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Seasonal Variation in Efficiency of Rice Farms in Bangladesh

MD. ABDUL WADUD[*]
MD. NURUNNABI MIAH[**]

Abstract *This paper aims to assess the seasonal variation in technical efficiency of rice farms in Bangladesh within the framework of the Cobb-Douglas stochastic frontier model. We use field survey data and estimate the frontier applying maximum likelihood single stage methodology. The technical efficiency among the rice producers in aman, boro and aus season shows almost similar trend ranging between 50 to100 per cent. The mean technical efficiencies of farms in aman, boro and aus seasons are 85.17, 80.42 and 86.85 per cent respectively. The minimum efficiency scores in aman, boro and season are 55.73. 48.73 and 57.51 per cent respectively and respective maximum scores are 98.22, 99.93 and 98,50 per cent. This exhibits that the mean technical efficiency score in aus season is slightly higher followed by that of aman and boro seasons. This can be explained that farmers in aus season are more capable of utilizing their inputs more properly. About 32.28 per cent rice farms in aman season, 26.70 per cent in boro season and 44.62 in aus season in our survey area belong to the technical efficiency group of 76 to 90 per cent. About 17.83, 19.58 and 13.15 per cent technical efficiency could be improved in aman, boro and aus season respectively without any changing or improving cultivation technologies if rice farmers operate at full efficiency scale.*

Results of inefficiency effects model show while extension services play a significant role to reduce inefficiency of rice farms in aman season; credit contributes positively to the improvement of efficiency in boro season.

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[*] Professor, Department of Economics, University of Rajshahi, Rajshahi 6205, Bangladesh, Email: wadud68@yahoo.com

[**] Assistant Professor, Department of Economics, Dwipnagar College, Bagmara, Rajshahi 6250, Bangladesh

1. Introduction

Agricultural productivity is an important source of income of rurally people in Bangladesh. Productivity gains can be obtained through technical progress and efficiency improvement. Gain from the former is likely to take long time, considerable effort and fund. Raising efficiency offers more immediate gain at relatively modest cost. The agriculture in Bangladesh is characterized by random variability in production resulting from natural factors such as drought, flood and some socioeconomic factors and environmental factors which affect farm efficiency.

Banik (1994) reported a value of 82 per cent efficiency for a sample of 99 boro modern variety rice farmers. Using a Cobb-Douglas functional form, Sharif and Dar (1996) reported mean estimate of technical efficiency for a sample of 100 farms. For aman rice, farmers were found to be over 90 per cent technically efficient. These results on efficiency are perceived to be rather high. Battese and Broca (1997) found education level to be positively related to technical efficiency, and tenancy for a sample of wheat farmers in Pakistan, and Phillips (1994) provided a detailed review of the influence of education on farmer efficiency. In a meta-analysis of existing research he found that education positively influenced productivity and this was especially so in Asia compared to Latin America. Huang and Kalirajan (1997) supported this finding for rice production in China. For Bangladesh, Sharif and Dar (1996) found that education was positively related to technical efficiency.

Wadud and White (2000) employed both data envelopment analysis (DEA) and stochastic frontier analysis (SFA) to examine the technical efficiency of a sample of 150 farmers in Bangladesh. For translog SFA, they found technical efficiency to be 79 per cent, whilst for DEA it was 79 per cent under constant returns to scale and 86 per cent under variable returns to scale. For SFA, they reported that the sample of farms exhibited decreasing returns to scale. Coelli et. al. (2002) employed a comprehensive set of variables in a second stage Tobit regression to explain technical efficiency for both aman and boro rice production, but found few statistically significant estimates. Simar and Wilson (2003) have identified significant technical shortcomings with the two-stage approach that stems from the upward bias in technical efficiency estimates of DEA.

Andersson et.al. (2008) studied efficiency in shrimp farming in a rural region in Bangladesh where formal microlending is well established, but where more expensive informal microlending coexists with the formal schemes. Both farmers who exclusively use formal loans and those who also use informal loans, are credit constrained; both types of farmers over-utilise labour in order to reduce the need for inputs that require cash at the beginning of the season, creating inefficiencies in production. However, the credit constraint is actually milder for the informal borrowers; the implicit shadow price of working capital is substantially higher in the group that only takes formal loans than in the group that also uses informal loans. Results suggest that, even in areas where formal microlending has existed for a long time, access to credit remains a problem for many smallholders. Moreover, informal lenders – with their closer ties to the individual farmers – remain more successful in identifying those smallholder farmers that are most likely to make the best use of the borrowed funds. Thus, although formal microcredit schemes avoid one of the problems of traditional formal lending - the high administrative fees that create barriers to small loans - they do not necessarily solve the problem of how to select successful borrowers. Informal lenders have an information advantage that formal microlenders lack. Formal lenders need to find routes for accessing this information in order for formal microcredits to succeed.

Constantin, Martin and Rivera (2009) estimated inefficiencies over time as well as respective TFP (Total Factor Productivity) sources for main Brazilian grain crops - namely, rice, beans, maize, soybeans and wheat for the period 2001-2006. They apply Cobb-Douglas, Translog Stochastic Production Function and Data Envelopment Analysis. Results indicate that, although positive changes exist in TFP for the sample analyzed, a decline in the use of technology has been evidenced for all grain crops in which it is observed a historical downfall in the use of inputs in Brazilian agriculture

Butso and Isvilanonda (2010) applied the time-varying Cobb-Douglas production frontier model with unbalanced panel data between the crop year (CY) 1987/88 and CY 2007/08. They found that returns to scale from rice production in Thailand have been decreasing. This is a sign that an increase in the amount of inputs may not improve rice yield performance. Even with the adoption of labor-saving technology and machinery over the last two decades, the efficiency of rice production in terms of yield increase has been less than the maximum potential yield. Instead, there has been a declining trend. Results also showed that the mean technical efficiency score was 88.32 percent in CY 1987/88 and this decreased to 72.63 percent in CY 2007/08, which indicates that the farmers in CY 1987/88 utilized their resources more effectively than the farmers in CY 2007/08. Moreover, the technical efficiency score of rice production in irrigated areas was higher than that in other areas, which implied that irrigation development was the key factor for improvements in technical efficiency.

Akinbode, Dipeolu and Ayinde (2011) examined technical, allocative and economic efficiencies in *Ofada* rice farming in South-West Nigeria and factors determining affecting efficiency of a total of 192 rice farmers applying the stochastic frontier analysis. Results reported that the mean technical, allocative and economic efficiencies were 0.726, 0.928 and 0.674 respectively. It was therefore concluded that rice farmers can still increase output or save cost without change to existing technology. Furthermore, extension contact and education were found to be very crucial to efficient rice production.

Kularatne et. al. (2012) examined the factors affecting the technical efficiency (TE) of irrigated rice farmers in village irrigation systems (VIS) in Sri Lanka using primary data for a sample 460 rice farmers applying stochastic translog production frontier for rice production. The mean TE of rice farming in village irrigation was found to be 0.72, although 63% of rice farmers exceeded this average. The most influential factors of TE are membership of Farmer Organisations (FOs) and the participatory rate in collective actions organised by FOs. Results suggested that enhancement of co-operative arrangements of farmers by strengthening the membership of FOs was considered important for increasing TE in rice farming in VIS.

Orawan and Isvilanonda (2012) estimated the production frontier to assess the technical efficiency of rice farms in Thailand. Results revealed that rice producers in general operates in a decreasing return to scale, suggesting the ineffectual yield of the input factor use to rice performance. The technical efficiency score of 88.32% in 1987/88 crop year and decreasing to 72.63% in 2007/08 crop year denotes a production trend that is less than the potential output possible over time. The study suggested crop diversification as one strategy to improve production efficiency at the farm level and supervised credit on fertilizers and seeds to farmers to provide farm managerial support.

Mohammad, Ismat and Rahman (2011) employed stochastic frontier production function to measure total factor productivity (TFP), technical change, and technical efficiency change covering the period of pre-market reform (1987) and post-market reform (2000 and 2004). The study used panel data of 73 farm households from a field survey of 1987–1988, 1999-2000 and 2003-04. It was evident from results that over time period (1987-2004), the TFP increased (31.76%) only due to upward shift in the technology. Technological change increased to 59.99% in post reform period. However, although TFP increased substantial inefficiencies remain in Bangladesh rice sector. Technical efficiency change (-34.46%) developed negatively over the years of study at farm level.

Market reform policy had negative impact on technical efficiency change but positive in technical change and TFP change although all are declining over the time period. Therefore, government policies need for further reform of domestic market and trade policies focusing on institutional changes, tariff and non-tariff barriers in order to develop a competitive environment in rice sector.

Ghee-Thean, Ismail, and Harron (2012) investigated the level of technical efficiency and the determinants of technical inefficiency for a sample of 230 paddy farmers operating in Malaysia by using a translog stochastic production frontier. The mean level of technical efficiency of farmers was estimated at 85.8%, while the efficiency of farmers varied from 0.263 to 0.982. Inefficiency model indicated that the attendance at seminar or workshop significantly influenced technical inefficiency. The attendance at seminar or workshop had become an ace factor in increasing technical efficiency and in increasing yield per hectare. Hence, this study suggests that, the farmers should attend seminar or workshop of paddy farming from time to time. Encouraging paddy farmers to attend seminar or workshop can be achieved through offering incentives, subsidies in order to offset the opportunity cost of attendance at seminar or workshop.

Daniel et. al. (2013) employed stochastic frontier production function to determine the technical efficiency of sugarcane farmers in Mubi Region in the north-east of Adamawa state using data from 160 farmers across the five Local Government areas which constitute the region. Results showed that the coefficients of land size, fertilizer, fuel are significant while seed-cane was significant. The mean efficiency of the farmers was 0.87 while the maximum and minimum were 0.97 and 0.12 respectively. The distribution of efficiency indices shows that 93.74% of the farmers operated above 70% of their maximum efficiency. This research recommended replacing manual labour with labour-saving technology such as tractors and simple machines, like ox-dawn plough as well as adequate extension services to the farmers.

Dağistan and Kemal (2010) carried out a study to determine technical efficiency of wheat growing farms in Cukurova region of Turkey during the period 2004-2005. Technical efficiency of wheat farming was estimated by using the data envelopment analysis (DEA). Technical efficiency scores were calculated by employing an input-oriented DEA and Tobit regression analysis was used to identify determinants of technical efficiency. Results showed that wheat farmers could save from the variable inputs by at least 20% at the same production level. The efficiency level is mainly affected by farmer education level and number, size and location of wheat plots of 103 farms, of which 13 showed constant, 87 increasing and 3 decreasing returns to scale conditions. Determining variations in technical efficiencies of wheat growing farms and the causes of inefficiencies, our results are expected to be useful for policy makers as well as wheat growers.

This paper is designed to estimate technical efficiency of a sample of rice farms in Northern Bangladesh over the three seasons – Aman, Boro and Aus seasons. To the best of our knowledge, there is no research which deals with the comparison of farm efficiency of three seasons in Bangladesh and hence this research is first of its kind.

Following this introduction:section 2 describes the analytical framework; Section 3 explains data and variables; Section 4 specifies the empirical model; Section 5 yields the empirical results and discussions; and Section 6 concludes.

2. Theoritical Framework

We use stochastic frontier model (Aigner et al., 1977; and Meeusen and van den Broeck, 1977) to estimate technical efficiency. We start with the general stochastic frontier production model defined as:

$$y_i = f(x_i;\beta)^{u_i} \qquad \text{i} = 1, 2, 3, ...\text{i}, \text{n} \tag{1}$$

where represents the output of the *ith* farms, a vector of k inputs, a vector of *K* unknown parameters, The composed error term is decomposed into two components: a stochastic random error component and a technical inefficiency component, that is,

$$u_i = \xi_i - \zeta_i \tag{2}$$

The symmetric random error, ξ_i is assumed to be independently and identically distributed as . The asymmetric non-negative random error, $\zeta_{i,}$ measures the technical inefficiency and is assumed to be independently and identically distributed non-negative truncations (at zero from below) of the distribution. The variance parameters of the model are expressed as:

$$\sigma_u^2 = \sigma_\xi^2 + \sigma_\zeta^2 ; \gamma = \sigma_\zeta^2 / \sigma_u^2 \; and \;\; 0 \le \gamma \le 1 \tag{3}$$

The maximum likelihood estimation of (1) provides estimators for β and variance parameters. Given the distributional assumptions of ξ_i and $\zeta_{\text{i},}$ the estimate of - ζ_i can be derived from the conditional expectation of - $\zeta_{\text{i},}$ given u_i, applying standard integrals:

$$E(-\varsigma_i / u_i) = [\frac{1 - \Phi\{\sigma_i^* - (\mu_i^* / \sigma_j^*)\}}{1 - \Phi(-\mu_i^* / \sigma_i^*)}]e^{(-\mu_i^* + \frac{1}{2}\sigma_i^{*2})} \tag{4}$$

where $\mu_i^* \equiv \dfrac{\mu\sigma^2\xi - \mu_i\sigma^2\varsigma}{\sigma^2\xi + \sigma^2\varsigma}, \sigma_i^{*2} \equiv \dfrac{\sigma^2\varsigma\sigma^2\xi}{\sigma^2\xi + \sigma^2\varsigma}$ and represents cumulative distribution function (Battese and Coelli, 1988).

3. Data and Variables

The data used in this paper are collected from three upazilas of three different districts of Northern Bangladesh through a field survey conducted in 2010. The questionnaire is administered to 251 farms for the period of one year covering three growing seasons- aman, boro and aus. The data consists of information on rice output and seven inputs: land, labour, plough, seed, irrigation, fertilizer and pesticides and socioeconomic and other factors associated with inefficiency. These are discussed brief as follows.

For efficiency analysis we have taken only one output of rice and seven inputs. Output (y) indicates the market value of the observed rice production and are measured in taka. Revenue means quantity of output multiplied by price per mound (1 mounds = 37.32 kilograms (Kg). Land (x_{i1}) denotes the total amount of land used for rice cultivation and the price of land, p_{i1} represents 1 per cent increasing rental value of per acre land. Labour (xi_2) represents the per acre labour used in rice production which includes family and hired both labour and the price of labour, p_{i2} indicates the wage per man-day. Polugh (xi_3) indicates per times of land plough and the price of plough, p_{i3} represents as the money paid to the power tiller holder. Seed (x_{i4}) denotes the amount of seeds used on per acre of land and is measured in Kg. The seeds price, p_{i4} means the average price of seeds per Kg including both HYV and traditional type of seeds. Irrigation (xi_5) is the total amount of land irrigated for rice cultivation and the price of irrigation, p_{i5} represents irrigation price per acre. Fertilizer (xi_6) includes all organic and inorganic fertilizer and is measured in Kg. And the price of fertilizer, p_{i6} indicates the average price of all fertilizer per Kg. Pesticides (xi_7) denotes the total quantity of pesticides used per acre of land is measured also in Kg. The price of pesticides, p_{i7} is the price of all pesticides per Kg. All type of inputs costs are measured in local market price in taka ($ 1 = about 77 Bangladeshi taka). Each input plays as a vital role for rice production. Labour and seed costs are more significant than other variable costs.

Differences in efficiency may be due to factors that very among farmers. The literature indicates that a range of socio-economic and demography factors determine the efficiency of farms (Seyoum et al., 1998; Coelli and Battese, 1996, and Wilson et al., 1998). These include land use, credit availability and the education level of farmers (Kalirajan and Flinn, 1983; Lingard et. al., 1983) Shapiro and Muller, 1977; and Kumbhakar, 1994). Techniques of cultivation, share tenancy and farm holding size may also influence efficiency (Ali and Choudhury, 1990; Coelli and Battese, 1996; and Kumbhakar, 1994). Some environmental factors and non-physical factors like farming experience and extension services may affect the capability of a producer to utilize the available technology efficiently (Parikh and Shah, 1993; and Kumbhakar, 1994). We now consider the variables which may affect efficiency in agriculture.

The age of the farmers, *a priori*, could have a positive or negative effect on inefficiency. Farming experience can be achieved with increasing age and this may reduce inefficiency. However some older farmers are less respective to and more conservative in adopting new technologies and practices. *A priori*, we expect that more years of formal education will increase efficiency because education enables farmers to acquire and process relevant information. Schooling is the years of attending schools. Farmers can be exposed to new technologies and improved techniques with education.

Land fragmentation, that is the small plot size, is likely to have negative effects upon efficiency. Average plot size is used as a measure of land fragmentation, thus the smaller the plot size the greater is the land fragmentation. The greater the plot size (less fragmentation) of a farm, the greater in the opportunity to apply new technologies such as; tractor and irrigation systems and other modern equipments (Wadud, 1999).

Credit has a positive effect on efficiency of farmer. The cultivation system has been changed. Now, farmers turn their cropping pattern from traditional less-costly to modern mechanical more expensive system. Therefore, if credits are provided in a easiest way to the poor, marginal and small size farmers, they become more efficient in production process. Hence credit is a useful component to improve the technical efficiency of rice cultivation.

Extension services may have a positive or negative impact on efficiency of the farmers. Quality extension services could improve the ability of the farmers' to allocate inputs more successfully. Extension services availability and education level were found by Huffman (1977) to be important variables of the rate of adjustment in fertilizer use in response to price changes.

Land degradation is increasing because of dependence for household fuel on crop residues and animal dung along with wood, leaves and twigs which, if recycled back to the soils, would reduce the rate of soil erosion, and soil structure degradation (Idris, 1994). Visual inspection and a subsection of the questionnaire assessed the state of land degradation on the farm. All these factors contribute to inefficiency in production.

4. Empirical Model

The stochastic production frontier is required to specify to estimate technical efficiency (TE). The Cobb-Douglas stochastic frontier model is specified to fit the stochastic production frontier using maximum likelihood method as:

$$\ln y_i = \beta_0 + \sum_{k=1}^{7} \beta_{ik} \ln x_{ik} + \xi_i - \varsigma_i \quad (k \text{ indicates inputs}) \tag{6}$$

where y_i represents the rice output, z_{i1} is the amount of land x_{i2} s the total labour, x_{i3} is the total plough area x_{i4} is the total amount of seed x_{i5} is the irrigated rice area, is x_{i6} the amount of fertilizer x_{i7} is the quantity of pesticides applied during this farming operation and *In* indicates the natural log. The systematic error components ξ_i , are previously defined and the technical inefficiency effects, ς_i, are assumed to be independently distributed of ξ_i such that ξ_i is satisfied by the truncation (at zero from below) of the $N(\mu_i, \sigma_\varsigma^2)$ where μ_i can be specified and defined as:

$$\mu_i = f(z_{ik}) \tag{7}$$

where z_{i1} denotes the age of the farmer, x_{i2} s the farmer's year of schooling, x_{i3} represents land fragmentation, x_{i4} denotes credit facilities dummy variable which assumes a value one if the farmers takes credit and zero otherwise x_{i5} denotes extension services dummy variable which takes a value one if the farmers get services and zero otherwise and x_{i6} represents the land degradation dummy variable which takes a value one if the land is degraded and zero otherwise. The value of one for x_{i6} implies that most lands of a farm household are un-degraded.

The stochastic frontier model is estimated using both the truncated normal and the half-normal distributional assumption for the technical inefficiency effects term. The half-normal distribution is rejected by the generalized likelihood ratio (LR) test which is, $\lambda = -2In[L(H_0)/L(H_A)]$ where $L(H_0)$ and $L(H_A)$ re the values of the likelihood function under the null and alternative hypothesis respectively. The λ statistic has asymptotic chi-squire distribution with degrees of freedom equal to the number of restrictions imposed under the null hypothesis (Coelli, 1995). Therefore we use the results from the truncated normal distribution.

5. Empirical Results and Discussion

5.1 Stochastic Frontier Results

The maximum likelihood estimates of the coefficient of parameters of the Cobb-Douglas stochastic frontier are presented in Table 1. The signs of the coefficients of the stochastic frontier are all positive as expected and most of them coefficients are highly significant. These are land, plough, irrigation, fertilizer and pesticides. Coefficients of labour and seed are positive but insignificant. In field level survey, we have observed some insignificant behaviour for labour and seeds. It shows that there are already abundant supplies of labour in agriculture sector of our survey area in northern Bangladesh.

The stochastic frontier model yields the highest elasticity of output for fertilizer in aman season, for irrigation in boro season and for fertilizer for aus season. This

Table 1 : Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Frontier Model for Aman, Boro and Aus Season

		Aman Season		Boro Season		Aus	
Name of variables	Parameters	Coefficients	t-ratios	Coefficients	t-ratios	Coefficients	t-ratio
Constant	$?_0$	2.4432	6.5926	2.3863	5.1860	2.2730	6.6228
Land	$?_1$	0.1125	5.9513	0.2193	6.6461	0.1214	5.7314
Labour	$?_2$	0.2041	2.4737	0.6849	2.8674	0.2136	2.8654
Plough	$?_3$	0.4407	3.1399	0.3239	3.6088	0.2947	3.4594
Seeds	$?_4$	0.3525	1.8942	0.2485	1.6795	0.4068	2.1307
Irrigation	$?_5$	0.4354	5.6698	0.7906	5.4596		
Fertilizer	$?_6$	0.5167	4.5145	0.3468	3.1320	0.9571	4.9523
Pesticides	$?_7$	0.4326	3.5728	0.4594	4.3539	0.3918	4.2105
Inefficiency Model							
Constant	$?_0$	0.0415	5.1535	0.2559	4.9207	0.4846	5.1620
Age	$?_1$	-0.0089	-1.6415	-0.0072	-1.0417	-0.0076	-1.0290
Years of schooling	$?_2$	0.0033	0.3688	0.0049	0.3046	0.0123	0.4072
Experience	$?_3$	-0.0069	-2.5276	-0.0057	-2.3367		
Land fragmentation	$?_4$	-0.4996	-3.4165	-0.5147	-4.4574	-0.4151	-3.3204
Credit facilities dummy	$?_5$	0.0951	0.7803	-0.0764	-2.5942	0.0798	0.6186
Extension services	$?_6$	-0.0599	-0.5340	0.0362	0.4617	0.0918	0.4188
dummy	$?_7$	-0.0253	-3.6159	-0.0305	-4.1059	-0.0288	-4.1098
Land degradation dummy							
Variance Parameters							
Sigma-squared	$\sigma^2 = \sigma_\xi^2 + \sigma_\zeta$	0.1306	3.1304	0.1656	5.4656	0.6323	4.6248
Gamma	$\gamma = \left(\sigma_\zeta^2 \big/ \sigma^2 \right)$	0.9259	4.1582	0.5395	4.1261	0.9339	3.3012
	σ_ξ^2	0.0097		0.0763		0.0418	
	σ_ζ^2	0.1209		0.0893		0.5905	
Log likelihood value		42.2315		29.2432		35.2498	

Table 2: Frequency Distribution of Farm-Specific Technical Efficiency Estimates from the Cobb-Douglas Stochastic Frontier Model for Aman, Boro and Aus Season

Efficiency index (percentage)	Aman			Boro			Aus		
	No of farms	% of farms	Cumulative % of farms	No of farms	% of farms	Cumulative % of farms	No. of farms	% of farms	Cumulative % of farms
1 – 50	0	0	0	4	1.59	1.59	0	0	0.00
50 – 60	2	0.8	0.8	16	6.37	7.96	1	0.40	0.40
60-70	21	8.36	9.16	54	21.53	29.49	8	3.19	3.59
70-80	55	21.91	31.07	46	18.32	47.81	52	20.72	24.30
80-90	92	36.65	67.72	64	25.49	73.3	78	31.08	55.38
90-100	81	32.28	100	67	26.7	100	112	44.62	100
Total	251	100		251	100		251	100	
Summary Statistics of Technical Efficiency									
Mean	85.17			80.42			86.85		
Minimum	55.73			48.73			57.51		
Maximum	98.22			99.93			98.50		
Standard deviation	9.23			13.01			8.49		

implies that fertilizer is the most important factor of production in both aman and aus seasons while irrigation is the most important input in boro season. The coefficients of these inputs are expected and significant.

The overall technical inefficiency effects are evaluated in terms of variance parameters σ^2 and the parameters γ reported in Table 1. The coefficients of the σ^2 in aman, boro and aus seasons are 0.13, 0.16 and 0.63, and those of γ are 0.92, 0.54 and 0.93 respectively which all are highly significant. These indicate that the technical inefficiency effects are a significant component of the total variability of rice producers' output of farm households in northern Bangladesh. This result is consistent with Coelli and Battese and Sharma et. al., (1996 and 1997).

5.2 Results of Inefficiency Effects Model

The estimates of the coefficients associated with the rice producer specific technical inefficiency effects model is also presented in Table 1. We examine whether they have a significant effect on technical inefficiency. The sings of the estimated coefficients of need to be discussed carefully because variation in technical efficiency of producers arises due to these variables.

Table 1 shows that in aman, boro and aus seasons, the coefficients from Cobb-Douglas stochastic frontier technical inefficiency of land fragmentation and land degradation are negative and significant in all seasons. The coefficients of age are negative and insignificant in all seasons. The coefficients of schooling are positive but insignificant. The coefficients of credit are positive and insignificant in aman and aus seasons, but negative and significant in aus season. This implies that credit plays a significant role in reducing inefficiency in boro season.

5.3 Estimates of Technical Efficiency of Aman, Boro and Aus Seasons Together

The frequency distributions of the technical efficiency estimates and their summary statistics of the Cobb-Douglas stochastic frontier results are presented in Table 2. The estimated farm-specific technical efficiencies show substantial variability, ranging are between 56 to 98 per cent, 59 to 100 per cent and 57 to 99 per cent respectively in aman, boro and aus seasons.

The mean value of efficiency in aman, boro and aus season are 85.17 per cent, 80.42 per cent and 86.85 per cent respectively and their respective standard deviations are 9 per cent, 13 per cent and 8 per cent. These results indicate that there are considerable inefficiencies in rice production and hence considerable room for improving farm efficiency and thereby enhancing farm output, income and the welfare of farm households. The majority of 32.28, 26.70 and 44.62 per cent are 90 –100 per cent technically efficient in aman, boro and aus seasons respectively.

6. Conclusion

This paper applies the stochastic frontier model to evaluate technical efficiency of a sample of 251 rice farms of Northern Bangladesh. Technical efficiencies of the same farm in three seasons – aman, boro and aus - are calculated separately to make a comparison. The inefficiency effects model is assumed to be a function of some farm-specific socioeconomic and farm characteristics like age and education of the farmers and land fragmentation, irrigation infrastructure and land degradation of farms. Results show that farms are characterized by slightly decreasing returns to scale. Technical efficiencies of farms in aman boro and aus seasons vary from 56-98 per cent, 48-100 per cent and 58-98 per cent respectively with respective mean efficiencies of 85.17, 80.42 and 86.85 per cent.

Results of the analysis of inefficiency by socioeconomic factors show that the younger farmers with more receptive tendency to new technology and with more education are more capable of operating farming activities efficiently. Moreover the plot size is estimated to be inversely related to the levels of technical inefficiency. This suggests that larger plot size, i.e., less land fragmentation, contributes significantly to increasing farm efficiency. Results show that irrigation infrastructure and land degradation are the most statistically significant factors associated with technical inefficiency. Results also imply that land degradation as an environmental factor is positively associated with technical inefficiency; these indicate that land degradation lowers farmers' ability to utilize existing technology efficiently and hiders the allocation of inputs in a cost-minimizing way.

Evaluating efficiency suggests that there is considerable amount of inefficiency among farming activities in all three seasons and a substantial potential for increasing rice output through the improvement of technical efficiency. In particular, farms on average can reduce their production cost by about 13-20 per cent if production activity is operated as efficient as the most efficient farm. Assessing factors associated with inefficiency provides two policy in placation measures to decrease land fragmentation and reduce land degradation would enhance farm efficiency.

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