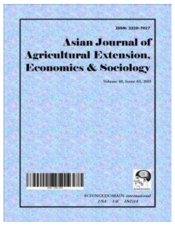

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Exploring Economic Efficiency of Pineapple Production at Madhupur Upazila of Tangail District, Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author KA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SM managed the analyses, supervised and edited the work. Author MAI reviewed the analysis and all drafts of the manuscript. Author AUN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to estimate the economic efficiency of pineapple production at Madhupur upazila of Tangail district in Bangladesh. Considering the 2016-2017 cropping season, data were collected through structured questionnaire administered on 100 pineapple farmers using multistage sampling technique and analyzed using descriptive statistics and translog stochastic cost frontier approach. The mean economic efficiency was estimated as 82.61% across the study area which means that farmers were not operating on the cost frontier (100% efficient). So, the results indicate that there is still an opportunity for pineapple farmers to minimize cost without compromising yield with present technologies available in the hands of farmers. The study reveals that age and micro credit had significant positive but extension contact had significant negative influence on economic inefficiency. The significant positive coefficient of age and access to credit indicate that economic inefficiencies are significantly lower for the younger farmers compared to old aged group and

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farmers with access to credit tend to exhibit lower levels of efficiency. The negative influence of extension contact implies that economic inefficiency will be reduced significantly by enhancing extension contact. It can be concluded that there was economic inefficiency in pineapple production in the study area despite high levels of economic efficiencies among the studied farmers. It is recommended that policies should be implemented for providing a favourable environment to encourage more youth to engage in pineapple production in a bid to increase efficiency. Concerned authority should need to monitor beneficiaries of credits to reduce the misapplication of credit money by the farmers. Extension agents have to improve the frequency of contact with the farmers for appropriate input allocation and cost minimization to enhance efficiency in pineapple production.

Keywords: Pineapple; economic efficiency; Translog stochastic cost frontier model; Madhupur upazila.

1. INTRODUCTION

Bangladesh is predominantly an agrarian country. Agriculture contributes about 11.70% to the total Gross Domestic Product (GDP) and accommodates around 42.7% of labour force of the country [1]. Bangladesh enjoys generally a sub-tropical monsoon climate. Due to its favourable weather and very fertile land, varieties of crops grow abundantly throughout the year. Agricultural land of this country is mainly used for production of rice, jute, potato, maize, wheat, fruits, seasonal minor crops and vegetables [2]. Food security and nutritional supports are essential for the sound health of the people of any country. Fruits play a vital role in both cases. Pineapple is one of the most important commercial fruit in the world. It is an important fruit crops among all other minor crops in Bangladesh. It provides economic strength to the poor people in some regions of Bangladesh where no other fruits or crops grow well [3]. Pineapple (*Ananas comosus)* belongs to the family *Bromeliaceae*. It is known as the queen of fruits because of its excellent flavour and taste [4]. It contains considerable amount of calcium, potassium, vitamin C, carbohydrates, crude fiber, water and different minerals that are good for the digestive system and help in maintaining ideal weight of human body [5]. The plants are drought tolerant and well adapted to the tropical sandy soils with pH ranging from 4.5 to 6.5. The plants are propagated from suckers, slips or crowns. It is a perennial fruit crop and the returns continue, usually, for a period of 4 years and the first yield is obtained within 15-22 months after planting [6]. Among all the fruits produced in Bangladesh, pineapple ranks 4th in terms of total cropping area and production [7]. During 2015-2016 cropping season, total area under pineapple production in the country was 13, 562 hectare and production was 200,701 metric tonnes [1].

Pineapples abundantly grow in the districts of Tangail, Mymensingh, Gazipur, Sylhet, Moulvibazar, Chattogram, Bandarban, Khagrachari and Rangamati. Pineapple is extensively cultivated in all over the Madhupur upazila of Tangail district [8]. During 2015-16 production period, about 53.82% of the total pineapple production came from this district [1]. The prospect of pineapple farming is bright in Bangladesh [8]. But, low capacity utilization of resources or use of traditional method in production by the farmers has led to decline in horticultural production. One of the main reasons for low productivity in horticulture is the inability of farmers to fully exploit the available resources and technologies, resulting in lower efficiencies of production [9]. So, productivity can be improved through either by the efficient use of input resources or by improving the existing technology. In a developing economy like Bangladesh where majority of the farmers are resource poor, preference should be given for efficiency improvement in utilization of available resources than for the technology improvement [10]. Since the pineapple cultivation requires heavy investments in the first year itself and the inefficient use of inputs indeed will affect the profitability that results in low income or even a loss to the farmers [11]. An emperical study on economic efficiency along with the probable determinants of inefficiency would help to decide whether pineapple farmers utilize full capacity in their production processes or not, and to find ways of improving their productivity if they are inefficient. In this context, an attempt is made to estimate the economic efficiencies of pineapple producing farmers in Madhupur upazila of Tangail district and identify the significant factors influencing the level of inefficiency in pineapple production. Determining the existing level of economic efficiency and the factors which are responsible for inefficiency will help farmers to allocate their resources more wisely and also to assist the government in designing and searching for new policy tools to reach sector specific goals.

2. THEORETICAL FRAMEWORK

The stochastic frontier cost functions model for estimating farm level economic efficiency is specified as:

$$C_i = C\,(p_{ji}, y_i; \beta) + \varepsilon_i \qquad i= 1,2,\ldots..n \qquad (1)$$

where, C_i is the observed cost incurred by ith farm, p_{ji} is a vector of jth inputs price faced by ith farm, y_i is a vector of outputs produced by ith farm, C(.) is the cost function that is non-decreasing, linearly homogeneous and concave in prices, β is a vector of unknown parameters to be estimated, and ε_i represents the error term that is composed of two elements, that is:

$$\varepsilon_i = v_i + u_i \qquad (2)$$

where, v_i is the symmetric disturbances assumed to be identically, independently and normally distributed as N $(0, \sigma_v^2)$ given the stochastic structure of the frontier. The second component u_i is a one-sided error term that is independent of v_i and is normally distributed as $(0, \sigma_u^2)$, allowing the actual cost to raise above the frontier because the cost frontier represents minimum costs and inefficiencies are assumed to always increase costs. The mean of this distribution is assumed to be a function of a set of explanatory variables: $\mu_i = \delta_i Z_i$, the inefficiency term is:

$$u_i = \sum_{j=1}^{n} \delta_j\, Z_{ij} + w_i \qquad (3)$$

where, Z_{ij} is a vector of variables that may have effect over farm efficiency, δ_i is a vector of parameters to be estimated, and w_i is a random variable defined by the truncation of the normal distribution with zero and variance σ^2. The production function coefficients (β) and the inefficiency model parameters (δ) are estimated by maximum likelihood together with the variance parameters: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$ [12].

Given that farm–specific cost efficiency is defined as the ratio of the observed total cost of production to minimum cost. But economic efficiency is the inverse of the cost efficiency [13]. Therefore, the farm specific economic efficiency (EE) is defined as the ratio of minimum production cost (C*) to actual production cost (C). That is:

$$EE = \frac{\{C(p_{ji}, y_i; \beta)\exp(v_i)\}}{(C_i)} = \frac{C_i^*}{C_i} \qquad (4)$$

The important point is that, the computer programme frontier version 4.1 was used in estimating maximum likelihood estimate of the parameters and it should be noted that this programme estimates the cost efficiency (CE), which is computed originally as the inverse of equation (4). The economic efficiency (EE) was then obtained from the inverse of cost efficiency as follows:

$$EE_i = 1/\,CE_i \qquad (5)$$

The efficiency scores obtained from this expression (5) take value one when the farm is efficient, and less than one otherwise [14].

3. MATERIALS AND METHODS

3.1 The Study Area

Tangail is a district in the central region of Bangladesh. The district is sub-divided into 12 upazilas. Madhupur is one of them. The upazila was formed as thana in 1898 and turned into an upazila in 1983. The land area is 332.13 sq. km., located in between 24°47´ and 24°31´ north latitudes and in between 90°10´ and 89°57´ east longitudes. It is bounded by Muktagachha and Jamalpur Sadar upazilas on the north, Gopalpur and Ghatail upazilas on the south, Fulbaria and Muktagachha upazilas on the east, Dhanbari and Gopalpur upazilas on the west. It has 1 municipality, 6 unions, 131 mouzas, and 171 villages. Total population is 234299 where; male 109387, female 104911. Average literacy is 25.3% with male 30.2%, female 20.1%. Main sources of income include; agriculture 63%, non-agricultural labourer 2.14%, industry 0.53%, commerce 13.05%, transport and communication 1.21%, service 8.90%, construction 2.40%, religious service 0.22%, rent and remittance 0.70% and others 7.85%. Main crops are paddy, wheat, jute, sugarcane, potato, cotton, ginger, turmeric, cassava and vegetables. Main fruits Mango, jackfruit, pineapple, papaya, litchi and olive. Main agricultural exports include; pineapple, jackfruit, silk, cassava, cotton and honey [15].

3.2 Sampling Procedure and Sample Size

The primary data were collected in a field survey by direct interview with pineapple farmers in the study area for the 2016-2017 cropping season. A multi-stage sampling technique was used as a sampling plan for collecting the data from Madhupur upazila of Tangail district. In the first stage, simple random sampling technique was used in selecting two unions out of the six unions. In the second stage, five villages were selected randomly from each union. This was based on the list of major pineapple producing villages obtained from the upazila agriculture office. Finally, the third stage involved random selection of 10 pineapple producers from each village who were at the initial stage of cultivation (i.e., harvested first yield from their pineapple fields), giving a total sample size of 100 farmers. A list of 993 pineapple farmers obtained from upazila agricultural office out of which 100 farmers was selected, representing 10% (99.3, this was rounded to 100) of the population.

3.3 Empirical Model Specification

The functional specification of the stochastic cost frontier was determined by testing the adequacy of the translog specification to the data relative to the more restrictive Cobb-Douglas and the null hypothesis was "The frontier is Cobb-Douglas form, that is, all the effects of interaction and square terms in the translog (non-homothetic) model is equal to zero, i.e. H_0: β_{jk} = 0; j, k =1,2,…,n (when j = k, β_{jk}'s represent the effects of square terms and when j ≠ k, β_{jk}'s represent the effects of interaction terms)". The above hypothesis was tested using the likelihood ratio test statistics which is defined as

$$\lambda = -2 \{\ln [L(H_0)] - \ln[L(H_1)]\} \quad (6)$$

$L(H_0)$ and $L(H_1)$ indicate the likelihood values under the null and alternative hypotheses that correspond to the Cobb-Doulas and translog model respectively. The test statistics λ had an approximately chi-square distribution with degree of freedom equal to the difference between the number of parameters involved in H_0 and H_1 [16]. The first row of Table 3 reports this test, where the first null hypothesis is rejected showing that the translog specification fits the data better than the Cobb-Douglas form. Another test which is also based on generalized likelihood ratio was carried out to check whether the translog stochastic cost frontier model follows the linear homogeneity constraint (i.e. constant returns to scale) or not. The following symmetric and linear homogeneity parameter restrictions were imposed prior to estimation of this function.

$$\sum_{j=1}^{n} \beta_j = 1,\ \sum_{j=1}^{n} \beta_{jk} = \sum_{k=1}^{n} \beta_{kj} = 0,\ \sum_{j=1}^{n} \beta_{jy} = 0 \quad (7)$$

Symmetric restrictions require $\beta_{jk} = \beta_{kj}$, because the cost function is homogeneous of degree 1 in the input prices (i.e., $p_{1i},\ldots,p_{ni}$). The result of this test is shown in Table 3. According to this test, it can be concluded that a homogeneity constrained trans-log stochastic cost frontier model was appropriate for the data on inputs' prices and cost of pineapple [17].

The specified homogeneity-constraint trans-log stochastic cost frontier model is expressed as;

$$\ln\left(\frac{C_i}{p_{7i}}\right) = \beta_o + \sum_{j=1}^{7-1} \beta_j \ln\left(\frac{p_{ji}}{p_{7i}}\right) + \frac{1}{2}\sum_{j=1}^{7-1}\sum_{k=1}^{7-1} \beta_{jk} \ln\left(\frac{p_{ji}}{p_{7i}}\right).\ln\left(\frac{p_{ki}}{p_{7i}}\right) + \beta_y \ln y_i + \frac{1}{2}\beta_{yy}(\ln y_i)^2 + \sum_{j=1}^{7-1} \beta_{jy}.\ln\left(\frac{p_{ji}}{p_{7i}}\right).\ln y_i + \varphi_1 D_{1i} + \varphi_2 D_{2i} + v_i + u_i \quad (8)$$

where,

C_i denotes observed cost of producing pineapple by the ith farm (tk.);
P_{1i} denotes the rent of land which takes the lease value of land at the area where the farm is located (tk./hectare);
P_{2i} denotes the tillage cost (tk./hectare);
P_{3i} denotes the price of manure (tk./kg);
P_{4i} denotes the price of fertilizer (tk./kg);
P_{5i} denotes the price of hormone (tk./100 ml);
P_{6i} denotes the wage rate of labour (tk./man-day);
P_{7i} denotes the price of seedling (tk./piece);
y_i denotes the return from pineapple production (tk.);
D_{1i} is a dummy variable for variety which takes value one, if the variety is Giant kew and zero, otherwise;
D_{2i} is a dummy variable for cropping pattern which takes one if follow intercropping system and zero, otherwise;

$\beta_{o,}$ β_j 's, β_{jk} 's, β_y , β_{yy} β_{jy} 's and φ's are the unknown parameters to be estimated; v_i 's and u_i 's are as explained above, that is $v_i \sim$ iid N (0, σ_v^2) and $u_i \sim$iidN^+($Z_i\delta$, σ_u^2).

The economic inefficiency effects are linearly related to the farmers' characteristics. The model for the economic inefficiency effects in the stochastic frontier of equation (8) is defined as follows:

$$u_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + w_i \quad (9)$$

where,

Z_1 = Age of the pineapple farmer (in years);
Z_2 = Education of the pineapple famer (in years of schooling);
Z_7 = Dummy variable for member of cooperative society (1 for yes and 0, otherwise);
Z_7 = Dummy variable for micro finance taken from any source (e.g., relatives, friends, NGOs, Banks, etc.) only for cultivating pineapple (1 for yes and 0, otherwise);
Z_5 = Dummy variable for extension service received by the pineapple farmer (1 for yes and 0, otherwise);
Z_6 = Dummy variable for training on pineapple farming participated by the pineapple famer (1 for yes and 0, otherwise);
and w_i's are random error that are defined by the truncation of the normal distribution with zero mean and variance, σ_w^2, such that the point of truncation is $-Z_i\delta$, i.e., $w_i > -Z_i\delta$. These assumptions are consistent with u_i being a non-negative truncation of the N ($Z_i\delta$, σ_u^2)-distribution.

The economic inefficiency of an individual farmer is determined as

$$\text{Economic inefficiency} = 1 - \text{Economic Efficiency}$$
$$= 1 - \frac{\text{minimum production cost}}{\text{Actual production cost}} \tag{10}$$

The parameters involved in models (8) and (9), together with the variance parameters which are expressed in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$ (where γ lies between 0 and 1) are estimated by the maximum likelihood method using the frontier program 4.1.

Individual significance tests of the parameters were done by using t-tests and the overall significance tests of the parameters in the frontier cost function and in the inefficiency effect model were performed using generalized likelihood-ratio (LR) tests. The null hypotheses "There is no inefficiency effect i.e. H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \ldots = \delta_6 = 0$", "The inefficiency effects are not stochastic. i.e. H_0: $\gamma = 0$" and "The coefficients of the factors in the inefficiency effect model are zero i.e. H_0: $\delta_1 = \delta_2 = \ldots = \delta_6 = 0$" were tested using the test statistic stated in equation (6). All the tests of hypotheses were conducted at the 5 % level of significance. The critical value of the test statistic was taken from [18]. If the calculated value of the test statistic is greater than or equal to its corresponding critical value, the null hypothesis was rejected.

4. RESULTS AND DISCUSSION

4.1 Basic Farm-specific Characteristics of the Sampled Farmers

An effort has been made to describe briefly some of the basic farm-specific characteristics of the farmers because these characteristics have a significant influence on overall efficiency performance. The summary statistics of these characteristics are presented in Table 1. It shows that the majority (43%) of the sampled farmers were in the middle-aged group with mean age 43.21 years. The result implies that majority of the farmers in the study area were in their middle age group. In this age category, farmers are more receptive to innovation, more effective and could strive to the stress and strain involved in agricultural production.

Again Table 1 exhibits that the highest proportion (38%) of the sample farmers had secondary education. The mean educational level was 6.45 implies that the farmers have had six years of formal education. The low level of education of the farmers could affect their choice of inputs combination and utilization of existing resources efficiently. The result also shows that 40% of the sample farmers had 11-20 years farming experience that was highest compared to other groups. The mean farming experience was 21.88 years. The farmers with high farming experience would be more efficient, have better knowledge of efficient allocation of resources and cost targets and are expected to run a farm more efficiently. Extension contact in the study area is also demonstrates in Table 1 and it exhibits that only 27% farmers under the study met extension agents during pineapple cultivation. This implies that farmers in the study area were poorly visited by the extension agents to solve their problems. The result also reveals that only 34% farmers have taken credit for pineapple production from formal and informal institutions. A timely flow of agricultural credit can meet farmers demand to ensure agricultural productivity and increase efficiency.

The result shows that only 21% farmers were the members of cooperative society and only a small proportion (15%) of farmers have received training on pineapple farming organized by different GOs and NGOs. Membership of cooperative society affords farmers for getting access to credit, taking training facilities and sharing information on production technology. The sampled farmers in the study area have had

Table 1. Distribution of farmers by socio-economic characteristics of the farmers

Variables	Percentage	Mean
Age		
Young (20-35 years)	28.0	
Middle (36-50 years)	43.0	43.21
Old (Above 50 years)	29.0	
Educational level		
No formal education	23.0	
Primary	24.0	
Secondary	38.0	6.45
Higher secondary & above	15.0	
Farming experience		
≥10	18.0	
11-20	40.0	
21-30	30.0	21.88
< 30	12.0	
Extension contact		
No extension contacts	73.0	
Having extension contact	27.0	
Credit taken for pineapple production		
Not taken	66.0	
Taken	34.0	
Membership of Co-operative		
Non-member	79.0	
Member	21.0	
Training status		
Not taken	85.0	
Taken	15.0	
Farm category		
Small (01 to 1.00 ha.)	27	
Medium (1.01 to 3.03 ha.)	50	2.25
Large (3.04 ha & above)	23	

Source: Field Survey, 2017

low access to these facilities. Table 1 also reveals that majority (50%) of the sampled farmers had a farm size between 1.01 to 3.03 ha. This result implies that farmers in the study area were mainly of medium farm categories.

4.2 Empirical Results of the Stochastic Cost Frontier Model

The maximum likelihood estimates of the parameters in the trans-log cost frontier model are presented in Table 2. Although the trans-log form coefficients cannot be directly interpreted economically [19], it is interesting to note that most of the coefficients are statistically significant in Table 2. The results reveal that the coefficients of the normalized manure price, normalized human labour price, normalized return, square of per hectare normalized rent, square of normalized manure price, square of normalized fertilizer price, square of normalized return, interactions of per hectare normalized rent and per hectare normalized tillage cost, per hectare normalized rent and normalized hormone price, per hectare normalized rent and normalized return, normalized manure price and normalized fertilizer price, normalized manure price and normalized hormone price are found to be positive and significant. However, the coefficients of per hectare normalized rent, per hectare normalized tillage cost, normalized fertilizer price, normalized hormone price, square of per hectare normalized tillage cost, interactions of per hectare normalized rent and normalized human labour price, per hectare normalized tillage cost and normalized manure price, per hectare normalized tillage cost and normalized fertilizer price, per hectare normalized tillage cost and normalized hormone price, per hectare normalized tillage cost and normalized human labour price, normalized manure price and normalized human labour price, normalized human labour price and normalized return are negative and significant in the cost frontier.

Table 2. Maximum likelihood estimates of the parameters of trans-log stochastic cost frontier model for pineapple production

Variable	Parameter	Coefficient	t-ratio
Intercept	β_o	22.978 (0.999)	22.992**
Per hectare normalized rent	β_1	-8.470 (0.991)	-8.548**
Per hectare normalized tillage cost	β_2	-4.614 (1.339)	-3.446**
Normalized manure price	β_3	0.238 (0.111)	2.141*
Normalized fertilizer price	β_4	-4.852 (1.096)	-4.429**
Normalized hormone price	β_5	-0.787 (0.216)	-3.653**
Normalized human labour price	β_6	15.778 (1.551)	10.173**
Normalized return	β_y	1.950 (0.904)	2.157*
(Per hectare normalized rent)^2	β_{11}	0.239 (0.049)	4.790**
(Per hectare normalized tillage cost)^2	β_{22}	-0.021 (0.006)	-3.747**
(Normalized manure price)^2	β_{33}	0.019 (0.002)	8.425**
(Normalized fertilizer price)^2	β_{44}	0.228 (0.060)	3.798**
(Normalized hormone price)^2	β_{55}	0.002 (0.002)	1.027
(Normalized human labour price)^2	β_{66}	-0.031 (0.123)	-0.254
(Normalized return)^2	β_{yy}	0.091 (0.023)	3.884**
Per hectare normalized rent × Per hectare normalized tillage cost	β_{12}	0.683 (0.144)	4.733**
Per hectare normalized rent × Normalized manure price	β_{13}	-0.015 (0.009)	-1.778
Per hectare normalized rent × Normalized fertilizer price	β_{14}	0.095 (0.133)	0.717
Per hectare normalized rent × Normalized hormone price	β_{15}	0.165 (0.039)	4.2591**
Per hectare normalized rent × Normalized human labour price	β_{16}	-0.707 (0.136)	-5.195**
Per hectare normalized rent × Normalized Return	β_{1y}	0.272 (0.082)	3.297**
Per hectare normalized tillage cost × Normalized manure price	β_{23}	-0.012(0.005)	-2.571*
Per hectare normalized tillage cost × Normalized fertilizer price	β_{24}	-0.007 (0.060)	-9.674**
Per hectare normalized tillage cost × Normalized hormone price	β_{25}	-0.069 (0.025)	-2.854**
Per hectare normalized tillage cost × Normalized human labour price	β_{26}	-0.219 (0.050)	-4.364**
Per hectare normalized tillage cost × Return	β_{2y}	0.048 (0.039)	1.233
Normalized manure price × Normalized fertilizer price	β_{34}	0.024 (0.009)	2.838**
Normalized manure price × Normalized hormone price	β_{35}	0.005 (0.001)	4.114**
Normalized manure price × Normalized human labour price	β_{36}	-0.029 (0.008)	-3.547**
Normalized manure price × Normalized return	β_{3y}	0.003 (0.004)	0.819
Normalized fertilizer price × Normalized hormone price	β_{45}	0.003 (0.018)	0.173
Normalized fertilizer price × Normalized human labour price	β_{46}	-0.128 (0.131)	-0.983
Normalized fertilizer price × Normalized return	β_{4y}	0.066 (0.046)	1.445
Normalized hormone price × Normalized human labour price	β_{56}	-0.046 (0.027)	-1.660
Normalized hormone price × Normalized Return	β_{5y}	0.005 (0.006)	0.755
Normalized human labour price × Normalized return	β_{6y}	-0.336 (0.086)	-3.925**

Variable	Parameter	Coefficient	t-ratio
Dummy variable for variety (Giant kew=1, others=0)	φ_1	0.062 (0.083)	0.746
Dummy variable for cropping pattern (intercrop=1, monocrop=0)	φ_2	0.030 (0.086)	0.351
Variance parameters	σ^2	0.074 (0.009)	8.438**
	γ	0.999 (0.002)	456.21**
Log likelihood function	62.490		

Source: Own estimation.
Figures in parentheses are the standard errors.
*** Significant at 1% probability level and * significant at 5% probability level*

Table 3. Generalized likelihood ratio tests of null hypotheses

Null hypothesis	Log-Likelihood under H_0	df[a]	Critical value ($\chi^2_{0.05}$)	Test statistic (λ)[b]	Inference
H_0: β_{jk} =0	22.16	28	41.34	80.66	Rejected H_0
H_0:$\sum_{j=1}^{n}\beta_j = 1, \sum_{j=1}^{n}\beta_{jk} = \sum_{k=1}^{n}\beta_{kj} = 0, \sum_{j=1}^{n}\beta_{jy} = 0$	62.49	9	16.92	13.58	Rejected H_0
H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_6 = 0$	41.91	8	15.51	41.16	Rejected H_0
H_0: $\gamma = 0$[c]	52.79	3	7.81	19.40	Rejected H_0
H_0: $\delta_1 = \delta_2 = \ldots = \delta_6 = 0$	51.49	6	12.59	22.00	Rejected H_0

Source: Own estimation
[a] Degrees of freedom, [b] $\lambda = -2[\ln\{L(H_0)\}-\ln\{L(H_1)\}]$
[c] $\gamma = 0$ indicates that $\sigma_u^2 = 0$ and $\delta_0 = 0$ so degrees of freedom corresponding to this hypothesis is 3

The variance parameter estimates for sigma square (0.074) is statistically significant at 1% level. The variance ratio parameter γ is closed to one, given the interval (0 <γ <1) within which it lies and is statistically significant at 1% level. The gamma parameter of 0.999 implies that 99.9% of variations in the total cost of production of pineapple were due to differences in the economic efficiencies. This indicates that the economic inefficiency effect made significant contribution to the cost of pineapple production in the study area.

Generalized likelihood-ratio tests of null hypotheses that the economic inefficiency effects are absent, are presented in Table 3. The first null hypothesis, which specifies that the inefficiency effects are absent from stochastic cost frontier model, is strongly rejected. The second null hypothesis, which specifies that the inefficiency effects are not stochastic for the model, is also strongly rejected. The third null hypothesis specifies that the inefficiency effects of stochastic cost frontier model are not a linear function of the age, education, member of cooperative society, credit, training and extension contact. This null hypothesis is also strongly rejected at 5% level of significance. This indicates that the joint effect of these six explanatory variables on the inefficiencies of cost is significant although the individual effect of one or more variables may not be statistically significant. The inefficiency effects in the stochastic cost frontier are clearly stochastic and are not uncorrelated to the age, education, member of cooperative society, credit, training and extension contact. Thus, it appears that, in this application, the proposed inefficiency stochastic cost frontier model is significant improvement over the corresponding stochastic frontier which do not involve model for the economic inefficiency effects.

4.3 Economic Efficiency Scores of Pineapple Production

Table 4 shows the percentage distribution of the estimated scores of economic efficiencies of pineapple farmers at Madhupur upazila of Tangail district. The percentage distribution of pineapple farmers' efficiencies indicates that the economic efficiencies range from 0.21 to 1.00 with an average economic efficiency of 0.8261. This means that if a farmer were to reach at the economic efficiency level of its most efficient farmer, then on an average the farmer could experience a cost saving of 17.23% [i.e., (1-(.8261/.9981))*100], while the most inefficient farmer suggests a gain of 78.8% [i.e., (1-(.2113/.9981))*100] in economic efficiency. The percentage distribution implies that about 21% of the farmers in the study area had economic efficiencies between 0.21 and 0.70, while 79 % of the farmers had economic efficiency of 0.71 and above. That is, most of the farmers were economically efficient in pineapple production. These results coincide with the findings of [20] for pineapple in Nigeria. They reported more or less similar finding where 79.44% of farmers had economic efficiency between 0.51 and 0.90.

Table 4. Percentage distribution of economic efficiencies of pineapple production

Efficiency level	Percentage (%)
0.21-0.30	1.0
0.31-0.40	0
0.41-0.50	1.0
0.51-0.60	8.0
0.61-0.70	11.0
0.71-0.80	17.0
0.81-0.90	20.0
0.91-1.00	42.0
Total	100.0
Mean	0.8261
Standard Deviation	0.1516
Minimum	0.2113
Maximum	0.9981

*Source: Own estimation, ** Significant at 1% probability level and * significant at 5% probability level*

4.4 Determinants of Economic Inefficiency among Pineapple Farmers in the Study Area

This section intends to identify the significant factors that influence economic inefficiency of pineapple farmers in Madhupur upazila of Tangail district. The results of this section will be a basis for making agricultural policy on what needs to be done to improve productivity of pineapple farmers. Table 5 shows the determinants of economic inefficiencies. The coefficient for age is significant and it is positively related to economic inefficiency at 1% level of significance. The significant positive coefficient of age indicates that as the age increases farmers will become more inefficient. Thus, economic inefficiencies are significantly lower for the younger farmers compared to old age group in the study area. Perhaps, older farmers become more averse to risk and hesitate to adopt new technologies. This finding coincides with the results of [21] and [22].

The results also indicate that access to credit has a positive and statistically significant effect on economic inefficiency at 1% level of probability, which implies that farmers with access to credit tend to exhibit lower levels of efficiency. This result is in line with the arguments of [23], who showed that receiving credit contributed to farmers economic inefficiency. This could be the result of disbursement of credit in cash rather than in kind and loan misapplication engendered by resource-poverty. If production credit is invested on the farm, it is expected that this will lead to higher levels of efficiency. Thus, access to credit is more likely to lead to an improvement in the level of farmers efficiency.

Extension contact has exerted statistically significant negative relationship with economic inefficiency at 1% level of significance. This implies that a frequent contact facilitates the flow of new ideas between the extension agent and the farmer thereby giving a room for improvement in farm efficiency. Advisory service rendered to the farmers in general can help farmers to improve their average performance in the overall farming operation as the service widens the household's knowledge with regard to the use of improved agricultural inputs and agricultural technologies. This result is also similar to those obtained by [20,24], and [25].

Table 5. Maximum likelihood estimates of the parameters of economic inefficiency effect model for pineapple

Variable	Parameter	Coefficient	Standard error	t- ratio
Intercept	δ_o	-1.162	0.227	-5.125**
Age (years)	δ_1	0.026	0.004	6.177**
Education (years of schooling)	δ_2	-0.004	0.008	-0.501
Member of cooperative society (yes=1, no=0)	δ_3	0.028	0.103	0.276
Credit (taken =1, not taken =0)	δ_4	0.217	0.076	2.842**
Training (taken =1, not taken =0)	δ_5	-0.073	0.109	-0.673
Extension contact (yes=1, no=0)	δ_6	-0.599	0.102	-5.866**

*Source: Own estimation, ** Significant at 1% probability level and * significant at 5% probability level*

5. CONCLUSION AND RECOMMENDATIONS

The study leads to the conclusion that economic inefficiency was present in pineapple production in the study area. The mean economic efficiency was estimated as 82.61% across the study area which means that farmers were operating their farms below the cost frontier (100% efficient). So, the results indicate that there is still scope for 17.39% improvement in economic efficiency in pineapple production by minimizing cost and without compromising yield with present technologies available in the hands of farmers. Results from the study indicated that age and micro credit had significant positive influence on economic inefficiency. On the other hand, extension contact had significant negative influence on economic inefficiency. The significant positive coefficient of age indicated that economic efficiencies were significantly higher for the younger farmers in the production of pineapple compared to old age group. Farmers with access to credit tend to exhibit lower levels of efficiency because of significant positive coefficient of access to credit. The negative influence of extension contact implies that economic inefficiency will be reduced significantly by increasing the frequency of extension contact. Despite of high levels of economic efficiencies among the studied farmers, economic inefficiencies prevailed among pineapple producing farms in the study area. Government should provide favourable environment to encourage more youth to engage in pineapple production in a bid to increase efficiency. In order to reduce the misapplication of credit money by the farmers, effective monitoring authority should need to monitor beneficiaries of credits. Extension agents should improve the frequency of contacts with the farmers for bringing a positive effect of their services on the farmer's efficiency.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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