms. This is what is calculated by FRONTIER (Version 4.1c) Package. With the help of FRONTIER (Version 4.1c) the parameters of the stochastic frontier production function (equation 1) are estimated, together with region-specific technical efficiencies and mean technical efficiency for the farms involved.

Results and Discussion

Table 1 shows the summary statistics of variable of C-D stochastic frontier production function and inefficiency effect model. It is revealed that the productivity is higher in Sadar upazila (5517.25 Kg) than in Phulpur upazila (4763.65 Kg). There is a significant difference in the production of Boro rice between the farmers of two regions (Z=4.73**). The amount of human labour is measured as man- days, which usally consist of 8 hours. The study reveals that the farmers of Sadar upazila used more human labour (170.79 man-days) than the farmers of Phulpur rpazila (145.57 man-days). There is a significant difference in per hectare human labour used by farmers between the two regions (Z=2.72**). The average age of farmers of Phulpur (43.62 years) is signifivcantly higher than that of Sadar upazila (38.30 years). There is significant variation of average family size of two regions. The farmers of Phulpur upazila used significantly more fertilizer (473.79 kg) than Sadar upazila (396.17 kg). There is a significant variation of tractor cost which is Tk. 2960.50 and Tk. 2435.82 in Sadar and Phulpur upazila.

Table 1. Summary statistics for variables in the Cobb-Douglas stochastic production function for Boro Rice farmers in two-selected area

	Sample Mean		
	Mymensingh Sadar	Phulpur Upazila	Z-value
Output per hectare (kg)	5517.254 (118.002)	4763.652 (106.869)	4.733**
Area (hectare)	1.84 (0.19)	2.031 (0.32)	0.49
Human labour (man-days/hectare)	170.79 (7.73)	145.576 (5.15)	2.715**
Seed (Kg/hectare	70.83 (3.67)	67.23 (5.01)	0.58
Fertiliser (Kg/hectare)	396.17 (13.54)	473.79 (17.14)	3.55**
Manure (Kg/hectare)	2496.66 (498.39)	3064.71 (444.16)	0.85
Tractor cost (Tk/hectare)	2960.50 (76.18)	2435.82 (61.01)	5.37**
Irrigationcost (Tk/hectare)	5200 (131.36)	7817.99 (291.96)	8.17**
`Age of farm operator (Year)	38.30 (1.04)	43.62 (1.38)	3.07**
Farming experience (Year)	30.38 (2.21)	26.76 (1.71)	1.29
Familysize (Number)	5.74 (0.17)	6.32 (0.20)	2.17*
Education of farm operator (Year of Schooling)	5.90 (0.61)	6.00 (0.60)	0.118

(Figures within parentheses indicate asymptotic standard error; *and ** indicate significance at 0.05 and 0.01 probability level respectively)

Table 2 presents the maximum likelihood estimates of the stochastic production frontier. For comparison purposes OLS estimates are also shown.

It is revealed that the coefficient of education is negative and insignificant which is unexpected but not surprising. It means that the rate of output decreases with the increase in education of farmers. There are many reasons for this. One of the reasons may be that most of the educated farmers were found to have alternative income sources (service, business etc.) and they are not very attentive to the farming practices and in that case they depend mostly on the fixed laborers- those who have minimum education or no education at all. Another reason is that most of the educated farmers are village leaders and they were found to be busy with the problem of villagers and many of them were also engaged in local or national politics. For that reason they have little time for there farming practices. Indeed, there have been many empirical tests of the effect of education on farm productivity. These generally have employed Cobb-Douglas production functions. Lockheed *et al.* (1980) surveyed many of these studies. Although they conclude that the effect of education on productivity is positive, a significant result of studies (40%) found earlier a negative effect or no impact on productivity. The function coefficient in the frontier model is 0.837 and in OLS models is 0.835, showing decreasing returns to scale for Boro rice.

The coefficient of Area, human labour, fertilizer and irrigation were found to be significantly positive. That meant with increase of these coefficient the production of Boro rice will be increased. The coefficient of seed, manure is negative but insignificant.

The coefficient of extension service, tractor cost and experience are positive but not significant.

The coefficient of Age of farmer is negative and significant which means that the age of farmer has negative impact on production. This is because the older farmers are likely to be more conservative and thus be less willing to adopt new practices, thereby perhaps having negative impact in agricultural production i.e., Boro rice.

Table 2. Ordinary least squares (OLS) estimates of a Cobb-Douglas (C-D) production Function and Maximum Likelihood (ML) Estimates of a C-D Stochastic Production Frontier

Variables	Boro rice	
	OLS estimates (std. error)	ML estimates (Asymptotic std. error)
Intercept	2.6755** (0.4237)	2.7365** (0.3972)
Education (Edu)	-0.0149 (0.0387)	-0.0159 (0.0371)
Extension (Dummy)	0.0020 (0.0040)	0.0020 (0.0039)
Area	0.0860* (0.0359)	0.0844* (0.0347)
Human Labour	0.3071** (0.0533)	0.3090** (0.0517)
Seed	-0.0035 (0.0477)	-0.0025 (0.0456)
Fertilizer	0.1572** (0.0509)	0.1592** (0.0493)
Manure	-0.0030 (0.0081)	-0.0028 (0.0078)
Tractor	0.1004 (0.0555)	0.0991 (0.0526)
Irrigation	0.3810** (0.0498)	0.3800** (0.0472)
Age of farmer	-0.2535** (0.0901)	-0.2514** (0.0862)
Experience	0.0769 (0.0416)	0.0765 (0.0395)
Function co-efficient	0.8357	0.8376
F-statistic model	211.443**	
Adj. R^2	0.956	
Variance parameters (σ^2)	0.0319	0.0347 (0.0239)
γ	-	0.2711 (0.8775)
Log-likelihood function	42.6380	42.6514

(Figures within parentheses indicate asymptotic standard error; *and ** indicate significance at 0.05 and 0.01 probability level respectively)

The coefficient of multiple determination for boro rice is 0.956 which means that 95.6% of the variation in total production is explained or contributed to by the explanatory variables used in the model. The model (OLS) is well fitted to the data since the F-statistic used to test the goodness of fit was found to be highly significant (significant at 1% level).

Table 3 shows the simultaneous estimation of the maximum likelihood estimates for parameters of the Cobb-Douglas stochastic production frontiers and the technical inefficiency effect model for Boro rice. If we estimate the technical efficiency effects frontier by the FRONTIER 4.1c Package, we can simultaneously estimate the stochastic frontier and technical inefficiency effect model. Kumbhakar, Ghosh and McGucKin (1991), Reifschneider and Stevension (1991), Huang and Lui (1994) and Battese and Coelli (1995) specify stochastic frontiers and models for the technical inefficiency effects and simultaneously estimate of all the parameters involved. This one-stage approach is less objectionable from a statistical point of view and is expected to lead to more efficient inference with respect to the parameters involved. However, most of the researchers used two-stage approach to explain the differences in technical efficiencies of farmers.

Table 3. Maximum likelihood (ML) estimates for parameters of Cobb-Douglas stochastic production frontier function and technical inefficiency effect model for Boro rice

Variables	Parameters	Boro rice
Stochastic Frontier: intercept	β_0	2.6168** (0.5786)
Human Labour	β_1	0.2836** (0.0716)
Seed	β_2	0.0094 (0.0702)
Area	β_3	0.0842 (0.0648)
Fertilizer	β_4	0.1597** (0.0496)
Manure	β_5	-0.00048 (0.01323)
Tractor	β_6	0.0927 (0.0622)
Irrigation	β_7	0.3605** (0.0506)
Age of Farmer	β_8	-0.06605 (0.23003)
Experience	β_9	-0.02881 (0.13182)
Education (Edu)	β_{10}	0.00440 (0.00612)
Extension (Dummy)	β_{11}	0.00903 (0.07257)
Inefficiency model: intercept	δ_0	-0.682381 (0.838292)
Age	δ_1	0.375075 (0.511264)
Experience	δ_2	-0.223122 (0.315562)
Education	δ_3	0.719231 (0.011891)
Extension contact	δ_4	0.093847 (0.213591)
Farm size	δ_5	-0.060775 (0.041680)
Variance parameters	σ^2	0.033050 (0.027990)
	γ	0.243352 (0.142928)
Log-Likelihood Function		43.914170

(Figures within parentheses indicate asymptotic standard error; *and ** indicate significance at 0.05 and 0.01 probability level respectively)

The first stage involves the estimation of a stochastic frontier production function and the prediction of farm-level technical inefficiency effects (or technical efficiencies). In the second stage, these predicted technical inefficiency effects (or technical inefficiencies) are related to farmer-specific factors using ordinary least squares (OLS) regression (Kalirajan 1981; Parikh and Shah 1994). This two-stage approach is less agreeable from a statistical point of view.

Table 3 reveals that the coefficients of Human labour, Fertilizer and Irrigation are positive and significant which means with the increase of these variables the production of Boro rice will be increased. In the inefficiency effect model there is no coefficient found to be significant.

Table 4 show that the coefficients of human labor, fertilizer, and extension service in the stochastic frontier production functions are positively significant in the both region. Which means that the production of Boro rice increases with the increase of these variables. In Phulpur upazila the coefficient of manure, irrigation and area are significantly positive.

Table 4. Maximum likelihood (ML) estimates for parameters of Cobb-Douglas stochastic production frontier functions and technical inefficiency effect model for Boro rice in the selected regions

Variables	Parameters	Boro Rice	
		Mymensingh	Phulpur
Stochastic Frontier: intercept	β_0	6.961253** (0.991106)	3.001974** (0.286443)
Human Labour	β_1	0.429900* (0.104560)	0.484515** (0.050720)
Seed	β_2	-0.044242 (0.890488)	0.003118 (0.050811)
Area	β_3	0.667252 (0.585963)	0.048769* (0.022704)
Fertilizer	β_4	0.041087* (0.016960)	0.167422** (0.044808)
Manure	β_5	-0.005661 (0.037125)	0.031794* (0.013299)
Tractor	β_6	-0.031713 (0.837004)	0.006427 (0.053517)
Irrigation	β_7	0.195194 (0.730760)	0.339651** (0.054846)
Age of Farmer	β_8	-0.294883 (0.866918)	-0.064071 (0.146722)
Experience	β_9	0.098720 (0.374011)	-0.087948 (0.071245)
Education (Edu)	β_{10}	-0.031020 (0.943544)	-0.189656** (0.031573)
Extension (Dummy)	β_{11}	0.050646* (0.025128)	0.031683** (0.003258)
Inefficiency model: Intercept	δ_0	0.003181 (0.983648)	-0.419788 (0.857059)
Age	δ_1	0.016201 (0.771687)	0.314284 (0.344682)
Experience	δ_2	0.001168 (0.501393)	-0.249125 (0.170108)
Education	δ_3	-0.038068 (0.341864)	0.034150** (0.011415)
Extension contact	δ_4	-0.011127 (0.431322)	-0.894331** (0.169528)
Farm size	δ_5	-0.015213 (0.565186)	0.039741* (0.017900)
Variance parameters	σ^2	0.024282 (0.030597)	0.052008** (0.008215)
	γ	0.182748 (0.971266)	0.999999** (0.000887)
Log-Likelihood Function		31.383578	33.865892

(Figures within parentheses indicate asymptotic standard error; *and ** indicate significance at 0.05 and 0.01 probability level respectively)

In technical inefficiency effect model in Mymensingh sadar upazila there is no significant effect on education but in Phulpur upazila the coefficient of education is found to have significantly positive effect. This means that technical inefficiency increases with the increase in education. This is unexpected but not entirely surprising since most of the educated farmers have alternative income sources and they do not depend fully on agriculture for their livelihood.

The coefficient of farmsize is found to be significantly positive in Phulpur upazila, which indicates that technical inefficiency increases with the increase in farmsize. That is farmers with small farms tend to have smaller technical inefficiency effects than the farmers with larger operations. According to Parikh and Shah (1994) said that small farmers seemed to be more efficient than large farmers. The coefficient of extension service is significantly negative which means that the technical inefficiency effect decreases with increase in the level of extension contacts of extension agents with the farmers. The same result was found by Kalirajan (1984), Herdt and Mandac (1981), in the study of technical efficiency of rice farmers in Philippines.

Table 5 reveals that technical efficiency varies from 69% to 98% for Boro rice. The mean technical efficiencies is 92% in the study area. There appears to be 8% technical inefficiencies at aggregate level for Boro rice.

Table 5. Frequency distribution of technical efficiency estimates from Cobb-Douglas stochastic frontier (Aggregate)

Efficiency Level (%)	Technical efficiency
Less than 65	0
65 – 70	1 (0.83)
70 – 75	2 (1.67)
75 – 80	2 (1.67)
80 – 85	7 (5.83)
85 – 90	17 (14.17)
90 – 95	54 (45.00)
95 – 100	37 (30.83)
Total number of farm	120 (100)
Mean Efficiency	92%
Maximum Efficiency	98%
Minimum Efficiency	69%

(Figures within parentheses indicate percentages)

Test of Hypothesis

We have already tested different coefficients on the Cobb-Douglas stochastic production frontiers and technical inefficiency effect models with the help of t-test. Here we are going to test the coefficients of region-specific variables on the technical inefficiency effect models using the generalised likelihood-ratio statistic, LR. Coelli (1995) suggested that the one-sided generalised likelihood ratio (LR) test should be performed when ML estimation is involved because this test has the correct size (i.e., probability of type I error). We were interested in testing the null hypothesis that the inefficiency effects were not present.

In other words, the null hypothesis is that there are no technical inefficiency effects in the model. That is, $H_0 : \gamma = \delta_0 = \delta_1 = ... = \delta_5 = 0$.

Table 6. Test of hypothesis for coefficients of the explanatory variables for the technical inefficiency effects in the Cobb-Douglas stochastic frontier production functions

Null Hypothesis	Log-Likelihood value	Test Statistic LR	Critical Value	Decision
$H_0 : \gamma = \delta_0 = \delta_1 = ... = \delta_5 = 0$				
All regions,	43.91	2.55	12.02	Accepted
Region-Specific :				
Mymensingh Sadar Upazila	31.38	12.34	12.02	Rejected
Phulpur Upazila	33.86	19.58	12.02	Rejected

Table 6 reveals that there is no significant technical inefficiency effect in the production of Boro rice in all regions since the null hypothesis is accepted for Boro rice. For region-specific efficiency measures for Boro rice, there are significant technical inefficiency effect in both Mymensingh Sadar upazila and Phulpur upazila of Mymensingh district since the null hypothesis is rejected in both regions.

Conclusion

In the productivity analysis the farmers of Mymensingh Sadar attained higher output per hectare (5517.254 Kg) than the Phulpur upazila (4763.652 Kg).

In the Cobb-Douglas stochastic frontier production function the coefficients of area, human labour, fertilizer, irrigation and extension service have significantly positive contribution to the increase in production of Boro rice. The farm specific technical efficiency varied from 69% to98%. The mean technical efficiency estimated from Cobb-Douglas production frontier was 92%.This implies that the production of Boro rice per farm can be increase 8% keeping the input constant.

There were significant technical inefficiency effects in the production of Boro in Phulpur upazila. The effect of farm size and education was found to have positive impact to increase the technical inefficiency. That is, technical efficiency increased with the increase in education and farm size. The effect of extension service was significantly negative. This indicated that the technical inefficiency effect decreased with the increase in extension service.

The variance ratio parameter γ associated with the variance in the technical inefficiency effect model was significant. It also indicates that there were inefficiency effects in the production of rice.

Policy Recommendations

From the above study no concrete policy implication can be drawn since it was micro-study covering a very small area of Bangladesh. Nevertheless, on the basis of various findings of the study the following recommendations may be useful for policy formulation.

1. Due to the importance of extension services on agricultural production as shown in this study, the government of Bangladesh should take the initiative to extend agricultural extension services to all farmers in order to enhance sustainable growth.

2. Educated farmers were found be technically less efficient. Several factors were identified to be responsible for the unusual impact of this finding: (i) Most of the educated farmers were found to have alternative income sources (service, business etc.) and they were not very attentive to their farming practices. They mostly depend on fixed labourers with minimum education levels. (ii) Most of the educated farmers were village leaders and were found to be engaged in local or national politics. The empirical evidence of a negative relationship between education and efficiency should, therefore, be interpreted with caution and the following general recommendations can be made in this area: (i) Education should be one of the top priorities of the government to develop the necessary human capital for sustainable development and (ii) the government should make the labour market more flexible to use the educated farmers in other sectors than agriculture.

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