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Economic Efficiency of Freshwater Artisanal Fisheries in Ijebu Waterside of Ogun State, Nigeria

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Abstract - This study is on the impact of co-operative societies on capital formation using a case study of Temidere-co-operative and Thrift-society, Ijebu-ode, Ogun state. The objectives are to: identify the socio-economic characteristics of the cooperators in the study area; identify the uses of funds of co-operative societies; determine to what extent co-operatives have benefited members in financing their investments; identify problems militating against the effectiveness of co-operative societies; and offer suggestions and recommendations on how to improve the cooperative societies towards enhancing the capital formation of members. The study adopted a non parametric method of analysis which involved Chi-Square method, descriptive statistics and correlation analysis to achieve the stated objectives.

Keywords : gross margin analysis, B-C ratio, economic efficiency, stochastic production frontier, and artisanal fisheries.

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ECONOMIC EFFICIENCY OF FRESHWATER ARTISANAL FISHERIES IN IJEBU WATERSIDE OF OGUN STATE, NIGERIA

Strictly as per the compliance and regulations of :

Economic Efficiency of Freshwater Artisanal Fisheries in Ijebu Waterside of Ogun State, Nigeria

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Abstract - This study was on analysis of economic efficiency of artisanal fisheries in Ijebu Waterside of Ogun State, Nigeria. The objectives were to: determine the profitability of the artisanal fishery enterprises; estimate the technical, allocative, and economic efficiency of artisanal fisherfolks and determine the factors influencing the technical, allocative and economic efficiencies of artisanal fisheries in the study area.

A multistage sampling technique was used to select a total of 400 fisherfolks from the study area. Primary data were collected using structured questionnaire administered on artisanal fisherfolks and data collected included production inputs and output prices. The data collected were analyzed using both descriptive and inferential statistics. Gross margin analysis was used to determine the profitability of artisanal fishery enterprise. Stochastic production frontier model was used to estimate the technical, allocative and economic efficiencies of artisanal fishery system and the factors influencing the technical, allocative and economic efficiencies of the fishers.

The gross margin analysis revealed that fisherfolks earned N7,471,857.15 per annum. The cash flow showed net returns of N7,447,464.99 per annum with an average of N620,622.08 per month. The maximum likelihood estimates of the parameters for the technical efficiency of the fisherfolks revealed that number of fishing gears, outboard engine, litres of kerosene used and quantity of bait used were found to be significant variables in the fish catch level ($P<0.01$). The inefficiency function of the sampled fisherfolks revealed that age of the fisherfolks, household size, gender and mode of operation were found to be significant factors determining the level of efficiency with a mean technical efficiency of 0.77. The mean allocative efficiency was found to be 0.91 while the mean economic efficiency was 0.70. It was concluded that there was a significant difference in the level of profitability and that inefficiency existed in the use of fishing inputs among the fisherfolks.

Keywords : gross margin analysis, B-C ratio, economic efficiency, stochastic production frontier, and artisanal fisheries.

I. Background to Study

Fishing is one of the oldest livelihood income-generating activities of man since the world was created (Christopher *et al*., 2003). The history of fishing industry in Nigeria dates back to the pre-colonial era where basically small-scale fishing (artisanal) has been a major source of food for the inhabitants of coastal and riverine areas. It also provides employment and economic benefit to those engaged in artisanal fishery activity. Artisanal fisheries utilize open access resources in which the only human intervention is the harvesting of fish stocks (Ajenifuya, 1998).

Fish is also a good source of sulphur and essential amino acids such as lysine, leucine, valine and arginine. It is therefore suitable for supplementing diets of high carbohydrates contents. It has high content of Polyunsaturated (Omega III) fatty acids, which are important in lowering blood cholesterol level and high blood pressure. It has also been implicated to have decreased the risk of bowel cancer and reduces insulin resistance in skeletal muscles (Kudi *et al.*, 2008).

The fishery industry in Nigeria can be grouped under three broad categories: artisanal, industrial fishery and fish farming or aquaculture:Artisanal fishery is composed largely of traditional fishermen who are about half a million in number scattered all over the country. Artisanal fishing is carried out with the use of traditional dugout boats (canoes) and other gears (traps). On a comparative basis, it is labour intensive and requires relatively low capital investment. It can thus, be described as a small-scale industry. Artisanal fishing activities are mostly in the shallow continental shelf (coastline), lagoons, creeks, rivers, lakes and reservoirs (Ajao, 2006). Industrial fishery involves the use of large boats (trawlers) because operations are in the distant water (that is, mostly marine and deep sea). Therefore, it requires bigger and better equipped vessels, in contrast to the canoes used for artisanal fishery This distant water vessels are generally expensive and require high level organization with efficient shore-based facilities (such as berths for the trawlers and cold rooms for storage of products). Consequently, industrial fishery tends to be capital intensive.

According to Farrel (1957), efficiency implies an efficient utilization of resources in the production process. However, resource productivity is definable in terms of individual resource inputs or in terms of a combination of them. For instance, labour productivity is defined as the ratio of total output to labour inputs. Similarly, with respect to land, capital, water and

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management productivities can each be defined as the ratio of total output to inputs of land, capital, water and management respectively.

Allocative efficiency is another frequently used measure of efficiency which is defined as the ability of a farm to equate marginal value product and marginal cost (Dhungana *et al*., 2004). In other words, a farm is allocatively inefficient, if it utilizes the inputs in optimal proportions, given the observed input prices, and hence does not produce at minimum possible cost (Coelli *et al*., 2002 and Abay *et al*., 2004). The product of technical and allocative efficiency provides yet another efficiency measure, namely the overall economic efficiency.

Knowledge of the efficiency level at both the firm and fleet level and its determinant factors are valuable information for understanding the problems of fisheries subsector of agriculture. However, such information would include measures of total economic efficiency. Technical efficiency can be measured by different techniques (e.g. Färe *et al*. 1994), but given the stochastic nature of fishing, the stochastic frontier approach has so far been advocated in the literature (Kirkley, *et al*., 1995).

Thus, the allocatively efficient level of production is where the farm operates at the least-cost combination of inputs. Moreso, a firm is allocatively efficient if it was able to equate the value of marginal product (MVP) of each resource employed to the unit cost of that resource. Therefore, allocative efficiency measures, quantifies how near an enterprise is, to using the optimal combination of production inputs when the goal is maximum profit (Richetti and Reis, 2003).

Although, a number of studies have been carried out on efficiency in livestock and crops production in Nigeria, most of such studies dwelled on technical efficiency with only a few dealing with the critical issue of allocative efficiency (Okoruwa *et al*., 2001; Agbamu and Fabusoro, 2001; Ajibefun *et al*., 2002; Ojo, 2003; Ogunyinka and Ajibefun, 2004).

Moreso, researches conducted (Ogundari and Ojo, 2009; Kareem et al., 2008) have observed that the relative technical, allocative and economic efficiencies of the fishing industry has significantly declined in many countries in less developed countries, Nigeria inclusive. This decline in efficiencies also requires public policy that will reverse the short comings in this subsector of agriculture.

Some studies have been conducted on fisheries economics worldwide and in Nigeria, which include the following: Crutchfield and Zellner, (1962), Bromley, (1962), Sagua, (1976), Uboma *et al*., (1982), Williams and Awoyomi (1998), Ajao, *et al*., (2004), Ajao *et al,* (2005).The methodological approach adopted by majority was the ordinary least square (OLS) (Adeogun, 2010; Frederick *et al*.,1985) while some adopted data envelopment analysis (Ajao *et al,* 2004;, Ajao *et al.* 2005), and benefit-cost ratio analysis (Alfred-Okiya (1986)).The most recent study conducted used stochastic production frontier approach to estimate economic efficiency of fish farm in Lagos state which is basically on cultured fishery system (Adeogun, 2010).

Moreso, there have been several studies that have analysed the efficiency of fishery sector in Nigeria (Ajao, 2006 and Adeogun, 2010), most of them have focused on fish farming aspect. The knowledge of economic efficiency of artisanal fisheries in the study area is not only of significant importance for policy makers, but it also provides a missing link especially on the concept of technical, allocative and economic efficiency. It equally creates awareness concerning inefficiencies in artisanal fisheries, and an insight into possible improvement in the determinants of these inefficiencies in the study area.

Economic efficiency comprises both technical and allocative efficiency and it is the product of technical and allocative efficiency (Rahman, 1994). The measurement of technical efficiency/inefficiency indicates to what extent resource-savings can be made or output increases without increasing the input-use levels. This is a critical issue in developing countries where resources are meager and opportunities for developing and adopting better technologies are dwindling (Ali and Chaudhury, 1990).

Despite the rapid development and widespread use of stochastic frontier approaches in assessing efficiency in many industries, such studies on artisanal fisheries are scanty in the study area and Nigeria in general. Thus, implying that, there is inadequate empirical information on the economic efficiency of artisanal fishery in the study area which is expected to serve as knowledge base for expanding output of fishery enterprise as a way of increasing local fish production in the state and the country in general.

a) Description of Ogun State and the fishery system

Ogun State is one of the eight coastal states in Nigeria with about 15 kilometers of Nigeria's coastline having numerous rivers, streams and inland waterways (freshwater).These support varied fishing activities prevalence among the coastal inhabitants. Research reports have however shown that artisanal fishery is the main economic activity of the coastal population of the study area since there are limitations for alternative sources of livelihoods. Despite these numerous rivers, fish production in the state is grossly inadequate to meet the demand of the citizenry. Hence, the need for proper knowledge of the efficiency that will improve their source of livelihood is very essential. The knowledge of economic efficiency of artisanal fisheries in the study area is not only of significant importance for policy makers, but it also provides a missing link especially on the concept of technical, allocative and economic efficiency.

In an attempt to solve the problem of bridging the fish demand and supply gap, the understanding of the knowledge of technical, allocative and economic efficiency is very essential. Thus, the specific objectives are to: describe the socio-economic characteristics of the artisanal fisherfolks in the study area; determine the profitability of artisanal fisheries enterprises; estimate the technical, allocative and economic efficiency of the artisanal fisherfolks; and determine factors influencing the technical and allocative efficiency of artisanal fisheries in the study area.

II. Research Methodology

The study was carried out in Ijebu Waterside of Ogun State using multi-stage sampling technique. The first stage will be purposive selection of 16 villages known for enhanced fishery activities out of the 22 villages in the area. In each of the sixteen selected villages, 25 fishermen will be randomly selected from the list of fisherfolks to make a total of four hundred (400) fisherfolks.

Primary data was collected using structured questionnaire on artisanal fisherfolks in the study area from there recent fishing trip to enhance the reliability of the data. Types of data collected included socio-economic characteristics (such as age, sex, household size, and years of experience), fishing gear, size of canoe, capacity of the outboard engine, number of crew members, quantity of fuel used, and access to credit etc. Data collected was analyzed using descriptive statistics, gross margin analysis and stochastic production frontier model.

III. Analytical Techniques and Empirical Model Specification for the Study

a) Gross margin

A typical gross-margin framework is defined as:

$$\text{Gross margin } (GMi) = TRi - TVCi = \Sigma PiQi - \Sigma CijXij \quad (1)$$

Where; TR represents total value of different fish species caught (i.e fish catches) in naira (N) for *i-th* fisherfolk, TVC represents total variable costs involved in catching different fish species in naira for *i-th* fisherfolk, Pi represents price per kg of each fish specie, Qi represents the quantity of the different fish species caught by the *i-th* fisherfolk, Cij represents a unit cost of *j-th* input used by the *i-th* fisherfolk while Xij represents the quantity of *j-th* variable input used by the *i-th* fisherfolk.

b) Stochastic Production frontier

In this study, the Cobb-Douglas functional form was chosen because of the ease it provides in computation and interpretation. This study adopted this approach and estimated the stochastic frontier production and the inefficiency model in one step using the Frontier 4.1 software. Stochastic frontier analysis was used to estimate the technical, allocative and economic efficiencies of artisanal fishermen.

Therefore, the stochastic frontier catch function for artisanal fisherfolks in the study area is implicitly specified by:

$$Q = f\,(LNXi;\ \beta i)\ \exp(vi\text{-}ui) \quad (2)$$

The equation 2 is thus linearised as stated below:

$$LNCL = \Phi o + \Phi 1LNFSGR + \Phi 2LNVESSEL + \Phi 3LNGRTHP + \Phi 4LNCREW + \Phi 5LNFUEL + \Phi 6LNKERO + \Phi 7LNOIL + \Phi 8LNBAIT + \Phi 9LNFOOD + \Phi 10LNBATRY + \Phi 11LNMISC + vi - \mu l \quad (3)$$

Where;

CL = Catch level (or fish catch) in kg;

FSGR = Length of fishing gear in meters

VESSEL= Size of vessel/canoe in meters

GRTHP =Capacity of outboard engine (Horse power)

CREW =Number of crew/skippers per canoe per fishing trip

FUEL=Fuel (petrol) in litres

KERO= Kerosene used in litres

OIL=Amount of oil used in the fish expedition

BAIT=Number of baits used in the fish expedition

FOOD=Kilogram of food used in the fish expedition

BATRY=Number of battery used for torch-light during the fish expedition

MISC=Number of miscellaneous items which include plastic container, hand paddler etc)

Φo =Constant terms

LN=Natural logarithm;

vi and ui are as earlier defined

A priori 1: Φ1,Φ2,Φ3,Φ4,Φ5,Φ6,Φ7,Φ8,Φ9,Φ10,and Φ11 >0

c) Determination of allocative efficiency

Cobb-Douglas allocative function model: This was used to estimate the allocative efficiency of fisherfolks (objective 3). The allocative efficiency model for this study as adopted by Kareem (2009) and Ogundari and Ojo (2009) is explicitly linearized below:

$$LNTV = \Phi o + \Omega 1LNCFSGR + \Omega 2LNCVESSEL + \Omega 3LNCGRTHP + \Omega 4LNCCREW + \Omega 5LNCFUEL + \Omega 6LNCKERO + \Omega 7LNCOIL + \Omega 8LNCBAIT + \Omega 9LNCFOOD + \Omega 10LNCBATRY + \Omega 11LNCMISC + vi\ \mu l \quad (4)$$

Where,

TV=Total value of catch receipts from selling catches and the values of catches consumed (N);

CFSGR=Depreciated value of fishing gear (N)

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CVESSEL=Depreciated value of vessel/canoe (N)

CGRTHP=Depreciated value of outboard engine in Naira per horse power (N /HP)

CWAGE=Expenses on crew members (N /trip)

CFUEL =Expenses on fuel (petrol) per week (N /litre)

KERO=Expenses on litre of kerosene used (N /litre)

OIL=Expenses on oil used in the fish expedition (N /litre)

BAIT=Amount spent on bait used in the fish expedition (N /kg)

FOOD=Expenses on food used in the fish expedition (N /kg)

BATRY=Expenses on battery used for torch-light during the fish expedition (N /week)

MISC=Amount spent on miscellaneous items which include plastic container, hand paddler etc (N)

Φo represents the constant term

LN denotes natural logarithm;

vi and ui are as earlier defined

Note: N1.00=150.00USD (i.e One Naira is equivalent to $150.00)

A priori 2 : $\Omega 1, \Omega 2, \Omega 3, \Omega 4, \Omega 5, \Omega 6, \Omega 7, \Omega 8, \Omega 9, \Omega 10$, and $\Omega 11, > 0$

d) Determination of economic efficiency

The objective three was estimated through the product of the technical and allocative efficiency. The overall economic efficiency following Farell (1957) was obtained as:

$$EE = TE \times AE \qquad (5)$$

Where,

EE = Economic efficiency

TE=Technical efficiency

AE =Allocative efficiency

The **inefficiency model** can be explicitly defined as:

$$\mu i = \delta o + \sum_{n=1}^{7} \delta ni\, Z ni + \sum_{n=1}^{2} \delta n Dni \qquad (6)$$

where: Zni represents farmer's specific variables (such as education (years of schooling) age (years), sex/gender (1 for female, 2 for male), experience (years in fishing), trip (no of day in fishing expedition), Household size (number of people eating in the same pot), distance (distance from the fisihing village), credit (Dummy- dummy variables where, 1 = yes and 0 = otherwise and mode of operation (manually operated or motorized operated vessel).

e) Input elasticity

The price output elasticity for inputs included in the regression as variable inputs are of interest in the model, because elasticities are necessary for the estimation of the degree of responsiveness of change in output as a result of change in input (Abdula and Eberlin, 2001). Hence, given the specification of the derivative of the Cobb-Douglas stochastic frontier model, the output elasticities (Ep) with respect to the inputs are thus computed using the expressions in the equation below:

$$\varepsilon p = \frac{\partial \ln Yi}{\partial \ln Xi} = \beta 1 \qquad (7)$$

Where; ep = elasticity of production, and other variables are as defined earlier.

f) Hypotheses test

The test statistics is needed to test for the presence of inefficiency effects among the fisherfolks. Appropriate testing procedure is the likelihood ratio (LR) test. The statistics associated with this hypothesis is defined as:

$$LR = (-2\,ln[L(Ho) - L(Ha)]) \qquad (8)$$

Where, L(Ho) is the log-likelihood value of the restricted model while L(Ha) is the log-likelihood value of the unrestricted model. The test statistics LR has an approximately mixed Chi-Square ($\chi 2$) distribution with degree of freedom equal to number of parameters specified to be zero in the null hypothesis. When estimated LR is lower than corresponding tabulated Chi-Square (for a given significance level), the null hypothesis is accepted, vice-versa. Thus, we assume that the test of hypothesis are conducted so that the size are a=0.05. If the $\chi 2$ statistics exceeds the 95*th* percentage point for the appropriate $\chi 2$ distribution, then the null hypothesis involved is rejected.

IV. Results and Discussion

a) Gross margin analysis of an average fisher for in the study area.

The results of gross margin analysis of an artisanal fisher in the study area is presented in table 2. The table shows the total revenue accruable per year from the sales of different fish species, at the rate of N 325.00 per kilograme amounting to N11,230,375.00 (Eleven million, two hundred and thirty thousand, three hundred and seventy five naira) per annum. The table further shows the gross margin accruable to an average fisher was N7,471,857.15 (Seven million, four hundred and seventy one thousand, eight hundred and fifty seven naira and fifteen kobo) and total variable costs was N 3,758,517 (Three million, seven hundred and fifty eight thousand, five hundred and seventeen naira only) per annum. The variable costs involve the cost of wage paid to crew members, expenses on fuel (petrol), kerosene, oil, bait, food and maintenance/ services.

Table 2 also shows that total fixed costs were N24, 392.16 (Twenty four thousand, three hundred and

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ninety two naira and sixteen kobo only) per annum. The total fixed cost involves the depreciated costs of fixed assets like fishing gear, vessels, outboard engine and miscellaneous items (paddle, aluminum/plastic boxes etc) using straight line method. The cash flow however, gave a net return of N 7,447, 464.99 (Seven million, four hundred and forty seven thousand, four hundred and sixty-four naira and ninety-nine naira kobo) per annum with an average of N 620,622.08 per month (Six hundred and twenty thousand, six hundred and twenty-two naira and eight kobo. This results show that the artisanal fishery business is highly profitable (Abowei and Hart (2008) and Anene *et al.* (2010) who reported a net revenue of N161, 444.52/month in Oguta, Imo State, Nigeria.

The benefit-cost ratio as a measure of profitability was estimated at 2.97. This implies that for every N1.00 invested in artisanal fishery enterprise, N2.97 would be realized. Also, the rate of return on investment which is also known as return to capital was also estimated to be 196.9 percent. This implies that for every investment by the fisherfolks, about N196.00 is benefitted. This therefore suggests that artisanal fishery enterprise is a profitable business.

Table 2 : Gross margin analysis of the average fisher in the study area.

	Items	Output (kg)	Price (kg)	Total (N)
A.	**Revenue**			
	Sales of different fish species	51320	325.00	11,230,375.00
	Fish (plus quantity consumed, Processed and stored)			
	Variable Costs			Annual Expenditure
	Wage			5,504,070. 00
	Fuel			20,624.5
	Kerosene			8,870.0
	Cost of oil			9, 234.0
	Cost of bait			2, 389.5
	Cost of food			7, 776.0
	Cost of maintenance/servicing			1, 200.00
B.	**Total Variable Cost**			**3,758,517.85**
C.	**Gross Margin (A-B)**			**7,471,857.15**
	Fixed costs (Depreciated value)			
	Fishing gear			2456.82
	Vessel			6921.00
	Outboard engine			14890.00
	Miscellaneous (Aluminum/plastic box)			83.82
	Paddle			40.00
D.	Total fixed cost			24,392.16
E	**Total cost**			3,782,910.01
F	Net returns/NFI (C-D)			7,447,464.99
	Net return per month			**620,622.08**
	Profitability index			
	Benefit-cost ratio (A/E)			**2.97**
	Rate of returns on investment (F/E)			**196%**

Source: Data analysis, 2010.

N.B: Maintenance/Servicing includes the costs of servicing fishing gear, vessel/boat, and outboard engine etc.

b) Maximum likelihood (ML) estimation of Cobb-Douglas catch function and inefficiency function

The maximum likelihood estimates of the parameter in the Cobb-Douglas production function as defined by equations (2,3 and 4), given the speculations for the technical inefficiency effects defined by equation (6), were obtained using a one-stage estimation procedure of frontier 4.1c (Coelli, 1994).

The ML estimates of the parameters in the Cobb-Douglas production function with their corresponding standard errors are presented in table 3.The factors affecting technical efficiency can be interpreted by the magnitude, algebraic sign and significance of the estimated coefficient. The positive coefficients of the parameters estimated showed positive relationship with the output. This means that a percentage increase in the positive parameters estimated would lead to a percentage increase in the fish catch level while negative estimate coefficients showed a negative relationship with the level of output. For instance, a percentage increase in the size of vessels used would lead to percentage increase in catch efficiency. Thus, any variable that is significant is an indication of the relative importance of the variables and its policy implication in the determination of catch efficiency.

Among the eleven catch variables considered in the estimation of the technical efficiency model of the fisherfolks (Table 3), number of fishing gears, vessels, and battery used were found to be positive, while amount of fuel used, kerosene, bait and number of miscellaneous items were found to be negative. However, only gear, engine and surprisingly, number of battery were found to be significant at 5 percent probability level. This implies that the more these production variables are used in the production, it would lead to a more proportionate increase in the output of fish catch.

Table 3 also shows the estimated technical efficiency model and inefficiency function of the sample fisherfolks. The results showed education, age, number of trips, gender and mode of operations to be positive while years of experience, household size and gender were found to be negative. A negative sign means that the variable increases efficiency while positive coefficient means a decrease in efficiency level. The negative coefficient of the years of experience for instance has influence on catch efficiency. This implies that with increase in the number years in fishing, the fisherfolks tend to be more efficient. This agrees with the findings of Ajibefun and Daramola (1999). It should be noted that the signs of the coefficients in the inefficiency model are interpreted in the opposite way. However, age, household size, distance, gender, and mode of operation were found to be significant determinants of the level of efficiency of the fisherfolks.

As revealed in table 3, sigma squared (σ^2) of 0.078. This however implies a variation in the level of technical efficiency. Moreso, it shows the correctness of the specified distribution assumption of the composite error term. The gamma (γ) value of 0.011 shows the amount of variation resulting from the technical inefficiencies of the fisherfolks.

The log likelihood function is often used to determine the differences between the restricted and unrestricted models while the likelihood Ratio (LR) test is used to determine the goodness of the model using the table of Kodde and Palm (1986). However, the value shows the rejection of the null hypothesis that (Ho:$\beta1 = \beta2 \ldots \beta11 = 0$ and Ho:$= \delta1 = \delta2 \ldots \delta9 = 0$) and the acceptance of the alternative hypothesis, which specifies the significance of the variables as a determinant of the efficiency level in the study area.

The mean technical efficiency (TE) is estimated to be 0.77, indicating that the realized output could be increased by about 23 percent by adopting the practices of the best fisherfolks.

Table 3 : Estimated catch efficiency model and inefficiency function of the sampled fisherfolks.

Variable	ML Estimation
Catch function	
Intercept	7.014(7.242)*
Ln Gear	0.108(3.08)*
Ln Vessel	0.068(0.664)
ln Engine	0.187 (3.74)*
Ln Crew	0.083(0.980)
Ln Fuel	-0.002(-0.146)
Ln Kero	-0.039(-1.2)
Ln Oil	0.005(0.656)

Ln Bait	-0.074(-1.226)
Ln Food	0.072 (0.772)
Ln Battery	1.052 (3.807)*
Ln Miscellaneous	-0.046(-0.597)
Inefficiency function	
Intercept	1.202(-1.895)*
Ln Edu	0.007(0.303)
Ln Age	0.678(4.307)*
Ln Exp	-0.041(-0.622)
Ln Trip	0.037 (0.368)
Ln Hhsize	-0.434(-4.304)*
Ln Dst	-0.172(-1.498)**
Ln Gender	0.057(0.155)
Ln Credit	0.629(3.558)*
Ln Mo	0.071(-1.112)
Diagnosis statistics	
Sigma square ($\sigma 2s = \sigma 2u + \sigma 2v$)	0.078 (11.204)
Gamma $\gamma = \sigma 2u/\sigma 2s$	0.011(0.316)
Log Likelihood Function	-64.853
LR Test	89.727
Number of Observations	400
Average TE	0.77

Source: Data analysis, 2010.

*significant at 5-percent probability level

**significant at 10-percent probability level

Values in parentheses are t-statistics

N.B: ($P<0.01=2.58$; $P<0.05=1.64$; $P<0.10= 1.28$)

c) The maximum likelihood estimates of the allocative efficiency model and inefficiency function of the sampled fisherfolks

The maximum likelihood estimates of the Cobb-Douglas production function for the allocative efficiency is presented in table 4. The results of table 4 show that many of the coefficients of the allocative function were found to be positive. The positive variables are costs of gear, fuel (petrol), kerosene, oil and bait while cost of food, battery and cost of miscellaneous were negative. Though, despite the positive coefficient of the variables, none was found to be allocatively significant.

The inefficiency function shows all the estimated variables to be negative. It should also be noted that a negative sign of the parameters in the inefficiency function means that the associated variables have positive effect on allocative efficiency, while a positive significant variables indicate the reverse. For instance, the negative estimates of the level of educational attainment showed that fisherfolks with greater years of schooling were less allocatively inefficient. This is inline with the findings of Abdulai and Huffman (2000). The estimated coefficient of age variable was also negative implying that younger operators in artisanal fishery enterprises tend to have higher level of efficiency (or less inefficient). The likely reason is that the people of such age are likely to be more agile and aggressive in pursue of higher level of efficiency (Ajibefun *et al.*, 2003). The finding is also in conformity with Battle *et al.*, (1996) who found that the coefficient of years of experience in fishing was also negative showing that, with increase in number of years in fishing, fisherfolks tend to be more efficient. Moreso, the coefficient of the number of trips being negative indicates that the more the number of times fishers go for fishing expedition, the more they will more allocatively efficient. This interpretation also holds for household size, distance covered during fishing, gender and mode of operations as factors affecting farmers' efficiency level.

The results of the diagnostic statistics show sigma squared to be 0.92. This implies that there is wide variation in the level of allocative efficiencies. Thus, there are ample opportunities for these fisherfolks to raise their levels of efficiency. The results of the gamma (0.99) show the magnitude of the variance associate with the allocative frontier model. This indicates that the percentage variation in output of the fisherfolks is due to differences in allocative efficiency. The mean allocative efficiency of 0.908 suggests that about 10 percent is forgone due to inefficiency in the input-price mix of the fishfolks (table 4).

Table 4 : Estimated allocative efficiency and inefficiency function of the fisherfolks.

Variable	ML estimates
Allocative function	
Intercept	7.617 (7.623)*
Ln Gear	0.001 (0.00095)
Ln Vessel	0.001(0.0011)
Ln Engine	0.005(0.049)
Ln Crew	0.993 (1.2305)
Ln Fuel	0.003(0.025)
Ln Kero	0.001(0.0012)
Ln Oil	0.0043(0.10)
Ln Bait	0.002(0.0021)
Ln Food	-0.004(-0.0044)
Ln Battery	-0.861(-0.904)
Ln Miscellaneous	-0.003(-0.0029)
Inefficiency function	
Intercept	-0.038(-0.0379)
Ln Edu	-0.074(-0.7625)
Ln Age	-0.145(-0.1623)
Ln Exp	-0.115(-0.1242)
Ln Trip	-0.167(-0.1958)
Ln Hhsize	-0.062(-0.0630)
Ln Dst	-0.051(-0.0515)
Ln Gender	-0.026(-0.0260)
Ln Credit	-0.008(-0.0082)
Ln Mo	-0.015(-0.01523)
Diagnosis statistics	
Sigma square ($\sigma2s = \sigma2u + \sigma2v$)	0.927(1.130)
Gamma $\gamma = \sigma2u/\sigma2s$	0.999(72.553)*
Log Likelihood Function	290.108
LR Test	1303.893
Number of Observations	400
Average AE	0.908

Source: Data analysis, 2010.

Values in parentheses are t-statistics

*significant at 5-percent probability level

N.B: ($P<0.01=2.58$; $P<0.05=1.64$; $P<0.10= 1.28$)

d) MLE estimates of the firm specific variables influencing economic efficiency indices

The results of table 5 show the economic efficiency indices of the sample fisherfolks on the firm specific variables. It should be noted that the economic efficiency was derived from the product of the technical and allocative efficiencies of the production variables and then regressed against the firm specific variables. Most of the firm specific variables considered in the model have negative coefficients implying that they contributed to the explanation of economic efficiency of the fisherfolks in the study area. The positive coefficient for experience and number of trips are somewhat unexpected, though the year of experience is significant. This result is in line with the finding of Squires *et al.* (2002) who found out that fishing experience of captains often provides better knowledge about the location of fish, weather pattern, currents and tides, bottom conditions and how best to catch fish contributed to the economic efficiency. However, negative sign of other variables indicate positive impact on economic efficiency (inefficiency) of the fishefolks in the study area. Similarly, the results showing the negative coefficient of the formal education also conforms to Squires *et al.* (2002) who opined that formal education of the captains (crew member) can improve the literacy and cognitive skills which may reduce economic inefficiency by increasing the ability of captain to adopt technical innovation. The results further revealed that age of the fisherfolks, experience household size , distance from the ports to the fishing ground and method of technology adopted were significant at both 5 percent and 10 percent level.

The sigma square is -0.317 and significant at 5 percent probability level. The Average economic efficiency estimate is 0.82 showing high level of economic efficiency in the study area.

Table 5 : MLE estimates of the firm specific variables influencing economic efficiency indices.

Variable	ML estimates
Inefficiency function model	
Intercept	-0.193(12.16)*
Ln Edu	-0.193(-0.460)
Ln Age	-0.159(1.758)*
Ln Exp	0.00829(2.53)*
Ln Trip	0.048(0.907)
Ln Hhsize	-0.132(-2.12)*
Ln Dst	-0.0777(-1.43)**
Ln Gender	-0.064(-0.46)
Ln Credit	-0.020(-0.714)
Ln Mo	-0.0248(-6.15)*
Diagnosis statistics	
Sigma square ($\sigma^2 s = \sigma^2 u + \sigma^2 v$)	-0.317(8.46)*
Gamma $\gamma = \sigma^2 u/\sigma^2 s$	0.97(139.2)*
Log Likelihood Function	260.56
LR Test	120.39
Number of Observations	400
Average Economic Efficiency	0.82

Source: Data analysis, 2010.

Values in parentheses are t-statistics

*significant at 5-percent probability level

**significant at 10-percent probability level

N.B: ($P<0.01=2.58$; $P<0.05=1.64$; $P<0.10= 1.28$)

e) Frequency distribution of the efficiency indexes/estimates of the sampled fisherfolks in the study area

The frequency distribution of the estimated efficiency levels of the fisherfolks is presented in table 6. The economic efficiency was derived from the product of technical and allocative efficiencies. The economic efficiency index ranges between 0.41 (minimum efficiency) and 0.94 (maximum efficiency). About 31 percent of the respondents have economic efficiency index ranging between 0.81 – 0.90, followed by economic efficiency index of 0.51 – 0.61 with 27.8 percent. About 22.0 percent have efficiency index ranges of between 0.10 – 0.50 and the least being efficiency index range of 0.91 – 0.99 with 2.0 percent of the respondents.

However, the predicted mean economic efficiency index is 0.70 with standard deviation of 0.146. This indicates that on the average, fisherfolk produced about 70 percent of the potential frontier output level, given the present state of technology and input prices. Thus, 30 percent of the economic efficiency potentials have not been realized. Therefore, the possibility of increasing fish output by an average of 30 percent can be achieved in the short run by adopting the practices of the best fishers.

Table 6 : Frequency distribution of efficiency indexes/estimates of the sampled fisherfolks in the study area.

Efficiency levels	No. of farmers	percentage	Mean	Min.	Max.	Standard deviation
Technical Efficiency						
0.40 – 0.50	6	1.5				
0.51 – 0.60	118	29.5				
0.61- 0.70	41	10.2				
0.71 – 0.80	27	6.8	0.77	0.45	0.99	0.166
0.81 - 0.90	95	23.2				
0.91 - 0.99	113	28.2				
Allocative efficiency						
0.81 - 0.90	189	47.2	0.91	0.85	0.99	0.031
0.91 – 0.99	211	52.8				
Economic efficiency						
0.40 – 0.50	50	12.5				
0.51 – 0.60	11.1	27.8				
0.61- 0.70	19	4.8	0.70	0.41	0.94	0.146
0.71 – 0.80	88	22.0				
0.81 - 0.90	124	31.0				
0.91 - 0.99	8	2.0				

Source: Data analysis, 2010.

f) Test of hypothesis of the parameters of stochastic production frontier and technical inefficiency sources (factors).

The hypothesis which specifies that there is no inefficiency effect among the artisanal fisherfolks across the fishing technology in the study area is presented in table 7. The result shows that the LR statistics (log ratio statistics) of one sided error of both MPT and MT are greater than the critical value of the Kodde and Palm (1986). Hence, the decision was to reject the null hypothesis (Ho) and accepted the alternative hypothesis (H1) that there is observed inefficiency among the fisherfolks among the fishing technologies.

The Cobb Douglas production function estimation also showed that variables considered in MPT and MT contributed to the fish catch level. This decision was however, based on $\chi 2$-Square critical value. It should be born in mind that the test statistics (LR) has an approximately mixed Chi-Square distribution with the degree of freedom equal to the number of parameters specified to be zero in the null hypothesis. Thus, when the estimated LR is lower than the corresponding tabulated Chi-Square, the null hypothesis is accepted, vice-versa (Ogundari and Ojo, (2009). However, the acceptance of the alternative hypothesis revealed the significance of those variables as determinants of the efficiency level in artisanal fishery level of efficiency in the study area.

Table 7 : Generalized likelihood ratio test of hypotheses of parameters of the catch frontier and technical inefficiency sources.

Null hypotheses	Fishing technology			
	MPT	MF	critical value	Decision
Production function is Cobb-Douglas (i.e Ho:βo = β1…β11 and δo=δ1…=δ8=0	36.85	27.02	18.3	Reject Ho
LR statistics (test of one sided error) (i.e Ho: No inefficiency effect)	199.12	532.74	16.27*	Reject Ho

Source: Data analysis, 2010.

Note: *This value is obtained from Table 1 of Kodde and palm (1986, p.1246).

g) Summary of findings

The results of the gross margin analysis of an average fisher revealed that an average fisher accrued N7,471, 857.15 per annum. The total variable cost was N 3,758,517 while the total fixed cost was N 24, 392.16 per annum. The cash flow accrued a net returns of N7, 447,464.99 per annum with an average of N620,622.08 per month. This results is however not surprising because the coastal inhabitants are in the remote area of the state which does not allow any enforcement of government regulation with respect to fishing activies. The results of the maximum likelihood estimates of the parameters in the Cobb-Douglas production function for the catch efficiency of the sampled fisherfolks revealed that number of fishing gears, outboard engine, litres of kerosene used, quantity of bait and battery were found to be significant variables in the fish output determining technical efficiency.

The inefficiency function revealed that age of the fisherfolks, household size, gender and mode of operations were found to be significant factors determining the level of technical efficiency of fishers with the mean TE of 0.77. The results of the maximum likelihood estimates of the Cobb-Douglas production function for the allocative efficiency of an average fisher revealed that only the wage paid to crew members was found to be significant at 5 percent level. This therefore answers the questions of factors influencing allocative efficiency of the artisanal fisherfolks in the study area. The inefficiency function of the model showed that all the variables were negative. The mean allocative efficiency was found to be 0.91. The results of the factors determining economic efficiency of the artisanal fisherfolks revealed that most of the variables considered in the model have negative coefficients and significant at both 5 percent and 10 percent levels. For instance, age, experience, household size, distance to the fishing ground and the mode of technology adopted were all found to be significant.Thus, implying that they positively influence the level of economic efficiency of the fisherfolks in the study area. The results of the frequency distribution of economic efficiency estimates of the sampled fisherfolks showed the mean economic efficiency to be 0.70.

The results of the hypothesis of the parameters of the stochastic production frontier and inefficiency function showed the null hypothesis (Ho) being rejected and alternative hypothesis accepted. The implication of this is that, there was an observed inefficiency among the fishers in the study area.

h) Conclusion

The cash flow accrued a net returns of N7, 447,464.99 per annum with an average of N620, 622.08 per month. Moreso, The results of the study concluded that age, experience, household size, distance to the fishing ground and the mode of technology adopted were all found to be significant variables influencing the level of economic efficiency of the fisherfolks in the study area. Similarly, the mean economic efficiency of the fisherfolks was 0.70 which indicates that fishers could still raise the efficiency level to the peak of frontier line by about 30 percent through optimum use of inputs.

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