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Efficiency Measurement of Rice Producers in South-West Region of Bangladesh

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Abstract: *This research aims to measure the production efficiency, more specifically technical efficiency of the hybrid rice producing farms of Dighalia Upazila in Khulna District from south west region of Bangladesh, based on cross-section data collected from 80 farmers chosen randomly from the study area in 2013. In order to estimate technical efficiency, stochastic production frontier approach has been used. Estimates of OLS demonstrate that labor, fertilizer, and herbicide have positive and significant influence on rice production; on the other hand, land and seed show significant negative relation with output. However, MLE estimates indicate that land, labor, seed, and fertilizer are positively and significantly related with rice production. Study finding also indicates that technical efficiency in rice production ranges from 28 percent to 97 percent with a mean of 75 percent. Estimated gamma value is 0.94, which, confirms that there is presence of inefficiency in the production system. An attempt to identify the variables responsible for observed variations in technical efficiency among the farmers has been made by considering socioeconomic variables like age, gender, family size, education, farm size, farming experience, land fragmentation, and formal training, but, they are found to be statistically insignificant.*
Keywords: *Rice Production, Technical Efficiency, Stochastic Frontier Approach, Technical Efficiency Index, Inefficiency Factors*

I. Introduction

1.1 Background of the study

Agriculture, one of the traditional and significant sectors plays a vital role not only in securing food supply and economic development of countries of the world [1] but also in upgrading the livelihood of the people of Bangladesh [2]. Significance of this sector is manifested in recent statistics, which shows that agriculture sector contributes 19.41 percent of total GDP along with occupying 47.5 percent of the total labor force of Bangladesh [3]. In both pre-liberation and post-liberation periods, agricultural sector was the main source of economic activities. Though its direct domination over the economy started decreasing from the next decades, but the indirect significance with respect to whole economy is still remarkable. Presently, agriculture sector is strongly supporting growth in several sectors such as service, specially the wholesale and retail trade; hotel and restaurants, transport and communication, etc. [4]. With an area of 147570 square kilometers, Bangladesh is heavily burdened by a huge population of near about 16 crore [5]. Principal agricultural crops of the country are rice, jute, sugarcane, potato, pulses, wheat, tea and tobacco [6]. Among them rice is the staple food of the people of the country. Since the cultivable land of the country is decreasing day by day due to high growth of population, it becomes challenging to provide enough food stuffs for the growing population. Hence, it is imperative to concentrate on increase of production efficiency in rice production. Traditionally, at all spheres of agriculture, production level in Bangladesh is below the optimum level for various reasons. This implies that there is still room for increasing the production level given the current state of technology [4].

1.2 Statement of the problem

Although agriculture is the main occupation of the people of Bangladesh, production level is still unsatisfactory in this sector. Each year, a lot of food stuffs are imported to meet up the excess demand. In fiscal year 2012-2013, around 11.77 lakh metric ton food stuffs have been imported as on February 2013, whereas the total amount of production was 348.85 lakh metric tons in the previous year [3]. On the other hand, the total cropped land area in 2008-2009 becomes 35616 thousand acres from 35267 thousand acres in 1999-2000 [6]. Above information implies that the amount of cultivated area has not increased significantly in the last decades to keep pace with the increasing demand for food. That is, cause behind insufficient production of food crops is not only shortage of enough land but also presence of inefficiency in the production process in the country. So, it is crucial to understand the current status of production efficiency in rice production and identify the factors influencing the same. Underlying information is, therefore, vital for policy formulation regarding advancement of agriculture sector to meet the demand of teeming millions through making it more efficient.

1.3 Literature review

Credit of measurement of efficiency goes to Farrell who defines efficiency as the ability to produce a given level of output at lowest cost [7]. He classifies the concept of efficiency into technical efficiency and allocative efficiency. According to him, technical efficiency is the ability of the farm to produce maximum level of output given a fixed level of inputs. On the other hand, allocative or price efficiency is attained when marginal value product of a factor of production equates its price. Later scholars introduced another term of efficiency i.e. economic efficiency. By them, economic efficiency is defined as the statistical product of technical efficiency and allocative efficiency [8].

Elaborate and extensive explanation of different types of efficiency has been given by various scholars in later periods. Among them Greene states that technical efficiency refers to the performance of the process of transforming a set of inputs into a set of outputs [9]. Level of technical efficiency of a particular farmer is measured through a comparison of relationship between observed production and some ideal or potential production. However, Enwerem and Ohajianya define technical or production efficiency as the ability of making use of implements or mechanical skill to bring about maximum output for a given set of inputs [10]. In case of measurement of efficiency of the farmers, Khanal et al. conclude that the efficiency of the farmers can be measured on the basis of production (technical efficiency), cost (allocative efficiency) and profit (profit efficiency) [11]. In addition Olayiwola adds that technical efficiency in production is the ratio of physical amount of output and factor input; the greater the ratio, the greater the magnitude of technical efficiency [12]. They also state that while technical efficiency is only concerned with the physical relationship between input and output; allocative efficiency takes into account price relationship in addition to the physical relationship. Supporting their view Shehu et al. express that the measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier [13]. An important assumption relating to efficiency measurement is that firms could have operated on the outer boundary of production function, that is, on their efficiency frontier. When firms fail to do so, they are considered to be technically inefficient.

In literature, there are different approaches to measure production efficiency. In broad sense, there are two categories namely parametric approach and non-parametric approach. Under parametric approach, stochastic frontier method and under non parametric approach data envelopment analysis have been widely used. Both methods have advantages and disadvantages. Stochastic frontier method considers the random shock in the production caused by exogenous factors out of the control of the producers. On the other hand, data envelopment analysis does not consider it. Hence, in the existing literature, most of the researchers are found to apply stochastic frontier approach to measure efficiency.

Stochastic production frontier function model of Cobb-Douglas type has been used by Dlamini et al. to incorporate technical inefficiency effects on the production of sugarcane in Swaziland [14]. They have found that the level of technical efficiency varied widely among the producers. Another study conducted by Baten et al. is aimed at investigating the technical efficiency of selected manufacturing industries of Bangladesh using a stochastic frontier production function [15]. They used panel data and found that over time technical inefficiency has declined. Using the same method, a study has been conducted by Haider et al. also to measure technical efficiency level prevailing in the agricultural sector, considering three subsectors namely, rice, fish, and livestock in Khulna District of Bangladesh [4]. They concluded that in the above mentioned sectors, respectively about 76%, 81%, and 73% variations in output are due to technical inefficiency. On the other hand, Olayiwola has conducted a research to analyze the factors influencing technical efficiency in fish production by using stochastic production frontier based on Cobb-Douglass production function and found that there is still scope to raise the present level of technical efficiency [12]. Khai and Yabe attempt to measure technical efficiency through using stochastic frontier in rice production and identify its determinants in the context of Vietnam [16]. According to this analysis, estimated technical efficiency level is 81.6 percent, and, therefore, the study concludes that increase in output and decrease in cost could be obtained using the available technology.

While measuring efficiency level of production, the researchers have identified some factors associated with it; which, influence efficiency level either negatively or positively. According to Ambali et al. while output increases with increase in farm size, amount of hired and family labor, and, planting material; it decreases with increased use of herbicide [17]. While determining the factors affecting technical efficiency in the context of Northern Ghana, Al-hasan found that technical efficiency of farmers is significantly determined by the level of their education, extension contact, farmers' age (farmers' accumulated experience) and family size [18]. Another study finds that in case of paddy production, non-input factors like age and education levels of the cultivator, proportion of land leased in by the cultivator have positive influences on technical efficiency. However, indebtedness and percentage of self-consumption of farm turn out to have negative influences. It also finds that, government support through agricultural department has an insignificant impact on technical efficiency [19]. In another study Ahmadu and Erhabor point out that the determinants of the farmers' technical efficiency are age, gender, family size, level of education and farming experience. They conclude that inefficiency of the farmers increase with increase in age and decrease with increase in the number of male farmers, family size, level of education and farming experience [20]. However Enwerem and Ohajianya mentioned that low capital base for investment, poor extension contact and poor access to credit were the major factors that influenced farmers' level of technical efficiency negatively [10]. While measuring technical efficiency Tiamiya et al. indicate that age of farmer, farming experience, extension contact and credit use have significant effect on technical efficiency of the rice grower [8]. On the other hand, Khai and Yabe demonstrate that the most important factors having positive impacts on technical efficiency in rice production are intensity in labor use, irrigation and education [16]. However, Haider et al. identified that farming experience and availability of credit significantly and positively affect the efficiency level of the farms [4].

1.4 Research gap

From the above literature review, it is seen that stochastic production frontier approach has wide range of application while measuring technical efficiency in production. In the context of Bangladesh there are a few literatures in this regard. For example, Baten et al. have used stochastic production frontier method to measure technical efficiency of some selected manufacturing industries in Bangladesh [15]. A comparative study on measuring technical efficiency among three sub-sectors of agriculture namely, rice, fish and livestock is conducted by Haider et al. at Batiaghata Upazila of Khulna District in Bangladesh considering data collected in three consecutive years from 2007 to 2009 [4]. In this backdrop, present research concentrates on measuring production or technical efficiency of the rice producers of Dighalia Upazila in Khulna District based on cross-sectional data collected in 2013. It is the first research initiative in the study area in the sense that it differs from the other studies in terms of locality, time period, data type and research approach.

1.5 Objective of the study

Present research focuses on determining production efficiency of rice farmers aiming to attain the following specific objective:

1.5.1 To measure the production efficiency of the rice producers of the study area

1.6 Research questions of the study

In order to address the objective of the study, answers to the following research questions are attempted to find out.

1.6.1 What is the actual level of production?
1.6.2 What is the level of potential production?
1.6.3 What is the extent of deviation of actual production from potential production?
1.6.4 What factors affect the technical efficiency of the farmers?

II. Research Methodology

2.1 Study area selection

This research adopts a multistage sampling technique to select the study area. At first stage Khulna District has been selected from a total of 64 districts in Bangladesh; because, it is situated in the south-west region of the country. At the second stage, Dighalia Upazila has been chosen purposively from a total of 9 upazilas of Khulna District; because, most of the farmers in the area are engaged in rice production. There are 6 unions in Dighalia Upazila, namely, Dighalia, Senhati, Barakpur, Gazirhat, Aaronghata, and Jugipole. Gazirhat Union has been chosen randomly from them. There are 18 villages in this union, from these, 5 villages namely, Bagmara, Domra, Jungosia, Permachondopur, and Sonakur are selected randomly for the purpose of this study.

2.2 Sample designing and data collection

Famers cultivating hybrid rice as main crop are considered as population of this study. From the study area, out of approximately 350 farmers (calculated during the time of pilot survey), 80 farmers taking 16 from each village have been selected randomly as sample for the research. All types of data required for research have been collected from primary as well as secondary sources. At first, for the purpose of primary data collection, a questionnaire has been prepared which have been pretested on the basis of pilot survey findings and experience. Then, it has been made final to be inclusive as much as possible for research work. On the basis of this, primary cross-section data have been collected at the time of field survey. Besides, secondary data have been taken from selected published books, journals, working papers, Annual Reports of the Ministry of Agriculture, Bangladesh Bureau of Statistics etc.

2.3 Selection of cropping season

There are three cropping seasons during a year in Bangladesh. These are rabi, kharif-I and kharif-II. While rabi season covers November to February, kharif-I continues over March to June and kharif-II extends from July to October. Main crop of rabi season is boro rice which is composed of hybrid rice and high yielding variety (HYV) rice. Most of the farmers produce hybrid rice in the study area. Rabi season (2012-2013) is selected to conduct the study.

2.4 Econometric analysis

Output variation is caused by mainly fluctuations in inputs, technical efficiency and random shocks [21]. They articulate that contribution of inputs can be captured through production function specification and variation in output due to technical inefficiency and random shocks can be decomposed through stochastic production frontier approach (parametric approach). There are different analytical approaches to figure out the level of efficiency in the production function. As there is uncertainty in agricultural production, the researcher adopts stochastic production frontier approach applied by Ahmadu and Erhabor and Abedullah et al. [20][21].

2.4.1 The Stochastic Production Frontier Function

The stochastic production frontier function specified for the research is given below:

$Y_i = F(X_i,\beta)e^{\varepsilon i}$ (where i = 1, 2, 3,……..,N)---(1)

Here,

Y_i = Output of rice of the i^{th} farmer

X_i = Vector of inputs used by the i^{th} farmer

β = Vector of k number of parameters to be estimated

ε_i = Error term

The stochastic production frontier is also termed as 'composed error' model because it incorporates error term ε_i, which can be separated into two components: a stochastic random error component (random shocks) and a technical inefficiency component as follows:

$\varepsilon_i = V_i + U_i$

Where,

V_i is a symmetrical two sided normally distributed random error term that captures the stochastic effects outside the farmer's control (e.g. weather, natural disaster, and luck). It is assumed to be independently and identically distributed, N (0, σ^2v). As a result, V_i allows the production frontier to vary across farms, or over time for the same farm and therefore, the production frontier is stochastic.

On the other hand,

U_i is a one sided ($U_i \geq 0$) efficiency component that captures the technical inefficiency of the i^{th} farmer. This one sided error term can follow different distributions such as, truncated-normal, half-normal, exponential, and gamma. In this research, we assume that U_i follows a half-normal distribution symbolically N(0, $\sigma^2\mu$) [21]. The truncated-normal distribution is a generalization of the half-normal distribution. It is obtained by the truncation at zero of the normal distribution with mean μ, and variance, $\sigma^2\mu$. If μ is pre-assigned to be zero, then the distribution is half-normal. Besides, the two error components (V and U) are also assumed to be independent of each other.

Other vital parameters estimated under this analysis include sigma square (σ^2s), gamma (γ) and log-likelihood ratio. σ^2s indicates the goodness of fit of the model used, and gamma gives the proportion of the deviation of the rice output from the production frontier caused by technical inefficiency. For example if $\gamma = 0$, it indicates that U_i is absent in the model. If $\gamma = 1$, it means all deviations from the frontier are due to technical inefficiency. The log-likelihood ratio is used to test for the significant presence of technical inefficiency effects in farmers' production. The log-likelihood ratio statistic has asymptotic distribution equal to chi-square distribution.

The variance parameters of the model are parameterized as given below:

$\sigma^2 s = \sigma^2 v + \sigma^2 u$ --(2)

Where,

σ^2s = Variance parameters of sample statistic

σ^2v = Variance of the error term due to noise

σ^2u = Variance of the error term resulting from technical inefficiency

$\gamma = \sigma^2 u / \sigma^2 s$ --(3)

$0 \leq \gamma \leq 1$

Where, all variables are as earlier defined.

According to Aigner et al., 1977, as cited by Ahmadu and Erhabor, technical efficiency of the farmer is expressed below [20].

$TE_i = Y_i/Y_i^*$ --(4)

Where,

TE_i = Technical efficiency of the i^{th} farmer

Y_i = Observed output of the i^{th} farmer (kg)
Y_i^* = Potential output (kg)

2.4.2 The inefficiency model

According to Coelli and Battese, 1996 as cited by Ahmadu and Erhabor the inefficiency model has been adopted as given below [20].

$U_i = b_o + b_1Z_1 + b_2Z_2 + b_3Z_3 + b_4Z_4 + b_5Z_5 + b_6Z_6 + b_7Z_7 + E_i$ --(5)

Where,
U_i = Production inefficiency of the i^{th} farmer
Z_1 = Age of the farmer (year)
Z_2 = Gender (dummy, male = 1, female = 0)
Z_3 = Family size (number)
Z_4 = Level of education (in years of schooling)
Z_5 = Farming experience (in years)
Z_6 = Land fragmentation (number of plot)
Z_7 = Formal training (in day)
E_i = Error term
b's = Coefficients to be estimated

2.4.3 Hypothesis testing

Hypothesis testing regarding technical inefficiency has been adopted from Haider et al. as it matches with the objectives of this research as given below [4].

H_0: $\gamma = 0$, technical inefficiency is not present in the model.
The corresponding alternate hypothesis is:
H_1: $\gamma \neq 0$, technical inefficiency is present in the model.

2.4.4 The empirical model

Technical efficiency can be defined as the ability of a decision-making unit (e.g. a farm) to produce maximum output given a set of inputs and technology [21]. In order to estimate technical efficiency, stochastic production frontier function model of Cobb-Douglas type has been specified as follows,

$Y_i = \beta_0 X_{1i}^{\beta 1} X_{2i}^{\beta 2} X_{3i}^{\beta 3} X_{4i}^{\beta 4} X_{5i}^{\beta 5} e^{\varepsilon i}$

The empirical model for estimation purpose is the logarithmic form of the above Cobb-Douglas production function modified and adopted from Tiamiyu et al. which is given below [8].

$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \varepsilon_i$--(6)

Where, subscripts i refer to the observation on i^{th} farmer
In = Log to base e,
Y_i = Total output of rice of the i^{th} farmer (kg)
X_1 = Farm size (acre)
X_2 = Total labor used in crop production (man-day)
X_3 = Quantity of seeds used in cultivation (kg)
X_4 = Total quantity of fertilizer (kg)
X_5 = Volume of herbicide (liter)
ε_i = Error term
β's = Coefficients to be estimated

In this research ordinary least squares (OLS) and maximum likelihood estimates (MLE) method are used to estimate the parameters of the stochastic production frontier depicted in equation (6). At present, there are a lot of software packages to estimate MLE parameters of the stochastic production function. In this study, computer software Frontier 4.1 has been used. However, it is important to note that, technical efficiency model and inefficiency effect model has not been estimated step by step as discussed above rather Frontier 4.1 software has been applied, which can estimate the coefficient of production function and inefficiency effect model altogether [21]. Besides, SPSS v17, STATA v 12.1, MS Excel 2007 and MS Word 2007 have been used for editing and analyzing the data.

III. Results And Discussion

3.1 Socioeconomic characteristics of the respondents

Socioeconomics characteristics of the respondents give a clear idea regarding the people in the study area as well as the demographic pattern in general. From the survey data mentioned in table 1, it is found that the average age of the farmers in the study area is around 39 years. Also seen from the table that on an average, family size of the respondents is 6 person and most of the farmers have passed their school life up to class seven. The table also describes that each farmer has on an average 8 years of farming experience. However, total cultivated land is divided into several plots with an average of 3 plots. On the other hand, the number of formally trained farmers is few in the study area.

Table 1: Socioeconomic characteristics of the respondents in the study area

Socioeconomic Variables	Measurement Unit	Observation	Mean	Standard deviation	Minimum	Maximum
Age	In year	80	39.52	9.30	20	60
Family size	In number	80	6.61	2.14	2	12
Level of Education	In year of schooling	80	7.16	4.96	0	16
Farming experience	In year	80	8.45	3.85	2	20
Land fragmentation	In number	80	3.35	1.55	1	8
Formal Training	In day	80	0.73	0.96	0	3

Source: Author's compilation based on field survey, 2013

3.2 Summary of descriptive statistics of the farm specific variables

Farm specific variables include production level and corresponding inputs used by the respective farmers. Summary of the farm related variables have been shown in table 2. The table demonstrates that the average production volume per acre is 2423 kilogram in the study area. On an average 1.29 acres of land is cultivated by the farmer while 93 labors are required to accomplish the production process. While amount of seed per acre used is 11 kilogram; it requires on average 328 kilogram fertilizer per acre by each farm in the study area.

Table 2: Descriptive statistics of the farm specific variables

Variables	Measurement unit	Sample mean	Standard deviation	Minimum	Maximum
Output of rice	in kilogram	2423.27	1.743	469	8748.6
Cultivated land	in acre	1.29	0.927	0.25	3.64
Labor	in man-day	93	66	12	290
Seed	in kilogram	11.59	5.083	3	25
Fertilizer	in kilogram	328.51	227.78	51	1000
Herbicide	in kilogram	3.34	3.23	0	15

Source: Author's compilation based on field survey, 2013

3.3 OLS and Maximum Likelihood Estimates (MLE) of Stochastic Frontier Cobb-Douglas production function

Estimated results of OLS and MLE are put simultaneously in table 3 for comparison. First two columns respectively demonstrate the variables of the production function and corresponding parameters. The next columns display the estimated coefficients and t-ratios of OLS and MLE respectively. The OLS estimates depict the average performance of the producers. The value of R^2 is 0.83 indicating that variation in the inputs used in the production can explain 83% of variation in rice production in the study area. Coefficients of the explanatory variables express the elasticity of output with respect to inputs used. As for example, 1 percent increase in labor tends to increase rice output by 1.39 percent which is statistically significant at 1% level. Similarly, fertilizer and herbicide are found to positively influence production of rice and the finding is statistically significant. However, the study finding shows that, on an average 1% increase in land leads to 1.04% decrease in output and also in case of seed 1% increase causes 0.43% decline in output. Moreover the estimates come out statistically significant. The reason behind former negative relation may be that as hybrid rice production requires a definite package of inputs; hence, increase in land is likely to disrupt the production process. Explanation for the second result may be the unique characteristics of the hybrid rice as it requires specific amount of seed for specific amount of farm size.

Table 3: OLS and MLE Estimates of Stochastic Frontier Cobb-Douglas production function

Variables	OLS Estimates			Maximum Likelihood Estimates	
	Parameters	Coefficients	t-ratios	Coefficients	t-ratios
Constant	β_0	- 0.826 (1.182)	- 0.70	5.9496(0.571)	10.40*
Ln(land)	β_1	- 1.046(0.600)	- 1.74***	0.4656(0.137)	3.39*
Ln(labor)	β_2	1.396(0.266)	5.25*	0.3931(0.134)	2.93*
Ln(seed)	β_3	- 0.430(0.092)	- 4.66*	0.1283(0.049)	2.61*
Ln(fertilizer)	β_4	0.572(0.033)	17.02*	- 0.0196(0.053)	-0.37
Ln(herbicide)	β_5	0.128(0.024)	5.18*	0.0066(0.018)	0.37
Diagnostic statistics					
Sigma_U	σ_U			0.2677(0.036)	7.44*

Sigma_V	σ_V		0.0625(0.016)	3.77*
ε	V+U		0.3302	
Gamma	γ		0.94	
Sigma square	σ^2		0.0755	
R^2		0.83		
Log likelihood ratio LR		0.70801276		

No. of observation = 80, * = significant at 1%, ** = significant at 5%, *** = significant at 10%
Figures in the parentheses show standard error
Source: Author's compilation based on field survey, 2013

Estimates of the maximum likelihood method capture the frontier production. The results point out that the estimates of coefficient of land, labor and seed are statistically significant at 1 percent level, but is not so in case of fertilizer and herbicide. Elasticity of output with respect to land, labor and seed are 0.4656, 0.393, and 0.128 respectively which are lower than the OLS estimates. The implicit assumption in this analysis is that there exists Hicks' neutral technical change, which means that the intercept term in MLE should be higher than that in computed by OLS, while the slopes should be more or less equal in both OLS and MLE results [22]. The figures for the intercept term in the table clearly support this proposition.

Estimated value of σ_U and σ_V are 0.0360 and 0.0166 respectively and are significant at 1% level. Their values indicate the deviation of observed and frontier production due to inefficiency and not by chance alone. The estimate of gamma (γ) is 0.94, which implies that about 94 percent of the variation in output of the farmers is due to factors which are under the control of farms in the study area. Thus, inefficiency effects were present which have significant influence on the level of production of the farms.

3.4 Test of hypothesis

Test of hypothesis of this study is based on the estimate of gamma (γ) in the frontier function for checking the existence of technical inefficiency in the model. The estimated γ in the frontier model is positive so, null hypothesis is not accepted and it can be concluded that technical inefficiency effect is present in the model.

3.5 Technical efficiency index of the rice producing farm in the study area

The frequency distribution of the technical efficiency estimate from the stochastic frontier model is depicted in the table 4 given below.

Table 4: Farm level technical efficiency index in the study area

Frequency distribution (Technical efficiency)	Number of farms	Percent
0.00-0.10	0	0
0.10-0.20	0	0
0.20-0.30	1	1.25
0.30-0.40	2	2.5
0.40-0.50	5	6.25
0.50-0.60	6	7.5
0.60-0.70	12	15
0.70-0.80	14	17.5
0.80-0.90	26	32.5
0.90-1.00	14	17.5
Total	80	100
Descriptive statistics		
Number of observation 80		
Mean 0.75		
Minimum 0.28		
Maximum 0.97		
Standard deviation 0.16		

Source: Author's compilation based on field survey, 2013

Efficiency index in table 4 shows that the range of efficiency level varies from 0.00 to 1. The mean efficiency of the rice producing farms is 0.75 which is similar to the finding of Haider et al. [4]. It indicates that there is still room for increasing efficiency in the production process. In the study area about 32 percent farms are operating at efficiency level ranging from 0.80 to 0.90. The table also displays that the minimum and maximum level of efficiency achieved by the sample farms are 0.28 and 0.97 respectively.

3.6 Determinants of technical inefficiency

In general, some socio-economic factors contribute to farm level technical efficiency. Some of these have positive and some have negative impact on the level of technical efficiency of the farmers. In order to address this issue variables considered include, age of the farmer, gender, family size, education level, farm size, farming experience, land fragmentation, and formal training of the farmer.

Table 5: Determinants of technical inefficiency

Variables	Parameters	Coefficients	Standard error	t-ratios	P>|t|
Constant	b_0	0.34	0.134	2.54**	0.013
Age (year)	b_1	-0.0021	0.0537	-0.75	0.456
Gender	b_2	-0.0322	0.053	-0.60	0.551
Family size	b_3	0.0061	0.01	0.61	0.546
Education	b_4	-0.0059	0.0051	-1.15	0.252
Farming experience	b_6	-0.0022	0.0076	-0.29	0.771
Land fragmentation	b_7	-0.0016	0.0155	-0.10	0.917
Formal training	b_8	0.0041	0.024	0.17	0.863

* = significant at 1%, ** = significant at 5%, *** = significant at 10%
Source: Author's compilation based on field survey, 2013

It is seen in table 5, that none of the variables significantly affect the production inefficiency of the farm. So, it requires further study to identify the unexplored explanation behind this result in the study area.

IV. Conclusion

4.1 Conclusion

This study attempts to measure the production efficiency or technical efficiency of the rice producers in the south west region of Bangladesh with special focus on Dighalia Upazila under Khulna District. Productivity of agriculture varies due to technical efficiency, geographical set up and production technology. This research finds that most of the farmers in the study area are male and married. The distribution of land size varies from 0.25 acre to 3.75 acre. On an average the mean production of rice per acre is 2423 kilograms which requires on an average 93 labors in man-days, 11.59 kilograms of seed, 328 kilograms of fertilizer, and 3.34 kilograms of herbicide. The estimates of the OLS and MLE of Cobb-Douglas production function show that the farmers are producing below their frontier production. Elasticity of the Cobb-Douglas production function using maximum likelihood method shows it possible that one percent change in land size on an average will change the output by 0.46 percent. There is statistically significant effect of labor and seed on the production volume. In case of labor and seed on an average 0.39% and 0.12% increase in rice production is possible with 1% increase in labor and seed respectively. On the other hand, fertilizer has negative significant effect on production, as manifested in the finding 1% increase in fertilizer leads to 0.37% decrease in production level. Estimated value of γ is positive and implies that technical inefficiency causes variation in rice production in the study area.

The estimated results of the study also suggest that there is presence of technical inefficiency in the production process responsible for the variation in rice output of the farms. The result of technical efficiency index shows that the rice producing farms in the area are not fully technically efficient as average efficiency level of the farms is about 75 percent. It implies that there is still scope to increase the production volume by 25%. The sturdy also tries to figure out some of the determining factors of the production inefficiency in the study area. The study finding suggests that the farmers can increase the output of rice through optimal use of land, labor, seed, fertilizer, and herbicide, given the existing state of technology.

V. Scope For Future Research

Avenue for further research in future can be in the direction of identifying the significant determinants of production inefficiency that influence level of the rice production of the farmers in the study area.

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