International Journal of Fisheries and Aquatic Studies 2016; 4(6): 168-174

ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2016; 4(6): 168-174

www.fisheriesjournal.com
Received: 22-09-2016
Accepted: 23-10-2016

Ketut Sukiyono
Department of Agricultural Socio-Economics, Faculty of Agriculture, University of Bengkulu, Indonesia

M Mustopa Romdhon
Department of Agricultural Socio-Economics, Faculty of Agriculture, University of Bengkulu, Indonesia

Correspondence
Ketut Sukiyono
Department of Agricultural Socio-Economics, Faculty of Agriculture, University of Bengkulu, Indonesia

Assessing technical efficiency for Bengkulu province catching fishery industries and determination of it's technical efficiency

Ketut Sukiyono and M Mustopa Romdhon

Abstract
This study estimated the level of technical efficency and investigated the determinant factors of technical efficiency in Bengkulu catching fishery. A stochastic analysis of production resulted in technical efficiency levels was applied and estimated by ML aproach. Two types of fishing gears, involving 90 fishing vessel with Gillnet and 70 fishing vessels with Hand Line fishing gears were included in the SPF model. The emprical results suggested that fishing vessels characteristics are the important and significant factor affecting technical efficiency.

Keywords: Technical efficiency, gillnet, handline, fishing vessel, Bengkulu

1. Introduction

Bengkulu province has a huge potency of pelagic and demersal fishery. The catching fishery zones were 500 kilometers sea and coastal areas. Marine and Fishery Department of Bengkulu Provincial (2006) reported that the total potential of catching was 145.334 ton consisted of 27.000 ton demersal, 86.000 ton pelagis, 8 600 ton tuna, among others. From those potencies, the fish production from fishery industries were only 39.203.3 tons. So, it was not surprising that the fishery sector has insignificant contribution to economic growth and to fisherman income in Bengkulu Province. Data published by Statistical Central Beaurau of Bengkulu Province (2014) reported that the contribution of this sector to Gross Domestic Product (GDP) of Bengkulu was only 4.95 percent of 39.85 percent agricultural sector contribution. Therefore, the study to investigate the obstacle for improving role of this sector in regional economics should be prioritized. Fishing industry in Bengkulu has a distinctive structures in terms of technology, natural and human resources. The technology operated by fishery industries in Bengkulu are indicated by their fishing gear and boat sizes. Data published by District Department of Marine and Fishery shows that in 2007, the catching fishery industry was dominated by small fishing industry with vessel size under 5 GrossTonnes (GT) and utilized gillnet and hand line fishing gears.

The utilization of those diverse fishing gears would have a different production and earning. Study by Sayeed *et al.* (2014) [26] and Rahman *et al.* (1999) [23] in Bangladesh fishery and Remiati *et al.* (2002) [24] in Banten West Jawa Indonesia shows that different fishing gear resulted in different production level. These studies confirmed early studies among other studies by Noetzel and Norton (1969) [21] and Roschild (1972) [25] These studies concluded that variations in the performance of fishing vessels in which some vessels perform better than other and in turn achieve higher production and earning. Follow-up question is whether the difference in fishing gear also produces technical efficiency differences. Early study on technical efficiency is conducted by Kirkley *et al*. (1995) [17]. They examined vessel efficiency using a stochastic production frontier based on a sample of sea scallop vessels operating in the Mid-Atlantic between 1987 and 1990. Study by Kirkley *et al*. was then followed by Sharma *et al*. (1999) [27], Garcia del Hoyo *et al.* (2004) [13] in Spain, Esmaeili (2006) [10] in Iranian Gulf, and Idda *et al*. (2009) [16] in Mediterranean sea.

Understanding the technical efficiency at fleet level and its determinant factors would be valuable information to attain the maximum output from a set of inputs or to produce an output using the lowest possible amount of inputs. This valueable information can be used by policy makers for policy desingning to improve fishery productivity growth in areas like Bengkulu where economic contribution of this sector is still insignificant. Therefore, a study of the level and determinants of technical efficiency can provide information required by policymakers to improve productivity of fishery industries in Bengkulu. In addition, to improve technical efficiency, there is a need to identify factors influencing the technical efficiency. The identification could be based for improving performance of fishery industry in Bengkulu. For these reasons, the objectives of this study are: (i) to examine the technical efficiency level of fishing gears of gillnet and hand line and (ii) to identify the determinants of technical efficiencies.

2. Materials and Methods

There are two different major approaches to measure and estimate technical efficiency. *First*, the stochastic frontier production function approach involve econometric estimation of parametric function (Aigner *et al.*,1976 and 1977; Meeusen and Broeck, 1977) [1, 2, 20] and *the second*, nonparametric programming, known as data envelopment analysis (DEA) (Charnes *et al.*,1978) [7]. The stochastic frontier approach is considered more appropriate for assessing technical efficiency, where data are often heavily influenced by measurement errors and other stochastic factors such as weather conditions, diseases, etc. (Fare *et al.*,1985; Kirkley *et al.*,1995; Coelli *et al*.,1998; Dey *et al.*,2005) [11, 17, 8, 9]. In fishery industries, there are several recent studies applied stochastic frontier technique for estimating technical efficiency. Among others are Sharma and Leung (1999) [27] in Hawaii for the fleet of long-liners and Kirkley, *et al* (1998) [18] in the Mid-Atlantic Sea Scallop fishery.

This research was conducted in Kota Bengkulu involving survey on 90 fishing vessels with gillnet and and 70 fishing vessel with hand line fishing gears. Gill net and hand line fishing gears are common fishing gears used in this location than other fishing gears. Following closely to stochasitic frontier model proposed by Huang and Liu (1994) [15] and Battese and Coelli (1995) [5], the fishery output is determined by production inputs sacrificed in the process of fishery production using a technology described by a well-behave production function $f(x)$ as follow:

$$\ln(y_t) = x_t\beta + \varepsilon_t \tag{1}$$

$$\text{with } \varepsilon_t = u_t - v_t \tag{2}$$

where y_t measures the value of fishing output of the i^{th} fishing vessels, x_t is (1 x K) vector of value of the inputs and other explanatory variables, β is (1 x K) vector of parameters to be estimated, and i = 1, 2,......, N. The error term ε_t in eqution (1) is defined as $\varepsilon_t = u_t - v_t$, where $v_t \sim N(0, \sigma_v^2)$, and u_t is a non-negative random variable, accounting for the existence of technical efficiency in production and it is identically distributed as half-normal $v_t \sim N(0, \sigma_v^2)$(Battesse and Coelli 1992) [4]. The noise component v_t is assumed to be independent and identically distributed and symmetrically distributed independent of u_t. The term v_t allows random variation of the production function across vessels and captures the effects of statistical noise, measurement error, and exogenous shocks beyond the control of the vessels such as weather.

Following Battese and Coelli (1995) [5], the technical efficiency distribution parameter can also be specified as

$$v_t = \delta_0 + z_t\delta + \omega_t \tag{3}$$

where ω_t is distributed following $N(0, \sigma_\omega^2)$, z_t is a vector of fishing vessel specific effects that determine technical inefficiency and δ is a vector of parameters to be estimated. Battese and Coelli (1995) [5] noted that nput variables may be included in both above Equations (1) and (2) provided that technical inefficiency effects are stochastic. From equation (2), when $v_t = 0$, production lies on the stochastic production function and fishhing vessel is teechnically efficient. However, if $v_t > 0$, then production lies below the stochastic production function and fishhing vessel is technically inefficient.

Battese and Coelli (1992) [6], and Kumbhakar and Lovell (2000)[19] stated that given the actual fishery production level is $x_i\beta + u_t - v_t$, while the technical efficiency level is $x_i\beta + u_t$, thus the technical efficiency is measured by

$$TE_i = \exp(-u_i) \tag{4}$$

where the efficiency could be estimated by the following formula:

$$E[\exp(-u_i \mid E_i)] = \exp\left[\mu_i^* + 0.5\sigma^{*2}\right] \times \left[\frac{\Phi\left(\frac{\mu_i^*}{\sigma^*} - \sigma^*\right)}{\Phi\left(\frac{\mu_i^*}{\sigma^*}\right)}\right] \tag{5}$$

where $E_i = u_i - v_i$ $\mu_i = \dfrac{\sigma_u^2 - \sigma_v^2}{\sigma_u^2 - \sigma_v^2}$,and $\sigma^{*2} = \dfrac{\sigma_v^2 \times \sigma_u^2}{\sigma_v^2 + \sigma_u^2}$

and Φ was normal distribution of random error function.

Empirical aplication of stochastic production model for this research is in form of natural logarithm. The model could be written as follows:

$$\log(Y_i) = \beta_0 + \beta_1 \log FD_i + \beta_2 \log CREW_i + \beta_3 \log FG_i + \beta_4 \log TOC_i + \beta_5 \log EP_i \mp \beta_6 \log VS_i + D_i + \varepsilon_i \tag{6}$$

Where i is i[th] fishing vessel, and ε_i was random error model. Independent variables in the production frontier model (6) are Fishing Day (FD), number of crew icluding skipper (CEW), Distance to fishing ground (FG), Total Operasional Cost (TOC), Engine Power (EP), vessel size (VS), and Dummy for fishing gear type (D =0 for Gillnet, and D =1 forhand Line). The dependent variable, the production (Y), was measured in monetary (rupiah) due to variation on type of fish and fish price.

In determining factors affected technical, two main factors included in the model,i.e, skipper and fishing vessel charactersitics. The inclusion of skipper characterisitics follows Kirkley, *et al* (1998) [17] and Squires *et al*. (2003) [29] arguments. They argued that attributes of the captain and vessel potentially affecting efficiency for artisanal gill net fisheries on the east and west coasts of Peninsular Malaysia, even though, the findings was insignificant. The skipper characteristics included in the technical efficiency model are skipper education (EDU), skipper age (AGE), skipper experience (EXP), and skipper fimily size (SIZE). Two other variables included in the model represent the characteristics of fishing vessels. Different with previous studies, two variables of fishing vessels characteristics, i.e., Vessel size (GT) and Engine power (PK) in this research, are divided by vessel crews. Technical inefficiency model of fishery could be written as follows:

$$eff_i = \alpha_0 + \alpha_1 AGE_i + \alpha_2 EDU_i + \alpha_3 EXP_k + \alpha_4 SIZE_i + \alpha_5 GT_i + \alpha_6 PK_i + D_1 + u_i \quad (7)$$

The model (6) is estimated by maximum likelihood method (MLE) then the values of coefficient and δ2 are used as initial value of estimation in MLE at given error specification. The values of MLE at equation (6), λ and σ is estimated. The model in equation (7) is estimated by OLS approach.

3. Results and Discussion

3.1. Descriptive Statistics of Fishing Vessel Characteristics

Fishing vessels, as presented in Table 1, shows considerable heterogeneity in term of fishing days, machine power, gross tons (GT) of fishing vessels, among others. It shoud be noted that all output and input variables in this survey were measured on the basis of trip and collected as per trip averages. The survey shows that fishing vessels with the different types of fishing gear have different fishing days. However, it should be noted that the fishing days is not determined by the type of fishing gear, but rather is determined by the vessel size and engine power. In general, the average fishing days were 8.56 days per trip. Among two types of fishing gear surveyed, fishing boats with hand line fishing gear have the longer fishing days than gillnet, that is, 9.68 days compared to 7.69 days. This finding was normal because fishing vessels with hand line fishing gear have bigger vessel size and engine power, as shown in Table 1.

Looking into vessel size for Gillnet fishing gear, it ranged from 3 Gross Tonnes (GT) to 28 GT with average of 5.5 GT while fishing vessels with hand Line fishing gear ranged from 3 GT to 46 GT with average of 7.6 GT. This vessel size also correlated to crew number per vessel. The number of vessel crew for Gillnet is fewer than that of for Hand Line, i.e., 4 crews for Gillnet 7 crews for Hand Line. These crews include a skipper. On average, both vessels with different fishing gear have relatively similar vessel ages.

Table 1: Descriptive Statistics of the Main Fishing Vessel Characteristics.

Variable	Total (n=160)		GILLNET (n=90)		Hand Line (n=70)	
	Mean	St Deviasi	Mean	St Deviasi	Mean	St Deviasi
Catches						
a. Volume (kg)	631.40	830.94	301.41	299.18	1055.7	1072.8
b. Price (Rp/kg)	21775.	8994.1	24122.	6939.8	18757.	10386.
c. Value (Rp.000 000)	11.605	13.216	6.8862	5.5515	17.673	17.215
Fishing days	8.5625	5.3219	7.6889	6.5164	9.6857	2.8668
Engine						
a. Power (HP)	39.400	48.413	29.067	25.005	52.686	65.391
b. Age	7.1750	4.0259	7.4333	3.8948	6.8429	4.1933
Fishing Vessels						
a. Gross Tonnes (GT)	6.4250	5.4283	5.5000	3.1809	7.6143	7.2318
b. Age (years)	7.1875	4.0113	7.4556	3.8662	6.8429	4.1933
c. Crew Number	5.0187	3.1312	3.7556	2.0185	6.6429	3.5469
Distance to Fishing Ground (mile)	13.306	14.957	14.844	9.5834	11.329	19.748
Operasional Cost						
a. Vessel (Rp 000 000)	2.9448	2.2967	2.4531	1.9374	3.5770	2.5676
b. Crew (Rp 000 000)	2.1438	1.4589	1.7407	1.3334	2.6621	1.4585
c. Total (Rp 000 000)	5.0886	3.5380	4.1938	3.1828	6.2391	3.6595
Skipper Atributes						
a. Age (year)	40.231	7.6571	40.533	8.0924	39.843	7.0969
b. Education (year)	7.4125	2.1931	6.8444	2.0219	8.1429	2.2020
c. Experience (year)	20.337	9.9899	22.011	9.8180	18.186	9.8633
d. Family Size (people)	3.5812	1.2712	3.6111	1.1386	3.5429	1.4314

The size of fishing vessel and the number of vessel crews as well as the length of fishing days affect the operational cost involving vessel operational cost, such as fuel, and crew operational cost such as food consumption. The total operational cost expended per trip by Gillnet is Rp. 4.19 millions involving vessel operational cost of Rp. 2.5 millions and crew operational costs of Rp. 1.7 millions. Meanwhile, the operational cost spent by Hand Line is Rp. 6.24 millions comprising Rp. 3.5770 millions and Rp 2.6621 millions for vessel and crew cost respectively. These differences due to the size and the crew numbers of fishing vessel as explained before.

Looking into distance to fishing ground, eventhough they have smaller size than fisshing vessel with Hand Line gear, fishing vessels with Gillnet trip relatively far distances comparing to Hand Line fishing vessels. However, if look at distance covered, Hand Line fishing vessels cover more wider area. This happened due to the size of Hand Line fishing vessels are bigger than Gillnet fishing vessels. Fishing vessel with Gillnet gear tripped 15 miles from shoreline on average ranging from 3 miles to 35 miles. On the other hands, Fishing vessel with hand line gear rove 11 miles avaragely and range from 3 miles to 100 miles.

Species of fish caught varies greatly affecting different market price recieved by fishermen. Various types of fish caught include mackerel, yellow tail, tuna, skipjack, trevally and so forth. While market prices recieved by fishermen ranges from Rp. 5,500,- to Rp. 77,500. per kg depending on type and size of fish with average price of Rp 21,775 per kg. Because of the various species of fish landed, the suitable measure for the stochastic production frontier analysis was the value of fish landed per trip instead of the volume.

3.2. Estimated Stochatic Frontier Fish Capture Function

The maximum likelihood estimates of the stochastic frontier Fish Capture Function using the translog function for in the study area are presented in Table 2. Looking at the case of Gillnet fishing gear, all variables included in the frontier fishing capture model significantly and positively affect the value of catch, with exception of of crew numbers. A positive sign and significant means that each additional production inputs used in the model will increase significantly the value of chatch. Conversely, a negative sign for the number of crews informs that the addition of one unit of vessel crew will decrease the maximum value of catch to be obtained. Results from frontier fish capture function for Gillnet fishing gear shows that the size of fishing vessel has the highest elasticity value, namely 0.85047. This figure indicates that the increase in the size of fishing vessels by one percent would increase the value of cacth to 0.85047 percent, *cateris paribus*. This also means that this fishing vessel factor has the greatest influence on the output to be generated. In contrast, the fishing days provides the smallest influence among variables were statistically very significant effected the value of cacth. The value of catch will increases by 0.21835 percent for each additional use of fishing days by one percent, which the other factors remains.

Table 2: Results for Parameter Estimation of Frontier Fish Capture Function

Variable	Regression coefficience		
	Combine	Gillnet	Hand Line
Constant	1.8174 (0.036158)***	2.0538 (0.00000053981)***	2.8595 (0.0012987)***
Fishing day	0.26696 (0.026425)***	0.21385 (0.00034533)***	0.94635 (0.074456)***
Number of Crew	0.69722 (0.048094)***	- 0.49205 (0.000080543)	0.43237 (0.0018238)***
Distance to fishing ground	0.18269 (0.011708)***	0.31222 (0.0003021)***	0.36699 (0.042824)***
Total Operational Cost	0.67490 (0.0000034159)***	0.60627 (0.000000077943)***	0.59622 (0.000019121)***
Engine Power	0.57408 (0.015649)***	0.64735 (0.000007445)***	0.24204 (0.0010746)***)
Vessel Size	- 0.12744 (0.039701)	0.85047 (0.00031264)***	0.084718 (0.11516)
Dummy for fishing gear (1 for Gillnet and 0 for Hand line)	0.18479 (0.040475)***		
$\lambda = \sigma_U / \sigma_V$			
Γ	0.57600 (0.00086861)***	0.6155 (0.048438)***	0.86552 (0.049071)***
$\sigma = \sqrt{\sigma_U^2 + \sigma_V^2}$	0.55255 (0.0095400)***	0.85384 (0.014577)***	0.47189 (0.0000022762)***

Source: Data processed (2008)
Remarks: Figures in brackets the value of the Standard Error
***, **, * Respectively significant at 99%, 95% and 90%

For the Hand Line fishing gear, all independent variables in the model are significant and have positive impact on the value of catch. Difference from the gillnet, the number of crews were significantly affecting the value of catch for the hand line. One percent increase in the number of crews will affect the increase of the value of cacth by 0.43237 percent. The research had also resulted that fishing days has the highest elasticity, i.e., 0.94635. This finding also overturnes previous findings in which fishing days has the lowest elasticity in the Gillnet fishing gear. Survey found that the cacth volume of hand line per day is aproximately 3 times higher than that of Gillnet. From Table 2, the catch productivity of Hand Line is 107.9957 kg per day while Gillnet wis only 39.2007 kg/day.

If all the samples are combined, then, the estimation results indicate that all the factors used in this study have the anticipated positive signs and are significanly different from zero with exception of Vessel Size variable. These findings conclude that fishing day, number of crew, distance to fishing ground, total operational cost, engine power and dummy for fishing gear (i.e.,1 for Gillnet and 0 for Hand line) are important factors affected the value of catch production, implying that any increase in each variable would causes higher catch production. These findings were nearly similar to Esmaeili (2006) [10]. Esmaeili (2006) [10] in his analysis for the Iranian fishery in the Persian Gulf found that the coefficients of labour, number of fishing days, and engine horsepower are significant and have the expected positive signs. While Garcia del Hoyo *et al.* (2004) [13], except for Gross Tonnes and crew member, found that engine power was the only variable that did not contribute significantly to the model, indicating that this is not a crucial factor for purse-seine vessels. Furthermore, the combined estimation of frontier production models have also found that the type of fishing gear has significantly different from zero. This finding was consistent with the hypothesis that the type of fishing gear will effect on catch production values. However, a positif sign informed that if fishermen use Gillnet fishing gear, they will get higher value of catch than they use hand line fishing gear, and *vice versa*. This explaination was differ from a fact that the catch value of hand line fishing gear per trip or per day is higher than that of Gillnet as shown in Table 1. Thus, the hypothesis should be rejected. This finding is reasonable because the type of fishing gear will catch fish of different sizes as well. Hand line fishing gears usually catch tuna larger than the other fishing gear, including a purse seine (Babaran 2006) [3].

The assumption that the stochastic frontier fish capture function is identical to the traditional response in which assumed there is no technical efficiency need to be tested. Hypothesis test results, as presented in Table 4, found that the value of λ and σ are big enough and different from zero at every level of significance. This result suggests that technical efficiency effects are significant components of total variability of fishing output for the sample of households (Battese and Coelli, 1995) [5]. These results also concluded that the assumptions about half normal distribution must be accepted. Some cases at the farm also proved the existence of half-normal distribution such as a research conducted by Hjamarsson *et al.* (1996) [14], Sharma *et al.* (1997) [28], Sukiyono (2005) [31] and Sukiyono and Sriyoto (2010) [30]. Another conclusion derived from the results of the test of this hypothesis was that the conventional production model does not fit with existing data. In other words, the null hypothesis, which specifies that the explanatory variables in the technical efficiency model are not stochastic, is rejected by the data. Therefore, fishing capture are not technically efficient, which implies that teechnical efficiency effects are present. Thus, it can be concluded that the explanatory variables in the technical efficiency model do contribute significantly to the explanation of the technical efficiency effects for fishing capture in the study area. Furthermore, the estimation also produced the estimated value of γ, i.e., 0.576, 0.6155 and 0.86552 for combined, gillnet and hand line. These figures informed that at least 57.6 percent variation of the value of catches is caused by differences in technical efficiency. The value of γ ranges from 0 to 1, with the value equal to 1 indicating that all the deviation from the frontier are due entirely to technical efficiency (Coelli *et al.*, 1998) [8].

Hypothesis aimed at finding out whether all the fishing operations been efficiently to be tested. Hypothesis test was conducted using test Likelihood Ratio Test. The LR estimation results were presented in Table 3. The conclusion of this test is no evidence that all all fishing operations in Bengkulu province is 100 percent efficient.

Table 3: Likelihood Ratio Test

No	Type of Fishing Gear	LR	χ^2	Conclusion
1	Combine	619.7376	129.561	Reject H0
2	Gillnet	87.8442	79.082	Reject H0
3	Hand Line	435.4936	90.531	Reject H0

3.3. Estimated Technical Efficiency Level

In general, the average technical efficiency achieved by capture fisheries that operate in the Bengkulu was 67.78 percent. This figures indicated that fishing vessels with Gillnet and Hand Line fishing gear reached at least 68 per cent of the potential catch production from the sacrificion of fishing production inputs combination. This figure also indicated that there are still opportunities approximately 32 percent to increase the value of catches. This Finding was similar to Battese (1992) [4, 6] conclusions from his survey concerning estimates of technical efficiency in various articles. Sukiyono research results (2005) [31] also found the achievements of technical efficiency on chilli farming in Rejang Lebong district is also about 64 percent. When compared to research conducted by Esmaeili (2006) [10] and Sharma *et al.* (1999) [27], then, technical efficiency gained by Bengkulu fishermen was relatively small. Those of in Hawaii as reported by Esmaeili (2006) [10] was 78 percent, while in Iraq was 84 percent as informed by Sharma *et al.* (1999) [27].

Table 4: Estimated Technical Efficiency in Different Fishing Gear: Summary

Description	Combined	Gillnet	Handline
N	160	90	70
Mean	0.67776	0.75732	0.67244
St. Deviation	0.093729	0.067648	0.081140
Variance	0.0087850	0.0457620	0.0065837
Minimum	0.46451	0.51862	0.47339
Maximum	0.92148	0.88795	0.93477

Based on the type of fishing gear, fishing vessels with gillnet fishing gear produced the high average technical efficiency, namely 75.73 percent while fishing boats with hand Line fishing gear got 67.24 percent. Likewise, more than 98 percent fishermen using gillnet fishing gear attained technical efficiency over 60 percent, as presented in Figure 1, while fishermen with Hand Line was only 10 percent. This finding is quite disturbing because fishermen used Gillnet fishing gear had lower catch productivity both per trip, per day and per crew compared to Hand line. One reasonable argument of these findings is that both fishing gears are not comparable because both fishing gear has different characteritics in many aspects, especially in term of size range of fish capture. Gillnets, for example, are designed to catch a specific size range of fish, but are not species specific. They often entangle many fish that fishermen are not trying to catch. They also frequently entangle large ocean animals, including shark. Hand Lines, on the other hand, designed to cacth specific fish species and have similar behaviour, such as tuna.

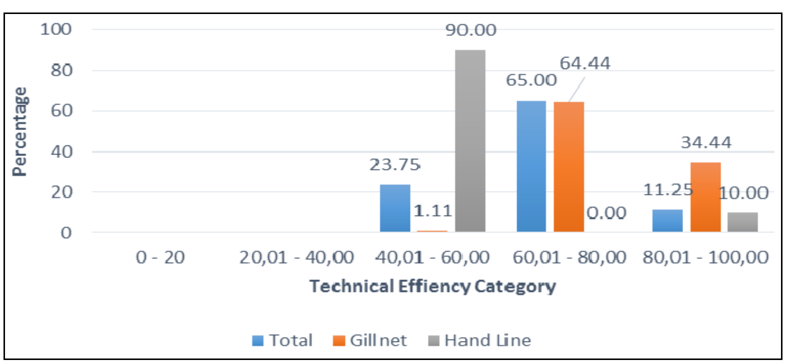

Fig 1: Frequency Distribution of Technical Efficiencies for the Gillnet and Hand Line in Bengkulu Province

3.4 Factors Affecting Technical Efficiencyy

Given the technical efficiency estimated for each fishing vessel, the next analysis is identifying the determinants of the technical efficiency. This analysis was to identify the factors affecting teechnical efficiency. In this empirical approach, model proposed by Kirkley *et al.*, (1995) [16] is followed closely. They said that skippers' skills and vessel characteristics are important factors in how a vessel performs. Furthermore Kirkley *et al*. explained that the skill of a skipper is a complex concept that has a profound influence on fisheries management models and the productivity of a fishery. Therefore, education, experience, and age are used as skipper - specific variables in this research. Meanwhile, engine power (PK) and Vessel Size (GT) are used as vessel characteristics including in this research. The technical efficiency model has been estimated using OLS approach and the estimated result was presented in Table 5.

Table 5: Determinant of Technical Efficiency

Variabel	Regresion Coefficiency		
	Combined	**Gillnet**	**Hand Line**
Constant	0.71640 (0.02602)	0.71762 (0.04850)	0.60234 (0.04599)
Skipper Education (EDU)	-0.00057216 (0.001778)	-0.0022203 (0.003468)	-0.00019272 (0.003131)
Skipper Age (AGE)	0.0016266 (0.0006033)***	0.0015830 (0.001132)**	0.0023231 (0.001194)*
Skipper Experience (EXP)	-0.0016328 (0.0004686)***	-0.0017443 (0.0008901)	-0.0019237 (0.0008756)**
Skipper household size (SIZE)	-0.0055739 (0.003169)**	-0.0000059159 (0.006300)	-0.012260 (0.005676)**
Engine Power (PK)	0.00032354 (0.0001079)***	0.000055811 (0.000002872)***	0.00071673 (0.0001689)***
Vessel Size (GT)	0.0026510 (0.0009766)***	0.0050048 (0.002331)**	0.0025957 (0.001608)*
Dummy for Fishing gear	-0.13591 (0.007920)***		
Fstatistics	73.095***	1.925*	16.621***
R^2	0.7710	0.5221	0.6129

The estimation results of the model showed that $F_{statistics}$ is greater F_{table} at every significance level. The test results concluded all the variables included in the model have an influence on the variation in achievement of technical efficiency. The magnitude of the independent variable effects is indicated by R^2 value, i.e., 77.10%, 52.21% and 61.29% for combined, Gillnet, and Hand Line respectively. The R^2 value of 77.10% informed that variations in the rise and fall of technical efficiency achieved 77.10% influenced by independent variables which exist in the model. The rest, i.e., 22.90%, influenced by other variables that are not included in the model.

Education (EDU) was not an important factor affecting technical efficiency in all basis of analysis. This finding was similar to study conducted by Sharma and Leung (1999) [27] who found no significant effect of education on technical efficiency in Longline Fishery in Hawaii. However, this finding differed comparing to Esmaeili (2006) [10] who found the positive and significant influence of education on technical efficiency in the Persian Gulf Iran. The insignificant effect of skipper education on technical efficiency was reasonable. One possible reason is that skipper skill and expertise in managing fishing boat comes from their parents or their own learning not come from their formal education.

Another quality input, i.e., skipper experience (EXP), was significance statistically but it had a negative sign. This finding informed that skipper experience is an important factor affecting technical efficiency. However, the negative sign indicated that the skipper experience will reduce technical efficiency achievement. Clearly, this finding was not as expected. Increasing skipper experience should improve its ability to manage fishing vessels, which in turn will improve the technical efficiency. Relative similar experience of all skippers and alleged discrepancy model may be the cause of this finding. In addition, factors such as "motivation", "effort" and "luck" could be the main factor of achievements of technical efficiency, not the experience of captain. However, these allegations need to be investigated further.

Two other atributes of the skippers included in the model were age (AGE) and number of family members skippers (SIZE). In relation to these variables, it was expected that the atributes of the skipper positevely and significantly affect technical efficiency with exception of SIZE that has unexpected sign,i.e, negative. The younger skipper could be related to the inability to manage the fishing vessel, solve the problem, and to maximize output given the used inputs, *vice versa*. Family members of skipper related to motivation of skippers to fullfil household needs, therefore, the higher the size of skipper family will motivate them to work hard in order to fullfill household needs. This research found an oposite result.

Variables associated to vessel characteristics, that is, vessel size (GT) and engine power (PK) are statistically significant at least at 10% level. Both variables have positively effect on technical efficiency. These findings were similiar to Sharma and Leung (1999) [27], Pascoe *et al*. (2001) [21] as well as study by Foisekis and Klonaris (2003) [12] that fishing vessel size raise technical efficiency even though they have different proxies for vessel size variable. Another vessel characteristic significantly effected technical efficiency is type of fishing gear. Type of fishing gear has negatively and significantly effect on technical efficiency. This research found that if fishermen use Hanad Line fishing gear rather than Gillnet, it will reduce technical efficiency. The estimation of technical efficiency show that the technical efficiency of fishermen using gillnet fishing gear have average technical efficiency - higher than the fisherman using Hand Line fishing gear (see Table 4).

4. Conclusion

This research showed that the level of technical efficiency was 75 percent for Gillnet and 67 percent for Hand line fishing gear. This level indicates that there are still opportunities to improve the technical efficiency at least by 33 percent. It is likely that fishing vessels characteristics are the important and significant factor affecting technical efficiency. Therefore, improving technical efficiency should consider this factors. In other words, the policy implications of these findings are that the increase in technical efficiency can be achieved through policies that are more focused on improving the quality and quantity of fishing vessel equipments. In addition, the capacity of the fishing vessel is also limited, it is difficut to lengthen fishing days. This constraint can be overcome by providing a modern instrumentation to track fish location, such as fish finder. Improving knowledge and skill of skipper and his vessel crews also should be considered as effort to increase technical efficiency.

Although this study found a dummy variable of fishing gear is an important factor affecting technical efficiency, it does not mean the ship's fisheries must be replaced by other fishing gear, such as Gillnet. Meaning, efforts to increase technical efficency was not made through the replacement of fishing gear, but it should focus more on the fishing management improvement by increase the extention intensity continuously. In addition, policies aimed at technical assistance and credit may be more easily implemented both in public policy and political aspects.

5. References

1. Aigner D, Lovell CAK, Schmidt P. Formulation and estimation of stochastic frontier production function models. Journal of Econometrics. 1977; 6:21-37.
2. Aigner DJ, Amemiya T, Porier DJ. On the estimation of production frontiers: Maximum likelihood estimation of the parameters of a discontinuous density function. International Economic Review. 1976; 17:377-396.
3. Babaran RP. Payao Fishing and Its Impact to Tuna Stocks: A Preliminary Analysis. Second regular Scientific Meeting WCPFC. 2006; 7(8):712.
4. Battese GE, Coelli TJ. Frontier production functions, technical efficiency, panel data: With application to paddy farmers in India. Journal Of Productivity Analysis. 1992; 3:153-169.
5. Battese GE, Coelli TJ. A model for technical inefficiency effects in a stochastic frontier function for panel data. Empirical Economics. 1995; 20:325-332.
6. Battese GE. Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics. Agricultural Economics. 1992; 7:185-208.
7. Charnes, A., Cooper, W. W., and Rhodes, E. Measuring efficiency of decision-making units. European Journal of Operational Research, 1978; 2: 429– 444.
8. Coelli TJ, Rao DSP, Battese GE. An Introduction to Efficiency and Productivity Analysis. Kluwer Academic Publishers, Boston, 1998.
9. Dey MM, Paraguas FJ, Srichantuk N, Xinhua Y, Bhatta R, Dung Le TC. Technical efficiency of freshwater pond polyculture production in selected Asian countries: Estimation and implication. Aquaculture Economics and Management. 2005; 9:39-63.
10. Esmaeili, Abdoulkarim. Technical efficiency analysis for the Iranian fishery in the Persian Gulf. ICES Journal of Marine Science. 2006; 63:1759-1764.
11. Fare S, Grosskopf, Lovell CAK. The Measurement of Efficiency of Production, Kluwer Nijhoff Publishing, Boston, 1985.
12. Fosusekis, Panos, Stathis Klonaris. Technical Efficiency for Fisheries: A study of trammel netters in Greece. Fisheries Research. 2003; 63:85-95.
13. Garci´a del Hoyo, Juan Jose´, David Castilla Espino, Ramo ´n Jime´nez Toribio. Determination of technical efficiency of fisheries by stochastic frontier models: a case on the Gulf of Ca´diz (Spain). ICES Journal of Marine Science. 2004; 61:416-421.
14. Hjalmarsson L, Kumbahar SC, Hesmati A. DEA, DFA, and SFA: A Comaprison. Journal of Productivity Analysis. 1996; 7:303–327.
15. Huang C, Liu J. Estimation of non-neutral stochastic frontier function. Journal of Productivity Analysis. 1994; 5:171-180.
16. Idda L, Madau FA, Pulina P. Capacity and economic efficiency in small-scale fisheries: Evidence from the Mediterranean Sea. Marine Policy. 2009; 33:860-867. http://dx.doi.org/10.1016/j.marpol.2009.03.006
17. Kirkley J, Squires D, Strand I. Assessing Technical Efficiency In Commercial fisheries: The Mid-Atlantic Sea Scallop fishery. American Journal of Agricultural Economics. 1995; 77:686-697.
18. Kirkley JE, Squires D, Strand IE. Characterizing Managerial Skill And Technical Efficiency In Fishery. Journal of Productivity Analysis. 1998; 9:145-160.
19. Kumbhakar SC, Lovell CAK. Stochastic Frontier Analysis. New York: Cambridge University Press, 2000.
20. Meeusen W, van den Broeck J. Efficiency estimation from Cobb–Douglas production function with composed error. International Economic Review. 1977; 18:435-444.
21. Noetzel B, Norton V. Costs And Earnings In The Boston Large-Trawler Fleet. Bulletin No.400, University of Rhode Island, 1969.
22. Pascoe S, Andersen J, De Wilde J. The Impact of Management Regulation on technical Efficiency of vessels in Dutch beamTrawler Fishery,, Eur. Rev. Agric. Econ. 2001; 28:187-206.
23. Rahman S, Mazid MA, Kamal M, Hossain MA, Hossain MS. Study on fishing gears, species selectivity toward gears and catch composition of BSK Beel Khulna Bangladesh. Bangladesh J. Fish. Res. 1999; 3(1):25-32.
24. Resmiati Teti, Skalalis Diana, Sri Astuty. Komposisi Jenis Alat Tangkap Yang Beroperasi Di Perairan Teluk Banten, Serang. Lembaga Penelitian Universitas Padjadjaran Fakultas Pertanian. Research Report, 2002.
25. Rothschild, B. An Exposition on the Definition of Fishing Effort. Fishing Bulletin. 1972; 70:601–79.
26. Sayeed Md Abu, Shaharior Hashem MA Salam, Mostafa Ali Reza Hossain, Wahab MA. Efficiency Of Fishing Gears And Their Effects On Fish Biodiversity And Production In The Chalan Beel Of Bangladesh. European Scientific Journal. 2014; 10(30):294-309.
27. Sharma KR, Pingsun Leung. Technical Efficiency of Longline Fishery in Hawaii: An Application of a Stochastic Production Frontier. Marine Resources Economics. 1999; 13:259-274.
28. Sharma KR, Leung P, Zaleski HM. Prodcutive Efficiency of Swine Industry in Hawaii: Stockastic Frontier VS Data Envelope Analysis. Journal of Productivity Analysis. 1997; 33:245-268.
29. Squires D, Grafton Q, Alam F, Omar IH. “Technical Efficiency in the Malaysian Gill Net Artisanal Fishery,” Journal of Environment and Development Economics. 2003; 8:481-504.
30. Sukiyono, Ketut dan Sriyoto. Analisa Efisiensi Teknik Usahatani Padi Pada Dua Tipologi Lahan Yang Berbeda di Propinsi Bengkulu. SOCA Februari 2010. (in Indonesian). 2010; 10(1):33-39.
31. Sukiyono, Ketut. Faktor Penentu Tingkat Efisiensi Teknik Usahatani Cabe Merah di Kec. Selupu Rejang, Kab.Rejang Lebong. Jurnal Agro Ekonomi, (in Indonesian). 2005; 23(2):176-190.