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Technical Efficiency of the Setbag Net Fishery in Bangladesh: An Application of a Stochastic Production Frontier Model

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Abstract

A study was conducted to examine the technical efficiency for Setbag net fishing boats operated in the year 2014. A total of 100 samples of Setbag net fishing boats were selected, of which 40 were from Cox's Bazar, 40 were from Chittagong and 20 were from Bagerhat. Stochastic frontier (with technical inefficiency effect) model was specified and estimated. Results have shown that the estimated mean technical efficiency of Setbag net fishing boats is 84 percent. The efficiency of Setbag net fishing boat was positively associated with total cost, while the number of nets were negatively related to fishing day and crew size. Head *maji*'s age had significant effect on inefficiency at 5% level. Although, the effect on boats' efficiency was positive, (though insignificant) for head *maji's* experience, head *maji's* education, engine horse power and boat age. The use of modern fishing boat and improved fishing technology should be promoted, through proper training and motivation program for fisher. At the same time old and unfit fishing boat and gears should be gradually removed and replaced by new and modern fishing boat.

Keywords: Technical Efficiency, Setbag net, translog stochastic, Bangladesh.

1. Introduction

The behundi net or setbag net is a fixed type of gear. The net is shaped like an elongated tapering funnel. The mouth opening is rectangular and held open by two vertical bamboo poles. The net is oriented into the tidal stream and held in place by attachment to stakes driven into the sea bottom. The setbag net is a traditional fishing gear which has been in operation since very long by small-scale fishers in the Bay of Bengal region with some regional variations in the design and mode of operation. It catches fish, which drift with the tidal current and passively swept into the net (and then unable to swim out against the velocity and/or force of the tidal current. Among the setbag net, Marine Setbag Net (MSBN) is placed at the deep sea, while the Estuarine Setbag Net (ESBN) is placed closer to the shore. The ESBN are operated in depths of 3 - 10 m. The marine setbag nets are large with a somewhat bigger mesh size and are operated during the dry season in 10 - 30 m from island bases. At present there are about 52,824 (BBS, 2014) Setbag net operating in coastal areas in Bangladesh.

The management and regulation of marine fisheries continues to be one of the biggest challenges for fishery agencies worldwide. In most cases, the regulations which have been developed based on traditional bio-economic models have failed to deliver the expected result (Khem *et al*., 1993). Several economists have provided a number of reasons why traditional measures have not been successful when analyzing the characteristics of multi-product (multi-species) technology of fishing firms in terms of profit or revenue functions. Most frequently cited reasons include the disregard of jointness-in-technology (Guttormsen *et al.*, 2011, Kirkley *et al*., 1998; Squires, 1987), substitutability among regulated versus unregulated inputs (Dupont, 1991) and the possibility of rent dissipation through inefficient fleet composition (Dupont, 1990).

The artisanal fishers use different types of gears, such as gill net, estuarine set bagnet, marine set bag net, beach seine, push net etc. to exploit the multi-species mix. According to Mazid (2002), 30%catch of the coastal small-scale fisheries is contributed by the set bag net fishery while the balance is from the seasonal gears like gill net, seine net, hook and line etc. Among the set bag net fishery, 73% is contributed by the estuarine setbag net (ESBN) while the rest is from the marine set bag net (MSBN) which is highly seasonal. Around one million people in the coastal area of Bangladesh are fully or partially dependent on the estuarine set bag net fishery in Bangladesh (Sabbir, 2005).

The stochastic frontier model proposed by Aigner *et al*., (977) and then extended by Hung and Liu (1994) and Battese and Coelli (1995) is a good approach to identify the significance of improving the productivity of small-scale fishing households The main objective of this paper is to examine the level and determinants of technical efficiency of Setbag net fishing boats, based on their 2014 operating cost and catch data. Due to its flexible properties, a translog stochastic production frontier is estimated. Other efficiency measures, especially allocative efficiency, are important in fishery management, but due to data constraints, this paper focuses only on technical efficiency.

2. Materials and Methods

2.1. Area selection, data source and collection

The study was based on primary data, were collected using a set of pre tested questionnaire in 2014. Based on preliminary information received, Cox's Bazar, Chittagong and Bagerhat region were purposively selected, where large numbers of small scale marine fishermen are involved in marine fishing. In these areas, most of the fishermen use three types of gears or technology, such as Gillnet, Setbag net and Longline. Of them study considered only Setbag net fishing boats. A purposive sampling technique was followed for achieving the ultimate objectives of the study. A total of 100 samples of Setbag net fishing boats were selected, of which 40 from Cox's Bazar, 40 from Chittagong and 20 from Bagerhat.

2.2. Analytical technique

The translog production frontier functions were specified as the empirical model of this study. The Cobb-Douglas stochastic frontier model was found to be unsuitable to represent the data, while the translog model for Setbag net fishing provide better estimates. Translog function is very commonly used which is a generalization of the Cobb-Douglas function. It is a flexible functional form with less restriction on production elasticity and substitution elasticity. The stochastic translog frontier production function, described in equations 1 and 2, were estimated by maximum likelihood estimate (MLE) method using computer software STATA.

All output and input variables, used in the production frontier analysis, were measured on a per trip basis as, except for trip days. While, all data on input variables were collected as per trip averages. Setbag net fishery involved multiple inputs, number of days at sea, crew size, fuel, ice, lubricant, number of net and other miscellaneous. However, for the purpose of this study, these inputs are aggregated into four categories; namely, trip days, crew size, total cost and number of net.

In order to determine the effects of predetermine variable of marine fish catch by Setbag net fishing boat as well as the efficiency of resource used, the translog stochastic production function was estimated, which is given below:

$$InY = \beta_0 + \sum_{i=1}^{4} \beta_i InX_i + \frac{1}{2}\sum_{i=1}^{4} \sum_{j=1}^{4} InXi.InXj + \sum_{i=1}^{3} \delta Li + V_i - U_i ----- (1)$$

The linearised double-log form of (1) is

$$InY = ln\beta_0 + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \beta_3 InX_{3i} + \beta_4 InX_{4i} + \delta_1 InL_{1i} + \delta_2 InL_{2i} + \delta_3 InL_{3i} + V_i - U_i \text{ ----------------(2)}$$

Where,

Ln= Natural logarithm, Y_i = Output (total catch kg/trip), β and δ are unknown parameter to be estimated, X_{1i}=Fishing duration (days/trip), X_{2i}= Number of crew (employed/trip), X_{3i}=Total cost (Tk/trip), X_{4i}=No. of net, L_{1i}=Cox's Bazar, L_{2i}=Chittagong, L_{3i}=Bagerhat, v_i-u_i= error term

Functional form of the technical inefficiency model:

$$U = \gamma_0 + \sum_{i=1}^{5} \varphi Zi + V_i - U_i \text{ ------------------------(3)}$$

The empirical model of gear specific technical inefficiency is

$$U_i = \gamma_0 + \varphi_1 Z_{1i} + \varphi_2 Z_{2i} + \varphi_3 Z_{3i} + \varphi_4 Z_{4i} + \varphi_5 Z_{5i} + Vi - Ui \text{ ,- - - - - - - - - - - - - -- -- - -- - - -- --------(4)}$$

Where

γ and φ are unknown parameter to be estimated, z_{1i}= Age of head *maji's*(year), z_{2i}= education of head *maji's* (Years of schooling), z_{3i}== Experience of head *maji's*(year), z_{4i}= Capacity of engine (Horse power), z_{5i}=Boat used (Age of boat), Vi-Ui = error term. Age, education and fishing experience of head *maji's*, which represents human capital, is generally postulated to have a positive impact on efficiency. Engine horse power and age of boat also have positive impact on efficiency. These common views the variables were select. It should be noted that the above model for technical inefficiencies in equation (2) can only be estimated if the technical inefficiency effects U_i are stochastic and have particular distributional properties (Coelli *et al.*, 1996)

3. Results and Discussion

The estimating parameters of the translog frontier production function and the determinants of the technical inefficiency models for Setbag net fishing boats are presented in Table 1. The coefficient of trip days of Setbag net fishing boat was found to be negative (-0.047) and insignificant. This negative impact means that trip duration of Setbag net boat increases with the decrease of fish catch, though not significant. The result indicated that trip duration for Setbag net boat was higher than usual and it should be reduced.

The coefficient for crew size was found to be statistically insignificant with a negative coefficient of 0.092. This result implied that there was more crew employment in Setbag net fishing boat than it was actually required.

The coefficient of total cost for Setbag net fishing boat was found positive (0.181) and significant at 10 percent level. This result between total cost and output is alike to general expectation. Often, better and more modern activities of fishing activity need more cost. The total cost variable used in the model was calculated by adding all variable costs namely food cost for crew, fuel cost, lubricant cost, ice cost and miscellaneous cost. It was observed that marine fishing needs various tools and equipment. Fishing boat, engine, net, hook, and other marine fishing equipment are very costly. The preliminary investment on marine fishing boat and equipment is very high.

The coefficient of Number of net for Setbag net fishing boat was found to be statistically significant at 1 percent level with a positive coefficient of 0.595. This suggests that increasing Number of net particularly on Setbag net fishing boat could similarly improve the output. The current use of Number of net in Setbag net fishing boat was insufficient. Hence, insufficient Number of net for this activity could result to low fish catch and it would increase the Number of net for Setbag net fishing boat.

3.1. Inefficiency parameters

The coefficient of head *majis*' age (-0.240) was found negative and significant at 5 percent level in the technical inefficiency effect model, indicating that technical inefficiency decreases with the increases in head *majis*' age in the aggregate situation. It also implies that the more aged head *majis* tended to have higher efficiencies than younger head *majis*. That is, the technical efficiency increases with the increase of age of head *maji*. The reason is that elderly head *maji* of Setbag net fishing boat has more experience and also operates fishing activities more effectively than that of younger one.

The coefficient of head *majis'* education (-0.023) was found to be negative and insignificant in the technical inefficiency effect model for Setbag net fishing, indicating that technical inefficiency decreases with the increases in head *majis'* education in the aggregate situation. It may also be said that the higher educated head majis tented to have higher efficiencies than lower educated head *maji*. Education level can improve literacy cognitive skills which may reduce technical inefficiency by increasing the ability of head *maji* to adopt technical innovation. That is, higher educated head *majis* were technically efficient than lower educated head *majis*.

Table 1. Parameter estimates of stochastic production frontier and technical inefficiency models of Setbeg net fishing

Variables	Coef.	Std. Err.	P>z
Stochastic Production Frontier			
Constant	0.184***	0.008	0.000
In (trip days)	-0.047	0.044	0.295
In (crew size)	-0.092	0.107	0.388
In (total cost)	0.181*	0.093	0.054
In (no. of net)	0.595***	0.037	0.000
$^{1/2}$(In trip days X In trip days)	-1.194***	0.172	0.000
$^{1/2}$(In crew size X In crew size)	0.387	0.366	0.291
$^{1/2}$(In total cost X In total cost)	-2.179***	0.351	0.000
$^{1/2}$(In no. of net X In no. of net)	2.805***	0.125	0.000
$^{1/2}$(In trip days X In crew size)	0.1035	0.207	0.617
$^{1/2}$(In crew size X In total cost)	0.834***	0.218	0.000
$^{1/2}$(In crew size X In no. of net)	0.490	0.389	0.208
$^{1/2}$(In total cost X In no. of net)	-0.417	0.287	0.146
Cox'bazar	-0.0759***	0.010	0.000
Chittagong	0.176***	0.048	0.000
Technical Inefficiency Model			
Constant	-38.476	816.519	0.962
Age of head maji	-0.240**	0.098	0.014
Education of head maji	-0.022	0.135	0.866
Experience of head maji	-0.117	0.081	0.152
Engine hp	-0.180***	0.045	0.000
Age of boat	-0.0476	0.045	0.289
Cox'bazar	-0.0487	0.551	0.929
Chittagong	1.252**	0.578	0.030
Constant	9.136**	3.539	0.010

Note: *** Significant at 1%, ** Significant at 5%,* Significant at 10% level.

Table 2. Summary statistics Setbag net fishing

Variables	Observation	Mean	Std. Deviation	Minimum	Maximum
Efficiency	100	0.824	0.158	0.424	1

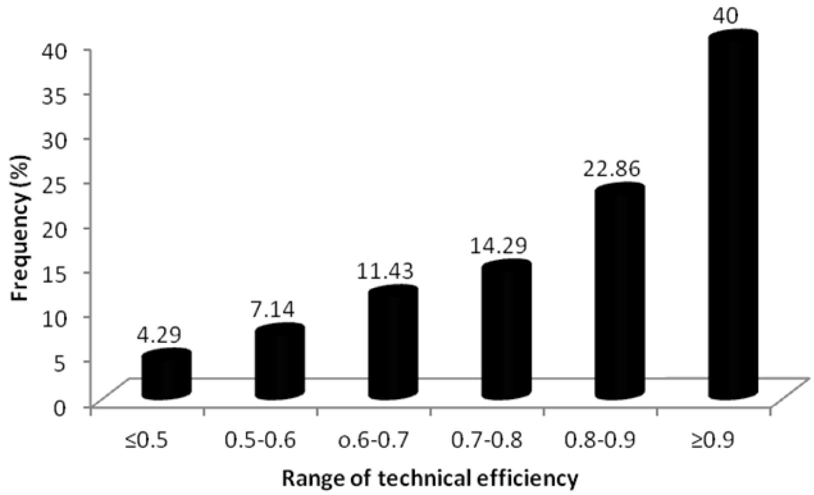

Figure1. Frequency distribution of technical efficiencies for the Setbag net fishing

The coefficient of head *majis'* experience (-0.117) was found to be insignificantly negative in the technical inefficiency effect modelindicating that technical inefficiency decreases with the increase in head *majis* experience in the aggregate situation. It may also be said that the head *majis* with longer marine fishing experience tended to have higher efficiencies than head *majis* with shorter fishing experience. That is, head *majis* with longer fishing experiences were technically more efficient than head *majis* with shorter fishing experience. Fishing experience of head *majis* often provides better knowledge about the location of fish, weather condition, currents and tide, bottom condition and how to best catch the fish in the sea. The variable for years of fishing experience was significant and negative which indicate that longer experience of marine fishing increased the scale of efficiency. So the head *majis* experience might play a more important role than non-experience one.

The coefficient of engine horse power (-0.180) was found to be negative and significant at 1 percent level in the technical inefficiency effect model, indicating that technical inefficiency decreases with the increase in engine horse power in the aggregate situation. The negative coefficient of engine horse power in the technical inefficiency effect model indicated that technical inefficiency effect was less with the increasing engine horse power. That is, the boat with higher hp was technically more efficient than the boat with less HP. This was happened due to higher HP engine boat generally larger in size, and large size boats are able to go to the deep sea for fishing. Besides, trip duration and number of crew are also higher than that of smaller boats and all of these have positive relationship with fish production or catch.

The coefficient of age of boat (-0.041) was found to be negative and but not significant in the technical inefficiency effect model, indicating that technical inefficiency decreases with the increase in age of boat in the aggregate situation. The negative coefficient of age of boat on marine fish production in the technical inefficiency effect model indicated that the technical inefficiency effect was less for the new boat than the old boat. It was also being told that the new boats are more efficient than that of old boats.

3.2. Technical efficiency of Setbag net fishing boats

The estimated technical efficiencies for the Setbag net fishing boats were ranges from 0.14 to 1.00, with a mean efficiency level of 0.82 and standard deviation of 0.16 for fishing. It implies that on an average, the Setbag net fishing boats catch marine fishes to about 82 percent of the potential (stochastic) frontier production levels, given the levels of their inputs and technology currently being used in the study areas.Khem et al. (1993) estimated technical efficiencies for the Hawaii-based Longline fleets, and found 0.84 level of technical efficiency of Longline vessels and Osawe (2010), however, found the mean technical efficiency is 0.906 of fish farmers in Ibadan metropolis of Oyo State, Nigeria. This also implied that the average existing level of technical inefficiency was 18 percent, i.e, there is a scope to increase the fish production by 18 percent without additional investment in input which, in turn denote that fishermen may increase fish supply with existing resources.

3.3. Technical efficiency distribution of Setbag net fishing boats

The frequency distribution of the estimated technical efficiencies of Setbag net fishing boat is depicted in figure 1. The majority of Setbag net fishing boat (40%) has a technical efficiency index of 0.9 or above followed by those with efficiency index of 0.8 to 0.9 (22.86%). Thus, about 63 per cent of the sampled Setbag net fishing boats have a technical efficiency index of 0.8 or higher.

4. Conclusions

This paper has examined the technical efficiency among a sample of Setbag net fishing in three location of Bangladesh using a translog stochastic frontier model. Also information has been provided on the extent of technical inefficiency in Setbag net fishing. The results obtained from this study have shown that the average technical efficiency level is about 84 percent. This implied that the average existing level of technical inefficiency was 16 percent i.e. there is a scope to increase the fish production by 16 percent without additional investment in input which, in turn denote that fishermen may increase fish supply with existing resources. The inefficiency model allows us to identify some determinants of inefficiency of Setbag net fishing efficiency. The findings indicate that the head *maji's* age had significant effect for improving technical efficiency. The use of modern fishing boat and improved fishing technology should be promoted, through proper training and motivation program for fisher. At the same time old and unfit fishing boat and gears should be gradually removed and replaced by new and modern fishing boat.

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