Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.51, 2016

Technical Efficiency in Artisanal Fishing in Akwa Ibom State, Nigeria

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Abstract
Central to any other economic activity in production is the issue of efficiency. This paper employed the stochastic frontier production function to analyse the technical efficiency of 232 randomly selected artisanal fishermen in Akwa Ibom State, Nigeria. The result shows that 96.7% of contract, 60.66% of the former contract, 26.25% of the non-contract and 94.8% of all fishers were 90% technology efficient; minimum efficiency were 0.82, 0.53, 0.71 and 0.86 respectively while the maximum and mean efficiency was 0.99 and 0.98 for all the categorised fishermen.

Introduction

Many poor rural dwellers rely on fisheries as their primary livelihood source especially in the coastal region of the sub Saharan Africa. This is because it provides direct and indirect employment opportunities, income and nutrition. According to IFAD (2004), it contributes to household resilience and reduced vulnerability to natural hazards and economic uncertainty. In Nigeria, it generates more than 3% of the country's foreign exchange earnings and provides paid and self-employment to 8% of the population. Central Bank of Nigeria Annual Report (2012) reported that the fisheries sector contributes 6% to the total GDP at a growth rate of 6%. The government distinguishes between artisanal and aquaculture, the latter being commercial fish farming. The artisanal sector is divided into two categories: small-scale and industrial. The fishery sector in Nigeria is dominated by small scale artisanal fishermen, which involve fishing households using "relatively" small amount of capital and energy, small fishing boats, making short fishing trips close to shore and producing mainly for local consumption (FAO, 2007). Central Bank of Nigeria Annual Report (2012) note that catches from artisanal inland rivers/lakes and artisanal coastal/brackish waters grew by 5.0 and 4.9% respectively. The development was largely attributed to the continued utilization of various constructed and rehabilitated fish cage structures and dam reservoirs across the six (6) geopolitical zones (2 per zone), coupled with the increased activities and investment by the private sector in fish farming. The output of the sub-sector was; however, lower than the estimated national annual demand of 1.5 million tonnes. It is apparent that the success of the agricultural sector in Nigeria is critical for raising living standards and for food self-sufficiency and as a sustainable source of livelihood for a large population.

The Nigeria's agriculture programmes, as proposed in the New Agricultural policy for Nigeria has not officially recognises the importance of the fishery sub-sector and has made several attempts over the years to increase its production and productivity through institutional and economic reforms. Such reforms include: the Sea fisheries decrees (No. 30) of 1971, the Exclusive Economic Zone (EEZ) decree of 1978, Agricultural Development Projects (ADPs) established in 1975, the National Council on Agriculture (NCA), the National Institute of Marine Research (NIOMR) and National Institute for Fresh Water Fisheries Research (NIFFR). Other programmes like the National Accelerated Fish Production Programme (NAFPP) was also introduced by the Federal Government with the mandate of supplying fishing inputs to fishermen at a 50% subsidy to increase maximum capture efficiency and the Fish Development Project of Directorate for Food, Roads and Rural Infrastructure (DFRRI) etc. However, the first comprehensive agricultural policy for Nigeria with fisheries as a component was put forward in 1988. The document decentralized the responsibilities to the three tiers of Government in Nigeria- Federal, State and Local Governments. The fisheries policy objectives were: to increase domestic production, increase fish export promotion, employment creation by mechanization of the sector, increase per capita income, development of local fisheries based industries and; rational management and conservation of fisheries resources. All, with the sole purpose of making agricultural production more profitable and competitive. Be that as it may, this policy objective is far from reality.

The artisanal fishers on like any other agricultural entrepreneur, typically produce to satisfy both household food needs and profit. With this dual interest in mind, he optimizes his effort and efficiently targets the use of resources. Thus, efficiency becomes an importance determinant in his productive bid. Efficiency which is how effectively the unit produces as large an amount of output as possible, for the purpose of profit maximization, given technology available is the kernel in resource allocation in agriculture. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources

(Udoh, 2005). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the agriculturists are resource-poor (Umoh, 2006). Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output. Technical efficiency is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology (Olayide & Heady, 1982).

Studies relating to technical efficiency in Nigerian's crop/livestock base agriculture abound. However, literature search reveals that empirical studies of technical efficiency in Nigerian fisheries on the traditional artisanal fishing operations are but very few. Such studies include; Dawang, Manggoel, and Dasbak, (2012), Kareem, Ayinde, Badmus, Bakare and Alawode (2013), Akanni (2012), Kirkley, Squires, and Strand (1995) etc. This study is a contribution to push forward and outward the frontier of knowledge on technical efficiency of artisanal fisheries. The question, therefore is: Are artisanal fishers more efficient in the use of resources? This study is an attempt to answer this question with specific emphasis on the technical efficiency in artisanal fishing.

2.0 Objective of the Study

The main purpose of the study is to empirically analyse the technical efficiency of resource use in artisanal fishing in Akwa Ibom State, Nigeria. The specific objectives are to: (i) analyse some of the socio–demographic characteristics of the fishermen (ii) estimate the technical efficiency of artisanal fishers in Akwa Ibom State, (iii) proffer recommendations with possible increase in productivity in mind.

3.0 Theoretical Framework

Relative technical efficiency between different production practices in developing countries is one of the most widely discussed and controversial issues in development literature. It is influenced by the celebrated hypothesis by Schultz (1964) that farm families in developing countries were "efficient but poor". According to Alhassan (2008) the hypothesis has been interpreted to mean that there are comparatively little significant inefficiency in the allocation of the factors of production in traditional agriculture. With the extension in the analysis of economic efficiency to include both allocative and technical efficiencies, efficiency is now viewed more in terms of system performance, including farmers and farm support systems, rather than focusing narrowly on farmer rationality (Ali and Byerlee, 1991). Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Technical efficiency is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology whereas Economic efficiency is a product of technical and allocative efficiency (Olayide & Heady, 1982).

An important assumption that guides production efficiency is that farms operate on, rather than within, the production possibility frontier (PPF) available to them. In other words, it is generally accepted that production takes place in the rational zone of production stages (stage II) because that is the zone where maximum profit (output) can be obtained.

Thus, technical efficiency is the maximum attainable level of output for a given level of production input, given the best technologies available to the farmer. Allocative efficiency describes the adjustment of inputs and outputs to reflect relative prices, the technology of production already having been chosen. These adjustments are the marginal conditions for profit maximization, which states that MVP should equal marginal factor cost (MFC) for any single variable input, and that MVP per unit of an input should be equal across different outputs (the principle of equi-marginal returns). Economic efficiency is the situation of both technical and allocative efficiency. A fisherman's technical efficiency is a measure of its ability to produce relative to the other best-practice frontier, the maximum output possible from a given set of inputs and production technology Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). Technical inefficiency is the deviation of an individual vessel's production from this best-practice frontier. The estimated frontier is stochastic because fishing is sensitive to random factors such as weather, resource availability, and environmental influences (Kirkley *et al.* 1995).

4.0 Data collection procedures.

Multi-stage sampling technique was used in selecting samples for the study. First, six coastal Local Government Areas (LGAs) were purposively selected. The selection was based on the commercial fishing status of the LGAs and the intensity of fishing activities. Information on the fishing intensity in the Local Government Areas (LGAs) was obtained from Moses (1990), FAO (2005) and reconnaissance survey. The Local Government Areas are; Ibeno, Ikot Abasi, Itu, Mbo, Oron and Uruan. Secondly, sampling frame of fishing settlements in each selected LGA was collected from the Fishery Department of Akwa Ibom State Ministry of Agriculture. From the sampling frame, five (5) fishing settlements were randomly selected from each selected coastal Local Government Areas. The last stage of sampling was the random selection of eight fishermen each from the selected five fishing settlements. Two hundred and forty (240) questionnaires were administered, out of which

232 were retrieved, giving a response rate of 97%. The 232 were used for the analysis.

5.0 Methods of data analysis.

The idea of frontier production function is built around the concept of efficiency adduced by Farrel (1957). The use of the stochastic frontier analysis in studies in agriculture in Nigeria is a recent development. The main feature of the stochastic production frontier is that the disturbance term is composed of two parts-a symmetric and a one-sided component. The symmetric (normal) component, vi captures the random effects due to the measurement error, statistical noise and other non-symmetric influences outside the control of the firm. It is assumed to have a normal distribution.

The first step was to estimate the parameters using ordinary least Square method. It is given by:

$$Ln\ TE = \beta_o + \beta_1 lnQ_1 + \beta_2 lnQ_2 + \beta_3 lnQ_3 + \ldots + \beta_8 lnQ_8 + \beta_9 lnQ_9 + \varepsilon_i$$

TE = Technical efficiency index of fishermen, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5 \ldots \beta_8$ are the coefficients to be estimated, β_0 is a constant and ε_i is the error term.

Step Two: With the acquired necessary information about the variables for inclusion in the frontier analysis, the empirical version of the stochastic frontier model was:

$$LnY_{ij} = \beta_0 + \sum\beta_1 InX_{ij} + \varepsilon_i$$

Where Y_i is fishing output in (kg), β_1 are the coefficients, X_{ij} are the variables selected based on the Ordinary Least Square (OLS) estimation in the first step, ε_i is the error term, β_0 is a constant and Ln is the natural logarithm, i = 1 - - - N.

$$\varepsilon_i = V_{ij} - \mu_{ij} \quad i = 1 - - - N.$$

Where V_i is independently and identically distributed as $V_i \sim$ iid N (0, δu2), independently of μ_i and measures the technical efficiency relative to the stochastic frontier. The μ_s are assumed to be non-negative random variable truncated at zero of the N(μ, δu^2) distribution and assumed to account for technical inefficiency in production - normal.

Estimated Equation. The estimated equation is as indicated below:

$$InY_{ij} = \beta_0 + \sum\beta_1 InX_{ij} + V_{ij} - \mu_{ij}$$

$$TE = \frac{Y_{ij}}{exp(\beta X_{ij})} = \frac{exp(\beta X_{ij} + V_{ij} - \mu_{ij})}{exp(\beta X_{ij} + V_{ij})} = exp(-\mu_{ij})$$

Where, Y_i is fishing output in (kg), β_1 are the coefficients, X_{ij} are the variables used in production. They include: (i) Net size (area of fishing net's eye in m^2), (ii) Labour (Mandays used for fishing)), (iii) Petrol (quantity of petrol used per trip in liters), (iv) boat size (length of fishing canoe in Meters), (v) Battery (average quantity (pair) of battery used per fishing trip), (vii) Oil (quantity of oil used per trip in liters). The sources of inefficiency variables were specified as those relating to the socio-demographic and institutional characteristics of the fishermen. There were: (i) age of household head, (ii) marital status of fisherman, (iii) level of education of fisherman, (iv) household size of fisherman, (v) experience of the fisherman (years), (vi) income of fisherman, (vii) Extension visits, (viii) Group membership and (ix) Credit (N). All are as earlier defined. V_{ij} is the two-sided error term, and μ_{ij} is the one-sided error term (technical inefficiency effects), β_0 is a constant and In is the natural logarithm. The ß and δ coefficients are un-known parameters to be estimated along with the variance parameters δ_2 and γ. The δ_2, and γ, coefficients are the diagnostic statistics that indicate the relevance of the use of the stochastic production frontier function and the correctness of the assumptions made on the distribution form of the error term. The δ_2 indicates the goodness of fit and the correctness of the distributional form assumed for the composite error term. The γ, indicates that the systematic influences that are unexplained by the production function are the dominant sources of random errors. The statistical significance of the shows the presence of a one-sided error component, vi, in the model specified. This means that a traditional response function estimated by the ordinary least square cannot adequately represent the data; and the use of a stochastic frontier function estimated by the maximum likelihood estimation procedures is therefore appropriate. The maximum likelihood estimates of the production function of the equation are automated in a computer programme, FRONTIER Version 4.1, written by Coelli and Battese (1996).

6.0 Results and Discussion

Inspite of the various problems enumerated by the artisanal fishermen, the biggest problems that has stagnated artisanal fishery is access to credit. This has translated to the value of assets owned by them and would dovetail to what they can accomplish because modern fishing is a function of capitalization. Unal (2006), from his research, gave an average minimum investment of a small scale artisanal fisherman in Karaburun to be $2705 and $4715 in Mordogan (approximately N405,750 and N707, 250 at N150/$) respectively. It is consistent with Berkes (1986) who gave an average investment for artisanal fisherman in Turkey as $4,000 (approximately N600,000 at N150/$). Industrial tested wisdom instructs that, output is a direct product of inputs and workers motivation. The fact that contract fishers make more income than others is a direct reciprocal of the input and incentive in the contractual arrangement. Perhaps, this may be because modern fishing is a direct function of capitalisation. The implication is that there is a meaningful impact in artisanal fish production when fishers are adequately motivated with the needed credit. This finding is shared by Ditton, Mertens and Schwartz (1978) who reported an annual income of $33,00 approximately N4,959,000 (at N150 per $) for small scale fishers compared to N1,753, 640 (extrapolation for one year income figure in Akwa Ibom State). The weekly income from non-fishing activities was N5303.42. This is in line with Udo and Nyienakuna (2008) who reported that 28.6% of their respondents were engaged in secondary occupation with N5000-N7000 as mean weekly income from non-fisheries activities. This figure may be higher depending on the time of the year that the survey was done. The hallmark is that, the level of engagement in non-fishing activities determines the income made from it. On frequency of fishing trip per week, the modal fishing trip per week is once a day. the implication is that, fishers make once a day fishing trip because they operate near the oceans and trips to oceans last longer hours than of the lakes/estuaries. Frequency of fishing trips pay day was used as proxy for commitment. The positive significant relationship is expected because contractors (financiers) are rational and will not consider fishers who are not consistent and committed. The contract fishers are recommended by contractor's confidants before negotiation commenced and they too serve as guarantors. Pollnaco (1988) summed it thus "middlemen in most fishing communities have had long relationship with fishermen and understand them". This study is consistent with Erbuomwan, Momah, Sere-Ejembi, Sodipo and Bada (2004) who confirmed that 53.6% of their respondents made a trip per day while 33.9% made two trips per day. Ditton, Mertens and Schwartz (1978) reported that, most chartered trips (54%) were involved in "a day" fishing trip.

Unfortunately, major recurring topics of fishing has dealt with the assumed needs of fishermen to catch fish, further research need to be directed at understanding the importance or relevance of catching fish in relation to all other possible fishing factors.

Another proxy used to test artisanal fishers perseverance and commitment is duration of fishing trip per day. Hours on work has been used to evaluate workers commitment in social research. The fishers were all found to spend more than ten hours during fishing trips, but, in percentage terms, the contract fishers were much more committed than others. Though, Unal (2006), was not comparing contract fishing, he reported an average days at sea to be 192 day/year. This translate to 13 hours (192 x 24 / 356) committed fishing duration per day. Equally, Anyanwu, Mkpado and Ohaka (2009) reported 36.25%, 33.75% and 30% for 1-5, 6-10 and 11-15 fishing hours respectively for their respondents.

The higher catch weight of contract fishers and indeed the positive significant relationship between contracting and catch level per trip is expected. This may not be unconnected with type of the fishing inputs used by then, operating area, boat capacity and inherent contract incentives. This argument holds for the differences in catch weight between former and never contract fishermen. The implication is that catch level increases as contracting is embraced by fishermen i.e contracting engenders increase in output. This finding is shared by Murray (2003) and Costales and Catelo (2008) in livestock production, Olomola (2010), Elepu and Nalukenge (2009), Stessers, Eeckloo (2004) in crops and Atherton and Kingdon (2000) on contract teachers output. It is consistent with Unal (2006) and Berkes (1986) who reported 33kg/day/two man boat and 20kg/day/2 man boat respectively.

The area of operation of the artisanal fishermen analysis shows that the modal area of operation of contract fishers is ocean represented by 52.75% meaning that more than half of the contract fishers operated in the oceanic suburb. This has implication on the type of fish caught, the boat capacity and the duration of the fishing trip. The modal class of operation for former and never contract fishers is the costal brackish water and are represented by 44.26% and 52.46% respectively. This implies that the former and never contract staff operated within the coastal waters perhaps because of their boat capacity and this has implication on the type of fish caught and the income. The finding is similar to that of Erbuomwan, Momah, Sere-Ejembi, Bada and Sodipo (2004) who reported that 65.1% of their respondents operated on the lagoon, 19.1% and 15.9% operated on coastal and brackish water and ocean respectively.

Socio-Demographic Characteristics of the Respondents

Variables	Total	Mean/%
Mean Value of Assets owned (N)	110,6002.00	368,667.2
Monthly Income per Fisherman (N)	159,115.3	530,38.42
Monthly Expenditure per Fisherman (N)	205,189.5	68,396.5
Average weekly income from non-fishing activities (N)	12828.00	4276.00
Frequency of fishing trip per week		
Once a day	112	37.33(%)
Twice a day	67	22.33(%)
Once every other day	53	17.67(%)
Duration of fishing trip per day		
4 - 5 Hours	47	15.67(%)
6 –7 Hours	56	18.67(%)
8 –9 Hours	45	15(%)
10 + Hours	84	28(%)
Average catch per fishing trip		
Below 10kg	13	4.33(%)
11- 20 kg	31	10.33(%)
21- 30kg	55	18.33(%)
31- 40kg	55	18.33(%)
Above 40kg	78	26(%)
Area of Operation		
Coastal and brackish Water	81	27(%)
Inland Waters	48	16(%)
Lake/Estuaries	32	10.67(%)
Ocean	71	23.67(%)

Source: Field Survey, 2013

Analysis of the technical efficiency of resource use was computed for the artisanal fishermen (respondents). All inputs in the efficiency model responded to the expected *a priori* positive sign except quantity of kerosene and oil. Net size, labour, petrol, boat size and battery were all positively significant at 1%. This implies that a unit increase of any of these associated variables will lead to an increase in output of fish of the sampled fishermen. Kerosene, though; having negative sign was statistically significant at 1%. This result implies that a unit increase in the quantity of kerosene would lead to a decrease in output of fish of the fishermen, *ceteris paribus*. The most plausible explanation may be that kerosene has multiple uses in the fishing households. It was use for both cooking and for lighting etc. Thus, may have increase the quantity of kerosene which may not have been used directly for fishing. On oil, the variable was not significant and thus, deserves no further attention.

The maximum likelihood estimates were also concerned with inefficiency effects. The inefficiency effect of extension contacts to artisanal fishermen in the model suggests decreasing technical inefficiency i.e. increasing technical efficiency. This is in line with the *a priori* expectation. This may be explained by the fact that, extension contacts to the fishermen is meant to change their perception and thinking, thereby increasing their output. This is in line with Charles, Ayuba and Malo (2011). They stated that the decreasing technical inefficiency of extension contacts reflected the fact that extension agents were working and such extension education was relevant considering its dual benefit to fishers and sustainable environmental fishing. If the variance parameter "sigma squared" (δ) which is an indication of the goodness of fit and correctness of the distributional form assumed for the composite error term vindicated the model, then gamma (γ) which is an indication of the systematic influences that are un-explained by the production function and the dominant sources of random errors underscores the presence of technical inefficiency among all fishermen in the State. Putting differently, the presence of technical inefficiency among all fishermen in the State explains about 4.62% of the variation in fishing output. It is deduced that the inefficiency effects made significant contribution to the technical inefficiencies of the fishermen in Akwa Ibom State. The generalized likelihood ratio test (λ = 8.01) is highly significant. This implies the presence of one-sided error component. The results of the diagnostic statistics therefore, confirm the relevance of stochastic parametric production function and maximum likelihood estimation.

Mean value of technical efficiency of artisanal fishermen implies that, all the sampled fishermen in the study area, on the average were 96% technically efficient. This means that, there is scope for increasing fishing output by 4% through adoption of techniques and technology employed by the best fisherman. The implication is that, an average fisherman could realize 4% cost saving (i.e. 1-0.96/0.99*100) to achieve the technical efficiency level of its most efficient counterpart. A similar calculation on the most technically inefficient fisherman reveals cost saving of 14% (1- 0.86/0.99*100) to achieve the technical efficiency level of its most efficient counterpart.

Conclusion and Recommendations

The study concluded that there was an observed inefficiency among the artisanal fishermen in the study area. However, there was a possibility of increasing the fish output of the fishermen by 4% through adoption of techniques and technology employed by the best fisherman as the average efficiency was 96%. The policy implication is that it will increase fish production in the State in particular and in the country as a whole, assist in the socio economic development of the fishers as well as check the Government expenditure on fish importation. It is recommended that the Nigerian government should strengthen its extension education outreach for the fishers as well as subsidize some of the fishing gadget for the fishers in the State and Nigeria in general.

Table 2. Maximum Likelihood Estimates of the Stochastic Frontier Function and Technical inefficiency of Artisanal Fishermen

Variables	Parameter	Coefficients	Standard Error	t- Statistics
Constant term		2.3537***	0.1568	15.010
Netsize		0.1874***	0.0258	7.726
Labour		0.1286***	0.0374	3.432
Petrol		0.0770***	0.0289	3.658
Kerosene		- 0.0604***	0.0202	-2.98
Boat size		0.4544***	0.0324	13.992
Battery		0.2083***	0.2783	7.480
Oil		-0.0040	0.0242	-0.164
Inefficiency Model				
Constant term		0.0272	0.2709	-0.1
Age		0.0010	0.0051	0.203
Marital Status		0.0002***	0.0457	0.003
Educational Level		0.0070	0.0433	-0.162
Household size		0.0001	0.0076	-0.014
Experience		0.0010	0.0029	0.34
Income		0.0000	0.0001	0.19
Extension Visit		0.0003	0.0003	-3.353***
Group membership		0.0095	0.001	1
Amount of Credit		0.0000	0.0004	1.135
Sigma-squared		0.0166	0.0015	10.905***
Gamma		0.0462	0.008	5.767***
Log Likelihood function		147.9148		
LR test		8.0061		

* = Significant at 1%, ** = Significant at 10%, *** = Significant at 5%

Table: 3. Artisanal Fishermen Specific-Resource Efficiency Indices

Class interval of Efficiency	Frequency	Percentage
0.50 – 0.59	-	-
0.60 – 0.60	-	-
0.70 – 0.79	-	-
0.80 – 0.89	12	5.17
0.90 – 1.00	220	94.83
Total	**232**	**100**

Maximum value = 1.00 Mean value = 0.96 Minimum = 0.86

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