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Analysis of the Technical Efficiency of Motorized Small Scale Shrimp Fishers in the Coastal Areas of Delta State, Nigeria

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Abstract: Inhabitants of the coastal areas of Delta State are faced with the problems of poverty, deteriorating economic conditions and unemployment and thus engage in shrimp fishing to earn income for their livelihood. The study examined the technical efficiency and its determinants among motorized shrimp fishers at the small scale level in the coastal shrimp producing areas of Delta State, Nigeria. Primary data were obtained from 108 shrimp fishers using a multistage random sampling procedure. We hypothesized that the motorized shrimp fishers at the small scale level in the coastal shrimp producing areas of Delta State were technically efficient. By applying a Cobb Douglas stochastic production frontier function analysis to the data, the findings were that: the mean technical efficiency (TE) of shrimp fishers was 58%: boat, nets (significant at 5%) and fuel use impact positively on shrimp output; access to credit and distance covered were negative and statistically significant (1% level of probability) in reducing the level of technical inefficiency and; age had a positive coefficient and was statistically significant (1% level of probability) in increasing the level of technical inefficiency. We concluded that shrimp fishers are technical inefficient in the study area and recommend that Government should implement policies aimed at the provision of subsidized inputs, improves access to credit, and encourages local cooperative group formation.
Keywords: Technical efficiency, Cobb Douglas Stochastic production frontier, shrimp production

INTRODUCTION

Nigeria has an estimated 853km. coastline and an entire maritime waters of 210 900 km^2 including a 200 nautical miles Exclusive Economic Zone (EEZ), in which it has exclusive rights to the fish and other natural resources[1-3]. Nigeria's coastal zone is endowed with living resources of fin and shellfish including shrimps and prawns. The Shrimp ground covers about 2,500 km^2 and typical shrimp fishing areas are Escravos, Forcados, Ramos, Pennington, Brass, Bartholomew and Calabar. The Nigerian coastline covers the nine southern states namely Akwa Ibom, Bayelsa, Cross Rivers, Delta, Edo, Lagos, Ogun, Ondo and Rivers. Shrimps fishing areas in the coastline of Delta State are Bomadi, Burutu, Dimigun, Escravos, Forcados, Oporoza, and Koko. Nigeria's shrimp fishing industry is based on capture not culture and an average of 12,000 tons of shrimps are produced annually [2]. The pink shrimp mostly caught at the commercial level by trawlers from 5 nautical miles and beyond are usually processed and exported to European Countries with export value estimated at $US 60 million annually [2]. The estuarine prawn (cray fish) fished in the creeks at artisanal level between 0 and 5 nautical miles are usually consumed locally or sold to earn income.

In the nine coastal States in Nigeria (located at Latitude; 10.00^{0}N; Longitude; 8.00^{0}E), of which Delta State (located at Latitude; 5^{0}30^{1}N; Longitude; 6^{0}00^{1}E) is one, majority of rural households live in abject poverty and deteriorating economic conditions. They derive their sources of livelihood from fishing, shrimp production and other fish related activities. This is true of especially the women and the youths. As shrimp is an important economic resource, the thrust of this research is to determine the technical efficiency of the motorized shrimp fishers at the small scale level in the coastal shrimp producing areas of Delta State and to identify the specific factors that affect the technical efficiencies of these fishers. We hypothesized that the motorized shrimp fishers at the small scale level in the coastal shrimp producing areas of Delta State were technically efficient

MATERIALS AND METHODS

The study was conducted in the coastal areas of Delta State which consists of 8 local government areas (LGAs) namely: Bomadi, Burutu, Isoko North, Isoko South, Patani, Warri North, Warri South and Warri South West. Multistage random sampling procedure was used in the collection of the primary data from four Local Government Areas (LGAs) namely Bomadi, Burutu, Warri South West and Warri North of Delta State between July and October, 2010. Twenty seven (27) motorized small scale shrimp fishers were randomly selected from each of the sampled coastal

LGAs. This gave a total of 108 respondent shrimp fishers that were selected and interviewed.

Model Specification:

The stochastic frontier production function was used to analyze the technical efficiency of shrimp producers and also to determine the determinants of technical efficiency of the respondents. According to Aigner *et al.* [4], extended by Battese and Coelli [5] and Bhattacharya [6], the production technology of the shrimp fishers was assumed to be specified by the Cobb – Douglas frontier production function, which is defined by

$$\ln Y_i = \beta_0 + \beta_1 \ln(Boats) + \beta_2 \ln(Gnets) + \beta_3 \ln(Flub) + \beta_4 \ln(Labour) + V_i - U_i \qquad \text{Eq. (1)}$$

Where;

ln	=	natural logarithm
Y	=	output of shrimp (aggregate quantity of shrimp caught) in kilograms
β	=	scalar parameters to be estimated
Boats	=	number of people boat can contain (capacity of boat)
Gnets	=	area covered by nets (size) used in meters
Flub	=	litres of fuel and lubricants used
Labour	=	no. of man hours per day used fishing for shrimp
V_i -	=	random error as previously defined
U_i	=	technical inefficiency effects as previously defined

The technical inefficiency effects of U_i for each shrimp fisher is defined by

$$U_i = \delta_0 + \delta_1 (Age) + \delta_2 (Edu) + \delta_3 (Fshexp) + \delta_4 (Acccre) + \delta_5 (Distfsh) + \delta_6 (Tranpcst) + \delta_7 (Techasst) + \delta_8 (Mlocgp) \qquad \text{Eq. (2)}$$

Where;

Age	=	age of shrimp fishers (in years)
Edu	=	educational level of shrimp fishers (in years)
Fshexp	=	shrimp fishing experience (in number of years)
Acccre	=	represent access to credit or not
Distfsh	=	distance from shore to shrimp fishing sites (in nautical miles or kilometer)
Tranpcst	=	transport cost (in naira)
Techasst	=	represent whether shrimp fisher has received technical assistance or not
Mlocgp	=	represent membership of local cooperative groups or not
δ_0	=	the intercept and
$\delta_{1 \ldots\ldots n}$	=	the unknown parameters to be estimated

These factors were included in the model to indicate their possible influence on the technical efficiencies of the shrimp fisher. The variances of the random errors (σ^2_v) and that of the technical inefficiency effects (σ^2_u) and overall variance of the model (σ^2) are related thus:

$\sigma^2 = \sigma^2_v + \sigma^2_u$ and the ratio $\gamma = \dfrac{\sigma^2_{mu}}{\sigma^2_v + \sigma^2_u}$ measures the total variation of output from the frontier which can be attributed to technical inefficiency [7]. The estimates for all the parameters of the stochastic frontier production function and the inefficiency model were simultaneously obtained using program frontier 4.1 (Coelli, 1994) [8]. In this study, two different models, Ordinary Least Square (OLS) and the Maximum Likelihood Estimate (MLE) were estimated for the study area.

Model 1: The OLS is the traditional response function in which the inefficiency effects are not present. It is a special case of the stochastic frontier production function in which there is restriction and the total variation of output from the frontier output due to technical inefficiency is zero, that is $\gamma = 0$.

Model 2: The MLE on the other hand, is the general model where there is no restriction, hence $\gamma \neq 0$. The two models were compared for the presence of technical inefficiency effects using the generalized likelihood ratio test.

RESULTS AND DISCUSSIONS

Small scale motorized shrimp fishers in the study area use outboard engines of 8hp to 40hp (mostly 25hp) in planked or dugout canoes using mostly dragnets locally called “Ogbugba” and or fixed bag nets together with other accessories such as floats, twines, sinks and anchors etc to fish for shrimps in coastal waters. The number of shrimp fishers per canoe varies from 3 to 6, fishing at an average distance of 3 to 7 nautical miles (about 5 to 12 kilometers) for about 10 months of March to December and sometimes all year round[3, 9, 10]. Their shrimp catches are dominated by the estuarine prawns (cray fish) and penaeus notialis (pink shrimps) and this is consistent with other studies by CEHRD[3] and Sogbesan *et al.* [1]. On the socio-economic characteristics of the shrimp fishers, all the shrimp fishers are male, but their fishing inputs such as boats, outboard engines, nets etc may be owned by women. The lack of women participating in motorized shrimp fishing activities is usually associated with the distance covered by going far into the coastal water and the associated risks involved. This is consistent with results obtained by Verstralen and Isebor[10]. The result of the survey also showed that most of the surveyed respondents (72%) are middle aged (31 - 50 years) suggesting that shrimp fishers are young with vigour and agility required for shrimp fishing activities. The result of other socio-economic indicators showed that 77% of the surveyed respondents had no education or primary education which is consistent with lack of education in the riverine communities and this impact negatively on the efficiency of small-scale fisher-folks. In terms of experience, the result of the survey indicates that 40% of the respondents had less than 11 years fishing experience while 60% had over 11 years fishing experience. This showed that the respondents had some level of experience which is required for any fishing or business enterprise to ensure increased productivity.

Technical Efficiency Analysis

Table 1 showed that the mean technical efficiency of the motorized small scale shrimp fishers in the study area was 58%. This indicates that production could be increased by 42% by improving technical efficiencies at the artisanal level. This result is in consonance with the result from a similar study in Tanzania by Sesabo and Tol [11].

Table 1: Estimates of stochastic production frontier by Ordinary Least Square (OLS) and Maximum Likelihood (MLE) and inefficiency functions of the Motorized Shrimp Fishers

Explanatory variables	Parameters	Motorized	
		OLS	MLE
General model			
Constant	β_0	-1.120 (-2.1)**	0.920 (1.941)***
Boat capacity	β_1	0.177 (0.616)	0.053 (0.199)
Nets used	β_2	0.927 (5.308)*	0.388 (2.184)**
Fuel and lubricants used / day	β_3	0.318 (2.048)**	0.174 (1.515)
Labour used (man hours / day)	β_4	-0.252 (-1.548)	-0.149 (-1.047)
Diagnosis statistics			
Sigma square $(\delta^2 = \delta_v^2 + \delta_\mu^2)$	δ^2	0.225	0.065 (4.955)*
Gamma $(\gamma = \delta^2 / \delta_v^2 + \delta_\mu^2)$	Γ	0.850	0.899 (191.54)*
Log likelihood function	L/f	-31.247	8.280
Likelihood ratio Mean Technical Efficiency Observation	LR		79.053* 0.584 (58%) 108

*significant at 1%, **significant at 5%, ***significant at 10%; Motorized (minimum TE=23%; maximum TE=99%); (Figures in parenthesis are t values)

Source: Computed from field survey 2010

Determinants of Technical Efficiency

The ordinary least square (OLS) and the maximum likelihood estimates (MLE) of the stochastic frontier production function for the motorized small-scale shrimp fishers are also presented in Table 1.

There was the presence of technical inefficiency effects in shrimp production among the motorized shrimp fishers. This was confirmed by a test of hypothesis using the generalized likelihood ratio test. The chi square computed was 79.05 while the critical value of the chi square at 95% confidence level and 8 degrees of freedom, χ^2 (0.95,8) was 15.51. The null hypothesis of no inefficiency effect in shrimp production, $\gamma = 0$ was therefore rejected. Thus we concluded that the explanatory variables in the technical inefficiency model do contribute significantly to the explanation of technical inefficiency of shrimp fishers. The OLS model was not an adequate representation of the data. Hence, MLE model was the preferred model for further econometric and economic analysis.

The generalized likelihood ratio (LR) test of 79.05 in Table 1 was highly significant at 1% level of probability and this suggests that there was the presence of a one sided error component. It means the effect of technical inefficiency was significant and a classical regression model of production function was an inadequate representation of the data.

In both the OLS and MLE, the slope coefficient of net size has the highest elasticity followed by fuel and boat. In the MLE, the coefficients of boat capacity (0.053), nets used (0.388), and fuel utilization (0.174) have the expected positive sign while labour use (-0.149) has a negative sign. This result indicates that boat, nets and fuel contribute positively to the output of shrimps in the motorized sector. The contribution of nets was not only positive but statistically significant to the value of shrimp output at 5% level of probability. Therefore, a 5% increase in the size of net use will increase shrimp output by 39%. In order to improve the technical efficiency and profitability of small scale shrimp fishers, Government should be encouraged to implement policies aimed at the provision of subsidized inputs (nets boats, and outboard engines). In the case of labour, the negative coefficient indicates that labour use, though not significant decreases shrimps output. This implies excessive use of labour in terms of number of people and/or man hours spent fishing resulting in a decrease in shrimps output.

The variance ratio defined as gamma (γ) was estimated at 0.899 suggesting that systematic influences that are unexplained by the production function are the dominant source of random errors and about 89.9% of the variation in shrimp output among motorized shrimp fishers in the study area was due to differences in their technical efficiencies.

Technical Inefficiency Analysis:

Table 2 which shows the factors that determine the technical efficiencies of motorized shrimp fishers revealed that the coefficients of credit (-0.051) and distance covered (-1.331) to shrimp fishing sites were negative and statistically significant in reducing the level of technical inefficiency effects at 1% level of probability. This result suggests that motorized shrimp fishers with access to credit to procure shrimp fishing inputs and covers longer distances into the coastal water to fish for shrimps are technically more efficient than their other counterparts. This finding is similar to that of Frito and Curtis [12] and Parikh *et al.* [13] who found that household who use credit were more efficient. Other factors with non significant but positive correlation with technical efficiency are education (-0.110) and membership of local cooperative groups (-0.036). Therefore in order to improve the technical efficiency and profitability of small scale shrimp fishers, Government should improve access to credit and encourage local cooperative group formation.

Table 2: Factors determining technical efficiency of Motorized Shrimp Fishers

Explanatory Variables		Motorized (n=110)
Inefficiency model		
Age of shrimp fisher (years)	δ_1	0.844 (3.656)*
Education (years)	δ_2	-0.110 (-0.528)
Fishing experience (years)	δ_3	0.161 (0.948)
Access to credit	δ_4	-0.051 (-3.878)*
Distance to shrimp fishing sites (Nkm/day)	δ_5	-1.331 (-3.982)*
Transport cost (naira/day)	δ_6	0.056 (0.530)
Technical assistance	δ_7	0.011 (0.331)
Member of local group	δ_8	-0.036 (-0.936)

* Significant at1% level, and **significant at 5% level.
Source: Computed from field survey 2010

On the other hand, Table 2 showed that age has a positive coefficient (0.844) which is statistically significant at 1% level of significance in increasing the level of technical inefficiency. This finding is similar to that of Abdulai and Eberlin [14] and Amos [15]. This indicates that motorized shrimp fishers that are older are technically more inefficient. This can be explained by the fact that although shrimp fishers become more skilful as they get older, the knowhow is attenuated as they approach their middle age, as their physical strength begins to decline thus resulting in decreasing productivity and technical inefficiency. Also, older farmers are less likely to have contacts with extension agents and are less willing to adopt new practices and modern inputs. Other factors that have positive coefficients which were not significant in explaining increasing level of technical inefficiency are fishing experience (0.161), transport costs (0.056) and technical assistance through extension (0.011). Generally, fishing experience and technical assistance through extension agents are postulated to have a positive impact on efficiency as they enable the shrimp fisher to have information on shrimp fishing sites, where shrimps go and spawn, water current and new methods and techniques of fishing. While these findings may seem perverse, it can be explained by the fact that as the experience of the motorized shrimp fishers increases over the years, they become overconfident and less willing to adopt new fishing methods or have contacts with extension agents resulting to decreasing productivity and efficiency over time. Also, the positive but not statistically significant coefficient of transport cost indicates that the motorized shrimp fishers pay lower transport costs and as such are less likely to access different markets to sell their shrimps output. This results to lower market prices for their shrimps resulting to inefficiency. This was true of most male fishers in the coastal area who found it difficult to transport their outputs to different markets to sell them.

CONCLUSION AND RECOMMENDATIONS

Motorized shrimp fishing is presently technically inefficient indicating high opportunity for improvement. That the technical efficiencies of the motorized small-scale shrimp fishers were positively and significantly related with access to credit and distance covered suggest possible areas of government intervention where the implementation of appropriate government policies, especially such directed at enhancing access to credit and subsidizing costs of inputs could contribute towards reducing the inefficiency gap.

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