

Measurement of Technical Efficiency of Paddy Farms at Jhenaidah District in Bangladesh: A Case Study by Using Cobb Douglas Production Function

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Abstract

This study's primary goal is to measure the technical efficacy of Amon paddy farms and identify the key variables that significantly influence the degree of technical inefficiency of the sample farms. Using a multistage random sampling technique, 200 Amon rice-producing farms in the Jhenaidah district were sampled for this study. The technical efficacy of Amon rice farms is estimated using the Cobb-Douglas production function method. The Cobb-Douglas production function approach's empirical findings indicate that the technical efficiency of Amon rice production is, on average, 0.95. This suggests that the studied region has a high level of technical efficiency. The factors influencing the degree of inefficiency of the Amon rice farms are also determined using an inefficiency impact model. The production of paddy was favorably connected with farm size, as indicated by the regression coefficient of farm size, which is 0.52. Additionally, it reveals that labor costs, irrigation cost, seed costs, and plowing cost are crucial elements that influence how efficiently Amon rice is produced. According to the estimated inefficiency impact model's findings, the technical inefficiency of Amon rice production is adversely correlated with farm size, age, education, training and credit availability. According to this study, actions to expand credit opportunities, education, and training are essential to lowering rice production's technical inefficiency in the study area. According to the results, it is advised that variables that positively and significantly affect production efficiency be researched and developed for best results toward sustainable agricultural and rural development in Bangladesh.

Keywords: Technical Efficiency, Amon Rice Production, Bangladesh, Cobb-Douglas Production Function.

INTRODUCTION

One of the most extensively grown and consumed grain crops worldwide is paddy. One third of the world's population relies on rice consumption to meet their daily dietary needs, with rice agriculture accounting for 11% of all arable land worldwide (Pramanick, Brahmachari, Kar, & Mahapatra, 2020). Bangladesh's economy is primarily dependent on the agriculture sector for development and growth (Sharmeen & Chowdhury, 2013). In rural Bangladesh, agriculture is the most significant and long-lasting source of income. In rural areas, where 60% of the population resides, agriculture accounts for the majority of people's incomes (Haq, 2016).

The main crop grown in Bangladesh is rice, which is produced year-round in a variety of agricultural goods. The rapid growth in Bangladesh's population has raised the need for rice (Rahaman et al., 2018). In order to meet the demand, farmers heavily rely on modern inputs such as fertilizer, pesticides, water, and other instruments and technologies (Parveen, 2010).

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How to cite this article: Md. Arif Billah, Measurement of Technical Efficiency of Paddy Farms at Jhenaidah District in Bangladesh: A Case Study by Using Cobb Douglas Production Function, J PHARM NEGATIVE RESULTS 2022;13: 652-658.

Access this article online

Quick Response Code:



Website:
www.pnrjournal.com

DOI:
10.47750/pnr.2022.13.04.087

Actually, the Bangladeshi government concentrated on enhancing agricultural education to boost economic development a few years following the Liberation War in 1971 (Alam et al., 2009). Productivity has increased significantly as a result of the adoption of contemporary agricultural technologies, improvements to the diffusion process, and enhancement of the farmers' existing but limited skills through agricultural extension services (AES).

However, the nation still lacks sustainable agricultural growth, and the farmers had low human capital (Adem & Gebregziabher, 2014). Consequently, agricultural extensions are necessary to promote faster output and rural revenue by quickening the spread of new technology (Athukorala, 2017). According to Haq (2013), who described the nation's current agricultural scenario, farmers now employ more irrigation and chemical fertilizers than they did in the past. Additionally, Rahaman et al. (2018) asserted that farmers typically rely on "pesticides" for enhancing productivity due to the rise in insect pests in recent decades. These cause ecological deterioration by contaminating food, water, air, and soil with pesticides. The socio-technical and environmental hurdles to production are two-fold, as are other key ones. Environmental constraints include soil depletion, salinity intensity, drought, and heavy rainfall, whereas socio-technical hurdles include an inadequate irrigation infrastructure, a lack of contemporary technologies, and bad management methods. These factors collectively have a negative effect on Bangladeshi farmers' productivity and effectiveness (Elias et al., 2014 & Miah et al., 2020). Therefore, overcoming these environmental and socio-economic challenges is essential for raising agricultural output and technical proficiency among Bangladeshi farmers (Hasan et al., 2020).

OBJECTIVES OF THE STUDY

This study's main goal is to estimate the technical efficiency of Amon rice farms in Bangladesh's Jhenaidah District. The precise goals consist of:

1. To identify the key variables that significantly influence the sample farms' level of technical inefficiency.
2. To pinpoint the barriers to Amon rice production in the research area.
3. To formulate different policies to increase the nation's production of Amon rice.

METHODOLOGY

3.1 Study Area and Data Collection

The primary data for the current study were gathered in Bangladesh's Jhenaidah district. The primary means of subsistence for the residents of the Jhenaidah district is agriculture, and paddy growing predominates in the area. A

survey was done on the production years of June 2021 to July 2022. The survey, which contains various socioeconomic data on 200 small, medium, and big farms, was carefully done. In conducting the research, multistage sampling technique was used. The first stage was the purposive selection of two from the six upazilas in the Jhenaidah district is chosen using simple random selection in the initial step. Kaligonj and Sailokupa are the upazilas. Under the Sailokupa and Kaligonj upazilas, there are 6 and 11, respectively. At the second stage, two unions—Nittanondopur and Abaipur of Sailokupa upazila and Triechandpur and Rakhalgachi of Kaligonj upazila—are picked by random sampling from each upazila. The final stage involves choosing two villages from each union using a random selection technique. The agriculture office for the upazila supplied a list of the villagers' farmers.

The size of sample of the paddy farmers were determined by

$$\text{(Guilford and Fruchter, 1978) formula: } N = \frac{Z^2 pq}{d^2}$$

Here, N = least size of sample, Z = 1.96 that refers to the 95% level of confidence, p = Prevalence 2% (0.02), q = 1-P = 0.98, d = level of precision 2% (0.02) and

$$N = \frac{1.96^2 \times 0.02 \times 0.98}{0.02^2} = 188 ; \text{ after adding ten}$$

percent for adjustment N is 210. Finally, total sample size set as 200.

3.2 Method of Data Analysis (Analytical Technique)

A Cobb-Douglas model has been utilized in this study to evaluate the technical efficacy of rice farming operations. The highest output that can be achieved with a specific set of inputs is known as technical efficiency (Narala and Zala, 2010). Technical efficiency analysis places emphasis on the maximum output that can be produced from a given set of inputs rather than the average output. The highest output a farm can produce given a certain level of inputs and technology is known as the frontier production function. The maximum output a company can create at a particular amount of inputs and technology can be calculated using the frontier production function (Farrell, 1957). In stochastic frontier, the disturbance term is divided into two parts: an asymmetric component that captures randomness that is not under the farmer's control, such as droughts, floods, and other similar events, as well as the statistical noise present in every empirical relationship; and a one-sided component that captures randomness that is. (i.e. inefficiency).

LITERATURE REVIEW

There haven't been many research conducted in Bangladesh that looked at the factors that influence technological efficiency. A sample of 150 Bangladeshi rice farmers' technical efficacy was examined by Khan et al. in (2010). For producers of boro and aman rice, separate Cobb-Douglas

production frontiers were computed. The results showed that farmers' technical proficiency in producing boro rice was significantly influenced by their degree of education. Using survey data from farms, it was determined how ownership of resources affected rice growers' productivity and technological efficiency in Bangladesh (Rahman & Rahman, 2009).

Biswas, Mallick, & Roy et al. (2021) demonstrated that, with respective yields of 162.74 and 136.48 maunds per hectare, participants and non-participants have respective mean technical efficiency ratings of 95% and 82%. The results are crucial for formulating plans for environmentally friendly agriculture practices and rural economic development in Bangladesh. Chandel, Khan, Li, & Xia, (2022) showed that through timely finance availability and agricultural information supplied to them via extension services, rice farmers' technical efficiency can be increased. They calculated the mean technical efficiency to be 91%, and they found that resource ownership and land fragmentation had a significant impact on efficiency differences. For a sizable dataset collected from 141 villages, (Asadullah & Rahman, 2009) studied the impact of education on farm production efficiency. Their studies showed that household education considerably reduced production inefficiencies. Services for agricultural extension can raise productivity among participants and level of living by educating farmers on how to use resources (such as inputs and technology) effectively, as shown by the positive correlation between their impact and technical efficiency (Athukorala, 2017). A similar relationship exists between agricultural productivity in emerging countries and the impact of agricultural extension services (Haq, 2013). According to their report, the technical effectiveness of farmers who participated and didn't participate in an AES program in Northern Ethiopia was 57%, 53%, and 72%, respectively. In Bangladesh, Chaity and Rahman (2017) found that NGO's support in agriculture increases access to new information and cutting-edge technical instrument. According to Ajibefun et al. (2006)'s calculation of the production function, farmers' income in Bangladesh increased in direct proportion to the level of extended contact between farmers and agents. Bio-slurry increases Boro production while requiring less labor, dry dung-cake, and chemical fertilizers. It also reduces CO2 emissions (Kabir et al., 2016). In their investigation into measuring farmers' technical efficiency, Afrin et al. (2017) found that farmers in southwest Bangladesh are around 86% effective. Farmer productivity is lower among those who don't use loans than it is among those who do. To increase the connections between farm and non-farm activity in Bangladesh, credit programs assist rural communities in using modern agricultural inputs and technologies (Khandker and Koolwal, 2016). Rahman et al. (2012) discovered the opposite; finding that whereas farm size is adversely correlated with technological efficiency, age level, educational status, and family size are positively correlated. Furthermore, several studies carried out in coastal Bangladesh by Alamgir et al. (2018); Hasan et al.

(2018); and Lázár et al. (2015) demonstrated the effects of climate change on agricultural livelihoods, food security, and income variation among cultivators in different regions. The effectiveness of traditional rice farms and farms using contemporary rice cultivars was compared by Balcombe et al. in 2007. Islam & Haider (2018) found that farmers in Bangladesh's southwest coastline region use a variety of marketing strategies in their study on the association between productivity and poverty. As a result, the literature demonstrates that research currently in publication rarely place a strong emphasis on evaluating the impact of agricultural extension services on paddy farmers' technical know-how in southwest Bangladesh.

THE EMPIRICAL MODEL

The Stochastic Frontier Production Function is the method of efficiency measurement that is most widely used (Rahman, 2003 and Coelli et al., 2005). For the analysis of agricultural efficiency, the Cobb-Douglas production function has been extensively employed in many empirical investigations, particularly in developing nations (Bajracharya, 2017 and Adhikari, 2018). The Cobb-Douglas production function is employed in the current study to calculate the technical efficacy of paddy farms. The following equation serves as the definition of the model employed in this investigation:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + (V_i - U_i) \dots (i)$$

Where, the subscript 'i', denotes the ith farmer in the sample, and X_1 is the total cost of labor (in Taka/biggha); X_2 is the total cost of fertilizer (in Taka/biggha); and Y_(i) is the total market value of Amon Paddy output of ith farm. X_3 = Irrigation costs overall (Taka/biggha); X_4 = Total cost (Taka/biggha) of the seeds; X_5 = Pesticide's total cost (Taka/biggha); X_6 = Total ploughing cost (Taka/biggha), Ln = Logarithm to base e; β_0 = Intercept (Constant); β_1, \dots, β_6 = Parameters to be estimated; V_i is a stochastic disturbance term. U_i is a random variable associated with production disturbances.

Technical Efficiency Model

A determinant of technical efficiency (inefficiency effects) is a function of socio-economic factors. The inefficiency effect model is built as follows

$$TE = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \epsilon_i \dots (ii)$$

Where, TE = the technical efficiency of the ith farmer, δ_0 = Intercept (constant), $\delta_1, \dots, \delta_7$ = Parameters to be estimated, Z_(1) = farmers age in years, Z_(2) = farming experience in years, Z_(3) = education in years, Z_(4) = size of farm in hectares, Z_(5) = access to credit in dummy (1 = yes and 0 = no), Z_(6) = extension contact in the production year in numbers of visit, Z_(7) = household size in number of persons in the house, ϵ_i = stochastic disturbance term.

RESULTS

6.1 Descriptive Statistics of the Variables

The total market value of the Amon rice produced in the production years of 2021–2022 is referred to as farm output. The whole cost of family and paid labor used in the production is included in the labor cost. The price of purchasing organic and inorganic fertilizers is included in

the cost of fertilizer. The entire cost of irrigation for paddy crops during the Amon season is used to compute irrigation cost. The cost of employing local and enhanced seed varieties is included in the seed cost. Cost of pesticides used in production comprises their overall cost. Table 1 displays the variables that were measured as well as summary statistics for the explanatory variables employed in the stochastic frontier model.

“Table: 1 Descriptive Statistics of the Variables”

	Unit	Minimum	Maximum	Mean	Std. Deviation
Output	Taka/bigha	10000.00	25000.00	18030.0000	3806.77787
Labor cost	Taka/bigha	1600.00	4500.00	2749.0000	793.94632
Seed cost	Taka/bigha	250.00	560.00	402.5500	92.88236
Fertilizer cost	Taka/bigha	1600.00	4000.00	2446.2950	569.17605
Irrigation cost	Taka/bigha	1000.00	2400.00	1562.8950	458.45657
Pesticide cost	Taka/bigha	250.00	600.00	427.7000	98.57635
Ploughing Cost	Taka/bigha	550.00	1050.00	771.5	99.9

Source: Field survey data

6.2 Results of the Technical Efficiency and Inefficiency Model by Using the Maximum Likelihood Method

“Table 2: Maximum Likelihood Estimates of the Cobb-Douglas Production Function”

Variables	Coefficient	Std. Deviation	t-ratio
Constant	.52	.613	0.549
Labor cost	.82***	.163	3.28
Fertilizer cost	-.51***	.03	-7.67
Irrigation cost	.04***	.022	2.41
Seed cost	.12***	.021	4.42
Pesticide cost	-.07***	.020	-7.08
Ploughing cost	.03	.13	.41
Inefficiency Model			
Constant	-.01	.10	-0.12
Size of Farm	-.45***	.11	-3.50
Size of Household	-1.35	.89	-1.53
Age level	-.41***	.12	-2.67

Educational status	-1.02***	.21	-3.30
Level of Experience	-.25*	.12	-1.57
Training	-.81**	.24	-2.30
Land fragmentation	.31	.70	.23
Exten. of service	-.32	.20	-1.23
Loan facility	-1.32***	.45	-2.56
Sigma-square σ^2	.26***	.05	4.18
Gamma γ	.70	6.25	.12

Source: Author’s calculations; Note: *, ** and *** indicate 1%, 5% and 10% significance level

Table 2 displays the outcomes of an estimation of the Cobb-Douglas production frontier parameters utilizing the Maximum Likelihood (ML) estimation technique. According to the statistics, the gamma value is 0.70. This demonstrates a 70% output divergence between the observed and maximal production frontiers. The labor cost, irrigation cost, and seed cost each have statistically significant coefficients of 0.82, 0.04, and 0.12, respectively. These suggest that a 1% rise in labor costs, irrigation costs, and seed costs may result in a 0.82%, 0.04%, and 0.12% increase in the overall value of rice produced in Amon, respectively. These outcomes are comparable to those attained and documented in (Paul, 2020;

Chandel, Khan and Xia, 2022; Biswas, Mallick, Roy & Sultana, 2021; Hasnain, Hossain and Islam, 2015). On the other hand, to describe the technical effectiveness of Amon rice production, the cost of fertilizer and pesticides has negative statistical significance. This suggests that a 1% rise in the price of fertilizer and pesticides may result in a 0.51% and 0.07% loss in the overall value of rice, respectively. These outcomes are in line with those of (Islam and Hossain, 2013; Khan, Huda and Alam, 2010). It is determined that the other variable, ploughing cost, included in the Cobb-Douglas production frontier is statistically insignificant to explain the technical efficacy of Amon rice production. The outcomes of the inefficiency model demonstrate that the statistically significant negative coefficients related with age, education, experience, and training. Accordingly, a 1% increase in any of these factors may result in a 0.41%, 1.02%, 0.25%, or 0.81% reduction in the technical inefficiency of Boro paddy production. These outcomes concur with the findings of (Nargis, and Lee, 2013; Chowdhury, Rumi, and Rahman, 2013; Donkoh, Ayambila, and Abdulai, 2013). In contrast to what Hossain and Rahman (2012) found, the coefficient of farm size, which is inversely connected with technical inefficiency, predicts that a 1% increase in farm size may lead to a 0.45% loss in technical efficiency. The land fragmentation coefficient is a positive number. This suggests that the level of inefficiency may rise as land becomes more and more fragmented. The coefficient linked to the credit facility is statistically significant in explaining the inefficiency of the Boro rice farmers and adversely correlated with technical inefficiency. This suggests that a 1% increase in credit availability might reduce inefficiency by 1.32%. Household size, experience, and extension service, though statistically negligible, are negatively connected with the level of inefficiency.

PROBLEMS AFFECTING RICE CULTIVATION

- One of the primary limitations for rice cultivation under rainfed circumstances in Bangladesh is drought, which significantly lowers output. In the reproductive or early ripening stages, transplanted aman typically experiences water stress, which lowers crop output.
- Flash floods mostly impact lowland aman rice seedling stages in rainfed environments. Transplanting often suffers from the erratic rainfall. Flooding and heavy rains delay planting and inflict significant seedling damage to crops.
- The coastal region is fallow during the winter because of salt. The main crop is aman, which is grown during the wet season. Farmers primarily use traditional rice varieties, which can survive salinity but produce poorly.
- Early boro rice in Bangladesh frequently experiences low-temperature stress throughout both the vegetative and reproductive stages (Nahar et al., 2009a). The productivity of boro rice in Bangladesh would be severely

reduced by a rise in air temperature.

- Bangladesh's intensive agriculture, uneven application of chemical fertilizers, limited use of crop residue addition, and little use of green manure cropping are all contributing to the country's diminishing soil fertility. In Bangladesh, the amount of rice produced without fertilizer has decreased over time (BRRI, 2007–08).
- Weeds, diseases, and insects numerous pests frequently attack rice plants. A significant barrier to the production of rice is insects. Major diseases include bacterial leaf blight, sheath blight, leaf blast, sheath blast, tungro, and stem rot. Aus rice has a significant weed invasion. When aman rice is being harvested, rats may also attack the crop, significantly lowering the output.
- Rice agriculture is subject to numerous challenges in Bangladesh. Bangladeshi farmers engage in year-round farming, which frequently reduces the amount of land available for the timely planting of the following crop. Young seedlings can be harmed by flooding caused by an early monsoon and high rainfall, while severe water stress is typically caused by a later arrival (Mahmood et al., 2004).
- Farmers don't follow integrated techniques for better management, such as timing planting, using high-quality seeds, using fertilizer sparingly, and controlling weeds and insects. The yield of the farmer's field and the potential output of a particular variety are different.

POLICY SUGGESTIONS

- Bangladesh's rice yield and overall rice production still have room to grow if the right crop management practices are used.
- In the field, boro rice is continuously grown in stagnant water during the dry season. For agricultural purposes, groundwater is the main supply of water. The groundwater in Bangladesh is currently under danger. An effective way to preserve the subsurface water table is to implement water-saving technology in the production of rice.
- Bangladesh's soil fertility is declining day by day. The application of fertilizers should be based on the findings of soil tests.
- Flood irrigation can be replaced with other wet and dry (AWD) irrigation methods. Surface water should also be conserved in ponds and small rivers during the rainy season and used for aman rice development, especially during the flowering stage. For rainfed aman agriculture during the flowering period, BRRI has devised rainwater gathering equipment to alleviate drought (Biswas, 2014). Farmers around the nation should be introduced to this technology.
- We must produce short-duration green-manure crops and incorporate agricultural leftovers into the soil to prevent the loss of organic matter. We must balance the application of organic and inorganic fertilizers in the soil to ensure

sustained crop production.

□ Bangladesh has a labor-intensive agriculture. Laborers are hard to come by during both planting and harvesting, which frequently delays the timely planting and harvesting of crops. Sometimes farmers neglect to eliminate weeds before the crucial point of crop-weed competition, which can result in significant output decreases. As a result of their reliance on the weather, rice crops can potentially sustain harm during the post-harvest period. Enhanced post-harvest technology can also cut down on crop loss.

□ It is important to improve the agricultural knowledge and information system, which brings together farmers, researchers, and extension workers.

□ Collaboration at the regional and global levels is necessary to share knowledge and technology and increase rice production sustainably.

CONCLUSION

In conclusion, Bangladesh produces enough rice on its own, but the production is low. Bangladesh has the ability to boost its rice production and exports, which will benefit the nation's economy. In order to adapt to Bangladesh's different surroundings, targeted breeding is crucial. Rice production and nutrition will be increased via the creation of additional nutrient-rich, high-yielding, early-maturing, drought-resistant, salt-tolerant, disease-resistant, submersible, cold-tolerant, and high-temperature tolerant cultivars. Additionally, effective crop management techniques will increase rice production. The study's conclusions suggest that the government should take the necessary steps to improve farmers' access to funding and elevate the level of education, training resources, and extension services that are accessible to them.

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