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Technical Efficiency Measurement of Green Chili Production in Bogra District of Bangladesh

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Abstract: Agriculture plays vital role and is taken as the most important sector of economy in Bangladesh. Bangladesh possesses very fertile land in which various types of crops are produced. Chilli is one of the most important crops grown in Bangladesh. Although chilli is a major spice crop of Bangladesh, but its production technologies has not been standardized from the scientific and economic point of view. The main objective of this study is to estimate the technical efficiency of chili production in Bogra district (the largest produced area) of Bangladesh. In order to estimate the level of technical efficiency in a manner consistent with the theory of production function, Cobb-Douglas type stochastic frontier production function was used in the present study. Among the elasticities, the elasticity for land used for chili production is the largest (31.1434) and for the cost on insecticide is the lowest (0.0401). The average technical efficiency for the sample is about 88 percent. The Government should provide priority by giving subsidy to the farmers on different inputs such as seeds, fertilizer, irrigation etc. to achieve self-sufficiency in chilli production. Government also should take necessary steps to improve the knowledge of a farmer to the modern cultivation technique and encouraged them to adopt the new technology to increase the production.

Keywords: Technical Efficiency, Frontier Production Function, Chilli, Bangladesh.

1 Introduction

Bangladesh is an agricultural country and most of the inhabitants directly or indirectly are involved in agricultural activities for their livelihood. Agriculture has a great contribution to the Gross Domestic Product (GDP) of the country. Agriculture plays vital role and is taken as the most important sector of the economy. Bangladesh possesses very fertile land in which various types of crops are produced. Chilli is one of the most important crops grown in Bangladesh. Chili peppers are native to South and Central America. They were introduced in South Asia in the 1500s and have come to dominate the world spice trade (Huq and Arshad [1]). The chilli is a plant of tropical and sub-tropical region. It grows well in warm and humid climate. Deep, loamy, fertile soils rich in organic matter are preferred by the crop for satisfactory growth. Also need well drained soils with adequate soil moisture for the growth of the crop. Chilli grows well in the dry and the intermediate part of the country. According to BBS [2], chillies are grown in all the district of Bangladesh but plenty of chillies are produced in the district of Bogra, Rangpur, Kurigram, Jamalpur, Natore and Jessore.

Chillies are rich in vitamins, especially in vitamin A and C. They are also packed with potassium, magnesium and iron. Chillies have long been used for pain relief as they are known to inhibit pain messengers, extracts of chilli peppers are used for alleviating the pain of arthritis, headaches, burns and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol. They are also helpful in getting rid of parasites of gut (Karpate and Saxena [3]). The peoples of Bangladesh are usually used chillies in all curry preparation like meat, fish, vegetables, pulses etc. for its typical color, taste and flavor.

Bangladeshi vegetable such as green chilli, yard long bean and okra are exported to about 30 market destinations in abroad. The major buyers are, in fact, located in two regions, the UK and the Middle East. In the Middle East, the major market outlets are Saudi Arabia, Kuwait, UAE, Qatar, Bahrain and Oman (EPB [4]). Chowdhury, *et al.* [5] determine the export supply and value chain analysis and estimate the marketing costs and margins for green chilli in 2005-06 in Bangladesh. Hossen [6] had done a statistical analysis of current chili production and its prospect in Bangladesh considering the various sources of variations on the time series data for 23 districts of Bangladesh over a period 2001-02

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to 2010-11. Hoq *et al.* [7] consider two chilli growing districts Jamalpur and Bogra to examine the profitability, marketing chain and efficiency, marketing cost and margin, post-harvest loss and seasonality of chilli in Bangladesh.

Although chilli is a major spice crop of Bangladesh, but its production technologies has not been standardized from the scientific and economic point of view. Farmers of Bangladesh are growing chilies following indigenous methods with the poor yield rate. The reasons behind such low yield due to lack of high yielding variety and method of production practices followed by the local growers. Therefore, research needs to bring improvement in production technologies as well as considering economic return. Thus, the main objective of this study is to estimate the technical efficiency of chili production in Bogra district of Bangladesh.

2 Methodology

2.1 Sample Size Determination and Data Collection

This study is mainly based on primary data. For this study, the information was collected by direct interview. In Bangladesh chili is highly produced at Bogra district. That's why Bogra district is selected in this study. The sample size is determined by the formula, $n=\frac{z^2pq}{d^2}$, where n is the desired sample size, z the standard normal deviate, p the proportion in the target population estimated to cultivate the chili, $q=1-p$ and d is the degree of accuracy desired (precision level of the estimate). From a pilot survey of the target area, we estimate p as 0.75. We also consider $z=1.645$ for 90% confidence level and $d=0.10$. They give $n=50.74$. Purposively three villages were selected from Shibganj Upazila of Bogra districts, where it is cultivated extensively. A total of 50 chili growers were selected from the three villages. Simple random sampling technique was used to select the farmers. Data were collected by visiting each farm personally and by interviewing them with the help of a pre-tested questionnaire. Data collection was conducted on September of 2015.

2.2 Method of Analysis

In order to estimate the level of technical efficiency in a manner consistent with the theory of production function, Cobb-Douglas type stochastic frontier production function was used in the present study. The Cobb-Douglas form of production function has some well-known properties that justify its wide application in economic literature (Henderson and Quandt [8]). Besides the sample size is only 50 which is not large enough to use any other production function rather than Cobb-Douglas stochastic frontier production function. The measurement of the efficiency of production has been an important area of research over the last two decades. For this purpose stochastic frontier production function has been used. The advantage of using stochastic frontier models are: (1) It introduces a disturbance term representing statistical noise, measurement error and exogenous shocks beyond the control of production units which would otherwise be attributed to technical inefficiency, (2) It provides the basis for conducting statistical tests of hypothesis regarding the production structure and the degree of inefficiency. The estimation of frontier function and efficiency can be completed either in one stage or in two stages. The two-stage analysis of explaining levels of technical efficiency (or inefficiency) was criticized by Battese and Coelli [9] as being contradictory, in the assumptions made in the separate stages of the analysis. In this paper, we follow the Battese and Coelli [9] approach of modeling both the stochastic and the technical inefficiency effects in the frontier, in terms of observable variables, and estimating all parameters by the method of maximum likelihood, in a single-step analysis.

The Cobb-Douglas stochastic production frontier model can be specified as:

$\ln Y_i=\beta_0+\sum\beta_i \ln X_i+\varepsilon_i$, here, $i=1,2,3,...,n$ (farm), Y_i = Production of chili, X_i = Inputs used in chili cultivation, $\varepsilon_i=(v_i-u_i)$ is a composite error, where, $v_i \sim N(0,\sigma_v^2)$ and independent on u_i's which is a non-negative random variables, associated with technical efficiency in production, which are assumed to be independently and identically distributed and truncated (at zero) of the normal distribution with zero mean. Here, $n=50$; Y_i represents the production of chili (in taka); X_{1i} represents the total area of chili (in bigha); X_{2i} represents the cost on plough (in taka); X_{3i} represents the cost on seed; X_{4i} represents the cost on cow dung; X_{5i} represents the cost on fertilizer; X_{6i} represents the cost on insecticide; X_{7i} represents the cost on irrigation; X_{8i} represents the cost on bamboo; X_{9i} represents the cost on others; X_{10i} represents the cost on total labor. The technical inefficiency effect for the i-th farmer, u_i, is obtained by truncation (at zero) of the normal distribution with mean m_i, and variance, σ^2, such that $m_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i}$, where, Z_{1i} represents the age of farmers in years; Z_{2i} represents the education of farmers in years of schooling; and the δ 's are unknown parameters to be estimated. The stochastic frontier model used in this study is estimated using the computer program, FRONTIER 4.1, written by Coelli [10]. The parameters of the frontier model are estimated, such that the variance parameters are: $\sigma_S^2 = \sigma_V^2 + \sigma^2$ and $\gamma = \frac{\sigma^2}{\sigma_S^2}$, where the γ parameter has a value between zero and one.

3 Results and Discussion

The maximum likelihood estimates of the parameters of the stochastic frontier production function are presented in Table 1, along with their standard errors and t-values.

Table 1: Maximum likelihood Estimates for Parameters of Stochastic Frontier Production Function and Inefficiency Model for chilli Farmers in Bogra District.

Variable	Parameter	Standard error	t-value
Constant	*243.9141*	*0.999*	*244.2*
Ln of land	*31.1434*	*0.6959*	*44.75*
Ln of cost on land preparation	*0.5506*	*0.1719*	*3.203*
Ln of cost on seed	*0.2856*	*0.02145*	*13.31*
Ln of cost on cowdung	*0.16*	*0.0146*	*10.96*
Ln of cost on fertilizer	*0.6825*	*0.309*	*2.209*
Ln of cost on insecticide	*0.0401*	*0.0363*	*1.105*
Ln of cost on irrigation	*0.0995*	*0.04297*	*2.316*
Ln of cost on bamboo	*0.377*	*0.19489*	*1.934*
Ln of other cost	*0.0632*	*0.01797*	*3.517*
Ln of cost on labour	*0.1714*	*0.01156*	*14.83*
Inefficiency Model			
constant	*0.1432*	*0.015794*	*9.066734*
Age	*-0.02563*	*0.00568*	*-4.51232*
Education	*-0.299785*	*0.013357*	*-22.444*
Variance Parameter			
sigma-square	*0.0323*	*0.012185*	*2.6508*
gamma	*0.7995*	*0.009725*	*82.2108*
Log likelihood function			*32.44965*
Likelihood ratio			*12.27805*

The estimate for the variance parameter, $\frac{\sigma^2}{\sigma_S^2}$ indicates that the variance σ^2, associated with the inefficacy effect is about 80% of the two variances. Except the elasticities for the cost on insecticide and bamboo all the inputs are differed from zero at the 5% significance level. Among the elasticities, the elasticity for land used for chili production is the largest (31.1434). This means a 10% increase in the land used for chili production will give rise to a 311.434% increase in output. The second largest elasticity is cost on fertilizer which is 0.6825. Among the elasticities, the elasticity for the cost on insecticide is the lowest (0.0401). The results of technical inefficiency effects are also presented in the lower part of Table 1. The results revealed that age and education level of the farmers has a positive effect on technical efficiency. The significant value of Likelihood Ratio test also reveals that there was technical inefficiency effect in the production of chili.

Table 2: Summery Statistics of Efficiency Estimates from the Stochastic Frontier Model.

Statistic	Efficiency Score	Statistic	Efficiency Score
Mean	0.879007096	Standard Deviation	0.0694247
Minimum	0.71294691	Kurtosis	0.012878532
Maximum	0.97135332	Skewness	-1.029472944

The average technical efficiency for the sample is about 88 percent, with a minimum of about 71 percent and maximum 97 percent (Table 2). This implies that on an average the respondents are able to obtain 88 percent of potential output from a given mix of production inputs. Thus, in the short run, there is a scope for increasing chilli production in Bogra district by 12 percent, by adopting the technology and the techniques used by the best practice chilli farms.

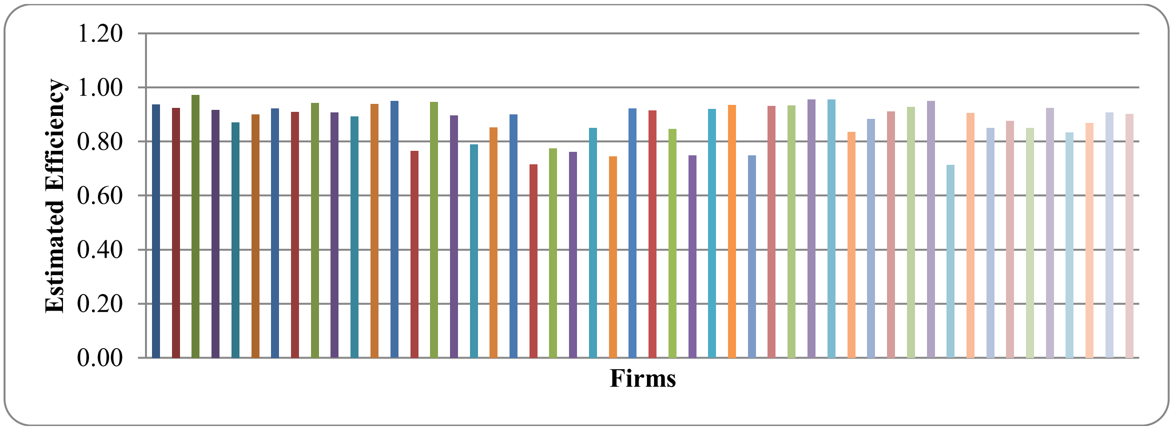

Figure 1: Estimated Efficiency of the Firms.

It is observed that the estimated firm efficiency almost nearer to one. Only 18 percent of the firm has efficiency score less than 0.80. About 54 percent of the firm considered in this study operate with efficiency level greater than 0.90 (Figure 1).

Table 3: Frequency Distribution of Technical Efficiency Estimates from the Stochastic Frontier Model.

Efficiency Score	Number of Firms	Percentage of Firms
0.70-0.75	5	10
0.75-0.80	4	8
0.80-0.85	3	6
0.85-0.90	11	22
0.90-0.95	24	48
0.95-1.00	3	6

The frequency distribution of the efficiency estimates obtained from the stochastic frontier model in presented in Table 3. About 54 percent of the firms operate with efficiency level greater than 90 percent as can be seen from the table. Only 18 percent of the firms operate with efficiency level less than 80 percent.

4 Conclusion

Agricultural productivity varies due to differences in production technology, differences in the setting in which production occurs and differences in the efficiency of the production process. Gaining efficiency through greater technical efficiency is an important source of growth for the agricultural sector. It is observed that among the elasticities, the elasticity for land used for chilli production is the largest (31.1434) and for the cost on insecticide is the lowest (0.0401). Age and Education level of the farmers has a positive effect on technical efficiency. It is observed that the estimated firm efficiency almost nearer to one. Yet there is a scope for increasing chilli production by 12 percent by adopting the technology and the techniques. The production of chilli largely depends on the use of fertilizers, land size, land preparation etc. The Government should provide priority to the agriculture sector to increase the production of chilli by giving subsidy to the farmers on different inputs such as seeds, fertilizer etc. to achieve self-sufficiency in chilli production. Government also should take necessary steps to improve the knowledge of a farmer to the modern cultivation technique and encouraged them to adopt the new technology to increase the production.

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