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Technical Efficiency Assessment of Dairy Farm in the South-west Region of Bangladesh

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Abstract
The paper concentrates on technical efficiency assessment of dairy farms in the south-west region of Bangladesh. Stochastic frontier approach is used in the paper. 70 dairy farms are considered as sample. The data reveals that number of labour and the quantity of food are statistically significant at 1 percent level of significance. In addition, the data also manifests that numerous farm specific characteristics i.e. farm size, farmer's age and amount of credit are statistically significant at 1 percent, 10 percent and 10 percent level of significant respectively. The range of technical efficiency for the farms varies from 26 percent to 95 percent. The mean technical efficiency is 68 percent for the dairy farms of the south-west region. This implies that an average output of milk production falls 32 percent short of maximum possible level. Hence, there is huge scope of improvement in dairy sector. Therefore, to improve the farm productivity proper training for the farmer and medical treatment facility should be given.
Keywords: Dairy farm, Cobb-Douglas production function, Technical efficiency, South-west region.
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1. Introduction

Bangladesh is an agricultural country and its economy is mainly based on agriculture (Saadullah, 2001). Among 140 million of people, 80 percent of them lived in rural area where 80 percent own livestock (Haque, 2007). Agriculture in Bangladesh is characterized by diversified farming like crops, livestock, fisheries and agro-forestry to meet the household requirements and minimize the risk and uncertainty (Sharmin et al., 2012). Among different agricultural activities dairy farming is one of them. Dairy sector is a major contributor to boost economy (Sharmin et al., 2012). In 2006, the livestock sector directly contributed 3 percent of gross domestic product (GDP). However, indirect benefits like draught power, manure for fuel and fertilizer are double i.e. 6 percent of GDP (Haque, 2007).

In Bangladesh, more than 70 percent of the dairy farmers are smallholders and contribute 70-80 percent of the country's total milk production. Milk production growth has increased from 4.1 percent to 7.4 percent per annum in FY 2000-2005 and FY 2005-2008, respectively. Even with this faster growth the per capita milk availability in the year 2008 is only 19 kg (Hemme et al., 2008) which is far below the requirements (92 kg/person/year) as indicated by the World Health Organization (WHO). Dairy farm is considered as a strong tool to develop a village micro economy of Bangladesh. It can improve rural livelihoods and to alleviate rural poverty (Shamsuddin et al., 2007). In order to achieve competitiveness dairy farmers need to find ways of reducing costs and increasing returns (Dayanandan, 2011). Therefore, the objective of the study is to investigate the technical efficiency level of dairy farm in the south-west region of Bangladesh.

2. Literature Review

Efficiency is an important factor of productivity growth especially in developing country perspective (Ohajianya, 2005). Efficiency in agriculture is associated with the possibility of farm production to attain optimum level of output at least cost (Ajibefun, 2000). Ellis (1993) points out three conditions for satisfying the production unit to be efficient under neoclassical assumptions: a) same prices for inputs and outputs, b) same production functions and c) profit maximizing behavior. Any violation of at least one point there is variation in efficiency level. Efficiency is composed of two components i.e. technical efficiency and allocative efficiency. The paper concentrates solely on technical efficiency of dairy firms of the South-west region of Bangladesh. Therefore, technical efficiency (TE) refers to the ability to avoid waste by producing as much output as input usage allows or by using as little input as output production allows (Lovell, 1993).

There are two methods to estimate technical efficiency i.e. Data Envelopment Analysis (DEA) and Sochastic Frontier Analysis (SFA) (Coelli, 2005). Stochastic frontier analysis (SFA) uses econometrics based on the deterministic parameter frontier of Aigner and Chu (1968). SFA method can handle cross-section data and panel data.However, DEA deals with panel data. Sharafat (2013), Kompas and Che (2004), Masunda and Chiwesh (2015), Binici et al. (2006), Zhu et al. (2012) and others use SFA technique for studying technical

efficiency of dairy farms in different countries of the world where they find mean efficiency is 39.5 percent,87.39 percent,54.9 percent, 50 percent,61.4 percent, 55.3 percent and 78.8 percent respectively. Since, the data used in the study is cross section data the study uses SFA approach.

Seyoum et al. (1998), Asogwa, et al. (2011), Umeh and Asogwa (2011) and Oladeebo (2012) apply Cobb-Douglas stochastic frontier model for efficiency analysis. For the simplicity of analysis the study considers Cobb-Douglas stochastic frontier model. Smallholder milk producers played an important role in dairy market of Bangladesh. They sold milk directly to consumers or milk middlemen at local markets. They supplied all domestic milk for informal and traditional market (Quddus, 2013). Khan et al. (2013) find that average milk production per cow is 6.05 liter per day. Quddus (2013) finds that 35 percent farmers owned milk yield 11.5 liter milk per day. Hussain (2013) examines that in Bangladesh almost two out of every three household rear cattle to produce milk for personal consumption.

2.1 Variables identification for Empirical Model

Farm size has a positive relationship with dairy farm efficiency. Sarafat (2013) and Tauer (2001) find positive relationship between farm size and technical efficiency at 1 percent and 5 percent significant level. These results are same for other authors' findings like Kalirajan and Flinn (1983), Kalirajan and Shand (1985) and Belbase and Grabowski (1985).

Formal education is commonly measured in years of schooling. Belbase and Grabowski (1985), Kalirajan and Shand (1985) find positive relation between TE and education. However, Kalirajan and Shand (1985) report that there is no significant relationship between these two variables. Experience is the number of years that farmers are involved in farming activities. This coefficient was expected to be positive and it was statistically significant at the 1 percent level in the TE model of Khai and Yabe (2011); Asogwa et al., (2011). Farming experience positively contributed to improve technical efficiency (Masunda and Chiweshe, 2015).

Area is the size of area cultivated for farming. Khai and Yabe (2011) detected that increase of area increases TE. It is statistically significant at 1 percent level. On the other hand Asogwa et al. (2011) find that area has negative impact on TE. Gelan et al., (2010) detected that Off-farm income has negative but insignificant effect on TE. Contact with an extension officer during the past year is positively related to efficiency but statistically insignificant. The relationship between TE and the contact with extension services is negative (Sarafat, 2013). Asogwa et al. (2011) cite that household size positively affect the TE.

3. Methodology

3.1 Study Area and Sampling

South-west region of Bangladesh is considered as the study area for this study. Authors select two districts for this study. The main occupation of the people of these two areas is agriculture. About 39.43 percent of total population of Khulna district and 39.84 percent of total population of Jessore district are involved with agricultural activities. People who have milk producing cow, these farms are selected as sample. People who have at least three cattle are considered as farm (Abdulai, 1998). This study also considers those dairy farms which have at least 3 cows. Here number of farm animals mean number of milking cow, calf and oxen. Total sample size is 70 where 35 dairy farms are considered in each district on the basis of purposive sampling. The sample unit of this study is those farmers who have own dairy farm in the study area.

3.2 Analytical Tools

The efficiency level of a farm is measured by the ratio of actual output to the maximum attainable output. The technical efficiency shows the farms' ability of maximizing output with a set of given input. The range of TE is 0 to 1. TE = 1 implies that the farm is producing on its production frontier and is said to be technically efficient. Hence, (1–TE) represents the gap between actual production and optimum attainable production that can be achieved by moving the firm towards the frontier through readjusting inputs (Ahmed et. al, 2010). If all the factors are utilized properly and efficiently, then the production would be at a maximum level. Otherwise, there will be a gap between the maximum level of production and the actual level of production and this gap will represent inefficiency. Relationship between influential factors of dairy farms' in producing milk is analyzed with the help of Stochastic Frontier Analysis (SFA).

3.3 Estimation of Cobb-Douglas Stochastic Production Function

The main Cobb-Douglas production function is given by Charles Cobb and Paul Douglas in 1928. Cobb-Douglas forms have been used in many studies, particularly in those relating to developing agricultures. Therefore, this study employed the following Cobb-Douglas Stochastic functional form. Therefore the model is

$$\ln Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i \ln X_i + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, Y_i denotes the output i.e. liters of milk production, X_1 indicates number of labor, X_2 means quantity of feed, X_3 shows medicinal cost, X_4 denotes electricity cost, β_0 is an intercept term, β_i is coefficient of i^{th} independent variables, V_i is statistical disturbance term (random error term), U_i is technical efficiency effect independent of V_i, i is the i^{th} dairy farmer, where i = (1,……., n)

3.4 Factors of Technical Efficiency Assessment

The factors responsible for technical efficiency model in the study area are given below:

$$TE_i = \delta_0 + \delta_i \sum_{i=1}^{n} Z_i + e_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, TE_i reveals efficiency function, Z_i is the vector of explanatory variables, δ_0 is intercept term, δ_i is the parameter for i^{th} independent variables and e_i is error term. A brief explanation of the vector of explanatory variables is depicted in Table 2 along with the literature support. The values of unknown coefficients in equation (1) and (2), that is, β and the δ can be obtained jointly by using the maximum likelihood method (ML). An estimated value of technical efficiency for each farmer is then calculated in

$$TE_{1i} = \exp(-U_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

4. Summary Statistics

Milk production depends on various factors like farm size, feed, labor, training, credit facility, socio-economic factors and others. Descriptive statistics of the variables used in stochastic frontier production function is presented in the Table 4. The mean value of milk production is 2836.5 liter per month. The mean farm size is 11 cattle with a minimum farm size of 4 cattle and maximum 37 cattle. For milk production the average number of labor is 4 where both family and hired labors are included. Average quantity of feed is 10035 kg. The medicinal cost which includes the vitamin cost, veterinary cost and breeding cost spend for cows. The minimum cost is BDT 400 and maximum BDT30000, and average electricity cost is BDT 700.

The average farmer age in the sample is 43 years old. The average year of schooling is 6 years and farming experience is 22 years. These data show that most of the producers although they are with good experience and young, they are not well educated and not hiring enough labor for their activity. The average household size is 5 in number and the maximum amount of taking loan is BDT 800000 where the average off-farm activity is BDT 19000. This means that income of the farmers is not sufficient to meet up their daily needs and the cattle also. For this reason they have to take higher amount of loan. The average training facility and contact with officer is 1.4 and 1.03 percent respectively.

4.1 Explanation of the Estimates of the Cobb-Douglas Stochastic Frontier Model

The parameter estimates of the Cobb-Douglas stochastic frontier model is shown in Table 5. The estimated elasticity of output with respect to labor, quantity of feed, medicinal cost and electricity cost are 0.26, 0.48, 0.21 and -0.03 respectively. These coefficients represent percentage change in the dependent variable as a result of percentage change in the independent variables. The explanatory variables used in the analysis are not multicollinear. Since, the value of VIF is 1.92 which is less than 4, bears the testimony that the data are not multicollinear. The coefficient of labor is 0.26. It indicates that 1 percent increase in the number of labor, milk production also increased by 0.26 percent when all other variables are constant. It is statistically significant at 1 percent level.

In addition, the coefficient of quantity of feed is 0.48 which describes that 1 percent increases in feed quantity, milk production also increased by 0.48 percent holding other variable constant. The coefficient of medicinal cost is 0.21 which implies a positive relationship with milk production and medicinal cost. If all other variables are constant, 1 percent increases in medicinal cost increases milk production by 0.21 percent. It is statistically significant at 5 percent significant level. Variances of one sided error term $\ln\sigma^2$ u (variance of inefficiency term) and variances of two sided error term $\ln\sigma^2$ v (variance of stochastic disturbance term) are also found to be statistically significant at 1 percent level. The parameter Lambda (λ) is greater than one. Such a result according to Tadesse and Krishnamoorthy (1997) indicates a good fit for the model.

4.2 Determinants of Technical Efficiency

Table 6 represents the estimated coefficient for the TE model and suggests a number of factors to explain TE. Table 6 shows that if farm size increase by 1 number of cattle, it will lead to an increase technical efficiency of almost 0.009 and it is significant at 1 percent level of significance. This increase in TE due to farm size increase could be attributed to the economies of scale which implies, as the farm size increase the lesser costs per production unit is attained. An increase of farmer's age by 1 year, it will lead to decrease the TE at 0.004 and it is statistically significant at 10 percent significance level. That is with the increase of age, TE of farm is decreasing. If the amount of credit increases by BDT 1, TE increased by 0.00002 and it is significant at 10

percent level of significance. The other factors i.e. off-farm income, education, household size, farming experience, training facility and contact with officer is not statistically significant. The value R^2 is 0.31 implying that 31 percent of the total variation in the dependent variable is explained by the variation in explanatory variables.

4.3 Level Technical Efficiency

Table 7 illustrates farm level technical efficiency of the dairy farm. The table reveals that a wide variation in the level of technical efficiency among the farmers. The measure of technical efficiency ranges from 0.00 to 1.00. In this paper the range of technical efficiency for the dairy firms are from 0.26 to 0.95 with mean technical efficiency 0.68. This indicates that an average output of milk production falls 32 percent short of maximum possible level. Therefore, in the short run it is possible to increase the output of dairy farm by an average 32 percent with the available set of inputs.

Table 7 shows that majority of the dairy farmers belong to the most efficient category that is 50 percent from 71 to 100 percent while few are less efficient that is 12 percent at the range of 1 to 50 percent. Although on average the technical efficiency of milk production of dairy farm is good, there is no farmer that has technical efficiency of 100 percent. The level of technical efficiency obtained in this study suggests that opportunities exist for increasing productivity.

5. Conclusion

Bangladesh is an agro-based country and most of the rural people are engaged in different agricultural activities. They are engaged in this sector as their hereditary business. The analysis of study area author finds that the average cost of milk production of 70 dairy farms is BDT 93886 and average revenue of milk production is BDT 95832. The profit figure of this sector is small. It is because of low milk price and high feed price of cattle. But as a hereditary business, most of the respondents cannot leave it. Some respondents claim that as a low milk price, they want to convert their business from milk producing cow to beef producing cow. Because they think that beef producing cattle business is more profitable than milk producing cattle business. As a low milk price, profit in this sector is decreasing.

Major portion of revenue comes from milk selling where major portion of cost is spending for feeding. In the production function three variables are statistically significant. Number of labor and quantity of feed are significant at 1 percent level and medicinal cost is significant at 5 percent level of significance. In efficiency analysis three variables are significant among the seven variables. Age and amount of credit is statistically significant at 10 percent level and farm size is statistically significant at 1 percent level. The mean technical efficiency of dairy farm is 68 percent which revealed a wide variation of technical efficiency among the farmers and it is possible to increase the output of dairy farm.

If people are educated they can efficiently use inputs and produce more output. So education is must for all and people have to engage in different training program so that they can be trained up correctly. Government should give different facility in dairy sector and ensure availability of medicine and treatment facility. So, from the above discussion it can be concluded that dairy farming is very important and essential sectors for Bangladesh. It helps to boost the economy of a country, increases employment opportunity and reduce unemployment problem.

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List of Table

Table No. 1: Distribution of Location and Sample Size

Name of District	Name of *Upazila*	Sample Size
Khulna	*Khalishpur*	5
	Dumuria	15
	Sahapur	15
Jessore	*Barakpur*	10
	Bodh Khana	10
	Chondipur	15
Total		70

Source: Authors' Compilation

Table No. 2: List of Variables for Cobb-Douglas Production Function Estimation

Sl. No.	Variable	Unit of Measurement	Expected Sign	Literature
		Dependent Variable		
1	Milk Production	Liter / Month	NA	Sharafat, 2012
		Independent Variable		
1	Labor	Number / Month	_	Binci et al, 2006
2	Quantity of Feed	Kg / Month	+	Sharafat, 2012
3	Medicinal Cost	BDT / Month	+	Sharafat, 2012
4	Electricity Cost	BDT / Month	+	Salma, 2014

Source: Authors' Compilation

Table No. 3: List of Variables for Technical Inefficiency Assessment

Sl. No.	Variable	Unit of Measurement	Expected Sign	Literature
		Dependent Variable		
1	Milk Production	Liter / Month	NA	Sharafat, 2012
		Independent Variable		
1	Farm Size	No. of Cattle	+	Sharafat, 2012
2	Age of Respondents	Year	+	Masunda&Chiweshe, 2015
3	Educational Status	Year of Schooling	+	Binci el at. 2006.
4	Farming Experience	Farming Age (Year)	+	Sharafat, 2012
5	Household Size	No. of Family Member	+	Todsadee et. al., 2012
6	Off-Farm Income	BDT / Month	+	Jwanya&Gojing, 2014
7	Amount of Credit	BDT / Month	?	Authors' Compilation,2015
8	Training Facility	Dummy (1 = Yes, 0 =No)	+	Salma, 2014
9	Contact with Extension Officer	Dummy (1 = Contact with Extension Officer, 0 = Otherwise)	+	Binci el at. 2006

Source: Authors' Compilation

Table No. 4: Descriptive Statistics of the Study Variables for Milk Production

Variables	Unit of Measurement	Mean	Std. Dev.	Min.	Max.
Milk Production	Kg	2836.5	1761.88	270	9160
Farm Size	Number	11.44	6.84	4	37
Labor	Number	3.5	1.98	1	10
Quantity of Feed	Kg	10035.26	5456.22	500	26695
Medicinal Cost	BDT	3471.42	2344.02	400	15000
Electricity Cost	BDT	705.85	611.81	200	3000
Age	Year	43.24	9.08	20	65
Education	Year	6.42	3.67	0	17
Household Size	Number	5.14	1.82	3	14
Off-farm Income	BDT	19392.86	15966.65	0	60000
Farming Experience	Year	21.57	6.23	8	35
Amount of Credit	BDT	139500	183836.2	0	800000
Training Facility	Dummy (1=Yes, 0=No)	1.4	0.49	0	1
Contact with Officer	Dummy (1=Yes, 0=No)	1.02	0.16	0	1

N.B.: N= Number of Observation; Std. Dev. = Standard Deviation
Min = Minimum; Max = Maximum.
Source: Authors' Compilation

Table No. 5: Estimates Cobb-Douglas Production Function

Variables	Coefficient	Standard Err.	t-value
ln labor	0.26***	0.10	2.65
ln Quantity of Feed	0.48***	0.07	6.27
ln Medicinal Cost	0.21**	0.10	2.00
ln Electricity Cost	-0.03	0.06	-0.50
Constant	1.97	0.87	2.25
$\ln\sigma^2$ v	-3.69***	0.89	-4.11
$\ln\sigma^2$ u	-1.23***	0.36	-3.34
$Sigma^2$	0.31	0.09	
Lambda	3.42	0.16	
Likelihood Ratio	2.07		
Log Likelihood Function	-24.60		

N.B.: ** and *** denote 5% and 1% significance level respectively.
Source: Authors' Compilation

Table No. 6: Technical Efficiency Parameters in Stochastic Frontier Function

Variables	Coefficient	Standard Error	t-value
Farm Size	0.009***	0.003	3.02
Age	-0.004*	0.002	-1.83
Education	0.002	0.005	0.41
Household Size	-0.01	0.013	-0.75
Off-farm Income	0.000001	0.000001	1.36
Farming Experience	-0.0007	0.003	-0.22
Amount of Credit	0.00002*	0.0000001	1.89
Training Facility	-0.04	0.04	-1.20
Contact with officer	-0.13	0.11	-1.11
Constant	0.98	0.18	5.30
N	70		
R^2	0.30		

N.B.: * and *** denote 10% and 1% significance level respectively, N= Number of Observation
Source: Authors' Compilation

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Table No. 7: Distribution of Technical Efficiency

Technical Efficiency	**Frequency**	**Percentage**
0.00-0.10	0	0
0.11-0.20	0	0
0.21-0.30	3	4
0.31-0.40	2	3
0.41-0.50	7	10
0.51-0.60	11	16
0.61-0.70	9	13
0.71-0.80	17	24
0.81-0.90	18	26
0.91-1.00	3	4
Total	70	100
Descriptive Statistics	Mean: .68	
	Minimum: .26	
	Maximum: .96	

Source: Authors' Compilation