AN EXAMINATION OF PRODUCTIVITY POTENTIAL OF AQUACULTURE FARMS IN ALLEVIATING HOUSEHOLD POVERTY: ESTIMATION AND POLICY IMPLICATIONS FROM NIGERIA

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ABSTRACT

This study examines income generation potential and resource- use efficiency of aquaculture farms in Nigeria. A total of 120 aquaculture farms were sampled. Using gross margin (GM) analysis, the result shows that, all the sampled farms were able to cover their total operating expenses with an average GM > 200,000 naira per annum. The assessed parameters of resource use-efficiency of the farms with stochastic frontier models (SFM) revealed that, elasticities of inputs, such as: pond size, feeds, fingerlings, and other costs were significantly different from zero. While returns to scale of 1.16 obtained from the analysis suggests that, an average farm from the study, exhibits increasing returns to scale. The estimated efficiency score revealed a significant level of inefficiency with an average technical efficiency of about 81%. This suggests that about 19% potential yield are forgone due to inefficiency from the study. The result of sources of technical efficiency shows that; extension, education, stocking density, and credit significantly influenced efficiency of the farms. Similarly, the result of the simulated marginal effects of the inefficiency variables shows that, extension has the highest marginal effects on the efficiency score follows by credit, education, and stocking density. The implications of these findings, therefore, suggest that, aquaculture will provide potential channel of income generation for households in the country considering the size of the profit obtained from the analysis. However, as matter of policy concern, extension with the highest simulated marginal effects on the efficiency score is expected to generate a large increase in the overall performance of the sector if strengthen for sustainable fish production in Nigeria.

Key words: Aquaculture, income poverty, resource- use, productivity, technical efficiency.

INTRODUCTION

Fish is adjudged the cheapest and most affordable source of animal protein to the common man in Nigeria. While recent accounts show that the domestic demand (because of progressive increase in the Nigeria population with over 140 million people) for fish in Nigeria could not be met only by dependence on artisanal fisheries, which experts say is fast depleting (Ojo and Fagbenro 2004). Ironically, the report of the FAO-World Fish Center workshop on Small-Scale Aquaculture in Sub-Saharan Africa in 2004 identified Nigeria as one of the country in the region with great potential to attain sustainable fish production via aquaculture considering extensive mangrove ecosystem available in the country (FAO, 2005).

The Central Bank of Nigeria annual state of economic report by sector shows that, Nigeria import of over US$200 million worth of frozen fish per annum and therefore, accounting for over 50% of fish consumed annually to offset the gap in the domestic demand in the country (CBN, 2006).

However, with coastline of about 960 km comprising lagoons, estuaries, wetlands and series of interconnecting creeks, and coastal zone covering an estimated 1 million hectares, which offers considerable potential for commercial aquaculture in the country, aquaculture development did not receive due attention in the country until lately. Most aquaculture farms in the country in the 80s and earlier 90s are owned by the government with little participation of private individuals in aquaculture production in the country (FAO, 2005).

Therefore, with the implementation of National Economic Empowerment and Development Strategy (NEEDS) in 2001, the good news is that, there are unprecedented surge in the numbers of small scale aquaculture farms and few numbers of large farms established across the country in recent time (CBN, 2006). NEEDS is a new policy guideline currently implemented in the country. The implementation of the policy guideline most especially as related to agricultural sector of Nigerian economy, ensure that, government at both federal and states level provide needed impetus to ensure sustainable agricultural production in the country to the farmers. These include provision of needed technical knowhow through extension, improved credit delivery systems to the farmers and among others.

The challenge before us is to investigate the productivity potential of aquaculture farms in alleviating household income poverty in Nigeria. The study proposes to answer the question: Is aquaculture production capable of creating income earning opportunities through improving efficiency environment in Nigeria?

We are motivated in part because, studies have shown that, concept of sustainable income is synonymous to poverty alleviation, while other findings have shown that, the surest way through which mankind can raise itself out of poverty to a condition of relatively material affluence is through improve productivity of his/her production or services (Schubert 1994, Horrell and Krishnan, 2007). Productivity improvement creates income that can be use to meet present and future needs in terms of investment. This assertion was further stressed by Schubert (1994) who noted a relationship between poverty and productivity and concluded that a push in form of increased productivity may be needed to empower the poor over the devastating effect of poverty.

Hence, this paper intends to examine profitability, as well as, resource-use efficiency of aquaculture farms in Nigeria with a view to assess the extent to which aquaculture farms are capable of creating income earning opportunities through improve efficiency in aquaculture production in the country.

METHODOLOGY

Study area and sampling technique

Study Area: The study was carried out in 2005 in Oyo State Nigeria. Oyo State lies between latitudes 7^0N and 9.30 ^{0} N and longitudes 2^0E and 4^0E. The state is characterized by two climatic seasons; the dry season between November and March and the rainy season between April and October. A study of the State showed that, the area is well suited for the production of fishery products that is both artisanal and aquacultures considering the presence of important rivers in the state.

According to the State´s publication of Agricultural Development Program (ADP), both indigenous and introduced species are cultivated in ponds, reservoirs, and cages across the state (OYSADEP, 2005), while Tilapias (*Oreochromis, Sarotherodon, Tilapia* spp.), Clarid catfishes (*Clarias* and *Heterobranchus* spp. and their reciprocal hybrids) and the common/mirror carp (*Cyprinus carpio*) are the most widely cultured fish in the state because of their fast growth rate, efficient use of natural aquatic foods, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity and tolerance to wide ranges of environmental conditions.

Data collection and sampling technique-: A cross- sectional data from four Local Government Areas (LGAs) of the state were employed for the analysis. The LGAs include: Oluyole, Egbeda, Bodija and Ogbomosho. The LGAs were purposively selected because of prevalence of aquaculture farms in the areas. A random selection of 30 aquaculture farms with aid of a well structured questionnaire from each LGA was carried out using the list of aquaculture farms provided by the fishery unit of the state´s agricultural development program (ADP). A total of 120 aquaculture farms in all were interviewed. Information collected include: cropped fish (kg) per annum and price per kg, pond/ tank size (m^2), feeds (kg), cost of feed per annum, cost of fingerlings, cost of labour, and other costs (cost of transportation and fertilizer). Other information collected include: age of the farmers, years of schooling, years of experience, type of fish produce, number of contacts with extension agents, stocking density, and access to credit.

Method of data analysis

Gross margin and stochastic frontier production models are employed for the study. We employed, gross margin to examine profitability of the aquaculture farms, while a stochastic frontier production models is employed to estimate technical efficiencies, as well as, parameters of production technology of the aquaculture farms.

Gross margin analysis: A typical gross-margin framework for farm budget can be defined as

$$\text{Gross margin } \left(GM_{\mathbf{i}}\right) = TR_{\mathbf{i}} - TVC_{\mathbf{i}} = P_i Q_i - \sum C_{ij} X_{ij} \qquad (1)$$

Where, P_i represents price per kg of the fish cropped by the i-th aquaculture farm; Q_i represents the quantity of mature fish cropped by the i-th aquaculture farm; C_{ij} represents a unit cost of the inputs used by the i-th aquaculture farm, while X_{ij} represents the quantity of inputs used by the i-th aquaculture farm. However, a gross margin greater than zero indicates a profitable enterprise.

Stochastic frontier model: Stochastic frontier models was proposed independently by Aigner *et al.* (1977) and Meeusen and Van de Broeck (1977). The models had been widely used to study farm level efficiency and sources of inefficiency inherent in the production process (for detail see Coelli *et al.*2005)

The model can be describe implicitly as

$$\mathbf{y}_i = \mathbf{f}\left(\mathbf{x}_{ij};\ \beta_{\mathbf{j}}\right) + \varepsilon_i \qquad (2)$$

Where, y_i is the output of the i-th aquaculture farm; *f* is a suitable functional form to represent the fish production frontier (either translog or Cobb-Douglas); x_{ij} is a vector of j-th inputs used by i-th aquaculture farm; β_j is a vector of parameter of j-th input to be estimated, and ε is the error term that is composed of two elements defined as

$$\varepsilon_i = \mathbf{v}_i - \mathbf{u}_i \qquad (3)$$

Where, v_{is} are random error terms assumed to be independent and identically distributed with zero mean and constant variance, as $v_i \sim$ iid (N (0, σ^2_v), and u_{is} are non – negative random variables associated with the technical inefficiency effects of the farmers, and are assumed to be independent and identically distributed with mean μ_i but truncated as $u_i \sim$ iid N^+ (μ_i , σ^2_u) and independent of v_{is}.
Subsequently, the technical efficiency $\mathbf{TE_i}$ of the i-th aquaculture farm is define in line with the Farrell (1957) definition as the ratio of the observed output to the maximum feasible output in environment characterized by exp (v_i) as

$$\mathbf{TE_i} = \frac{\mathbf{y_i}}{f(X_i;\beta) * \exp(v_i)} = \mathbf{exp(-u_i)} \quad (4)$$

$\mathbf{TE_i}$ takes value on the interval [0, 1]. Where $\mathbf{TE_i}$ =1 indicates a fully efficient aquaculture farm and zero a fully inefficient aquaculture farm.
The focus of this study is not only to estimate the technical efficiency of the farms, but to examine the sources of differences in technical efficiencies of the farms. In light of this, the study follows Battese and Coelli (1995) model in which distribution of mean inefficiency (μ_i) is related to the farmers' socio-economic variables. The Battese and Coelli model allow heterogeneity in the mean inefficiency term to investigate sources of differences in technical efficiencies of the farmers (inefficiency effect). With this, the farm-specific mean inefficiency (μ_i) is introduced and subsequent truncated at zero, such that non –negative error terms is ensured. The model is defined as:

$$\mu_i \;=\; \delta_0 + \delta_{\mathbf{k}} Z_{ik} \quad (5)$$

Where, μ_i are as earlier defined; z_{ik} is the matrix of k-th farmer's socio-economic variables that explain sources of (determinants) technical inefficiency and $\delta_{\mathbf{k}}$ is a vector of parameters to be estimated. In this formula, a negative sign of an element of the $\delta_{\mathbf{j}}$ -vector indicates a variable with positive influence of technical efficiency vice versa.

Model specification:
Likelihood ratio test was used to confirm the appropriate functional form vis-à-vis Cobb-Douglas or trans-log functional forms for the analysis. The result (see Table 3) indicates that equation (2) is best specify by a fish production frontier in Cobb-Douglas form as described below:

$$\ell n y_i = \beta_0 + \sum_{j=1}^{5} \beta_j \ell n x_{ji} + v_i - u_i \quad (6)$$

Where the subscript i = 1, 2 …….. N denotes the observation for i-th farm and j=1, 2 … J stand for inputs used. The dependent variable y_i represents the quantity of fish cropped (kg) by the i-th aquaculture farm. The aggregate input included as variables of the production frontier are described in Table 1. β_j are parameters to be estimated, v_i and u_i as defined earlier. All the input variables were in their natural logarithmic form.
The inefficiency model earlier defined by equation 5 can be explicitly specified for this study as:

$$\mu_i = \varphi_0 + \sum_{\mathbf{k}}^{5} \delta_{\mathbf{k}} Z_{ki} + \psi D_i \quad (7)$$

Where, z_{1i} is farmer's age; z_{2i} is the years of experience; z_{3i} is years of schooling, z_{4i} is the number of contacts with extension agents, and z_{5i} is the stocking density, while D_i is dummy variable which represents credit (access =1; otherwise =0). A negative δ_k implies decrease in inefficiency while a positive implies increase in inefficiency.

Marginal effect of variables explaining technical inefficiency

The estimated parameters (z_s) in equation 7 only indicate the direction of the effects that the sources of technical inefficiency, have on the estimated technical efficiency scores. Marginal effects of (z_s) provide a better measure of long term effect of (z_s) on efficiency scores while its value is interpreted differently from outcome of (7).

By definition, marginal effects, measures the change in the individual observed technical efficiency (TE) scores to the change in the z_k variables. A positive sign indicate an increase in TE in this regard *vice versa*.

The quantification of the marginal effects as used in Wilson *et al.* (2001) is possible by partial differentiation of the technical efficiency predictor with respect to z_k in the inefficiency function as presented in equation 8:

$$\frac{\partial \mathrm{TE_i}}{\partial \mathrm{Z}_k} = \left(\frac{\exp\left[\left\{(\gamma-1)\mathrm{Z}_k\delta + \gamma \mathrm{e_i}\right\} + 0.5\,\gamma(1-\gamma)\sigma_s^2\right]\left[(1-\gamma)\left\{\gamma\,\sigma_s^2 - \mathrm{Z}_k\delta\right\} + \gamma \mathrm{e_i}\right]\left[(1-\gamma)\delta_k\right]}{\left[(1-\gamma)\,\mathrm{Z}_k\delta - \gamma \mathrm{e_i}\right]} \right) \quad (8)$$

Where, γ, σ_s^2, and δ_k represent gamma, sigma-square, coefficient of the z_k variables in equation 7. The inefficiency variables (z_k) are evaluated at their mean values, while a value of one for dummy variable and the residuals $\boldsymbol{e}_i$ are calculated at the mean value from the estimated equation (6).

The parameters of fish production frontier model (equation 6- β_j), inefficiency model (equation 7- δ), and technical efficiency scores (equation 4), as well as, variance parameters σ^2_u, σ^2_v, σ^2 and γ were estimated through the maximum likelihood in FRONTIER 4.1 (Coelli, 1996).

However, according to Coelli *et al.* (2005), γ is not equal to the ratio of the variance of inefficiency to total residual variance. The reason is that the variance of *u* equals: $[(\pi-2)]\ \sigma^2/\pi$ and not σ^2. Thus, the relative contribution of variance of *u* (γ^*) to total variance σ^2, equals: $\gamma/[\gamma + (1-\gamma)\ \pi/(\pi-2)]$. γ^* is derived by substituting everywhere $[(\pi-2)]\ \sigma^2/\pi$ and by using $\gamma = \sigma_u^2/\sigma^2$ and $\sigma^2 = (1-\gamma)\ \sigma^2$.

Hypotheses tests

Statistical tests are needed to evaluate suitability and significance of the adopted functional form and model employed in the analysis. Also the test statistic is needed to test for the presence of inefficiency effects among the farms. Appropriate testing procedure is the likelihood ratio (LR). The statistic associated with this test is defined as

$$\mathrm{LR} = \left(-2\ell n\left[\mathrm{L}(\mathrm{H_0}) - \mathrm{L}(\mathrm{H_a})\right]\right) \quad (9)$$

Where, $\mathrm{L}(\mathrm{H_0})$ is the log – likelihood value of the restricted model, while $\mathrm{L}(\mathrm{H_a})$ is the log-likelihood value of the unrestricted model. The test statistic LR has an approximately mixed- chi-square distribution with a number of degree of freedom equal to the number of parameter restrictions. When the estimated LR is lower than the corresponding tabulate chi-square (for a given significance level), the null-hypothesis is accepted, vice-versa.

RESULTS AND DISCUSSIONS

***Production performance*:** The summary statistics of variables of interest are presented in Table 1. We observed that, an average, 1,361.51kg of fish was harvested during the period under investigation. An average pond size of 249.28m^2 was also recorded from the analysis. Implication of this is that an average 5.46kg of fish was harvested per m^2 of the pond per farm from the study. Further analysis, shows that, an average aquaculture farm from the study, expended approximately ₦13, 824.93, ₦ 43,684.12, and ₦ 39,184.12 on fingerlings, labour, and other costs (this include- cost of fertilizer and transportation) respectively.
Socio-economic variables of the farmers revealed, an average age and years of schooling of 44.51yrs and 15.71 respectively. Likewise, an average stocking density and number of contacts with extension agents of about 19 and 13 was observed from the study. 73% of the respondents were found to have access to credit.
On the other hands, we observed that 83% of the farms were considered as monoculture farms while 17% were regarded as polyculture farms. Also, we observed that over 80% of the farms produce tilapias as against less than 20% for catfishes.
Most of the farms interviewed rages from homestead concrete pond (31%), earthen ponds (53%), reservoirs (9%) to cages (7%)
In addition to that, we observed the farms receive supply of fingerlings/seed from both government and private own hatcheries. However, government owned hatcheries were found to have subsidized the seed prices for the farmers. We also observed that most farms (over 90%) received feed supply from the mills in the state. But they complained of high cost of feeds because of limited number of mills in the state.

Table 1: Summary Statistics of Variables of the stochastic frontier Model

Variables	Minimum	Maximum	Mean	Std. Deviation
Output (kg)	620	2,871.66	1,361.51	1,896.29
Pond size(m^2)	100	1200	249.28	614.37
Feeds(kg)	70	1600	216.27	375.85
Cost of Fingerlings(₦)	9,000	46,800	13,824.93	56,451.24
Cost of Labour (₦)	1,600	94,000	43,684.12	48,434.29
Other costs	11500	65,700	39,184.12	31,895.59
Stocking density	8	26	18.83	12.37
Years of experience (yrs)	1	13	4.20	2.14
Age (yrs)	26	63	44.51	53.09
Years of schooling(yrs)	6	21	15.71	38.90
No of Contacts with Extension	4	19	12.53	18.67
Credit (access = 1; otherwise = 0)	0	1	0.72	0.032

1US$ = ₦ 125

Profitability analysis: The breakdown of costs and return analysis revealed a total variable costs and total revenue of ₦ 105,083.25 and ₦ 311,815.59 respectively. The total variable costs when decomposed gave; cost of fingerlings as ₦ 13,824.93, cost of feeds as ₦ 8,390.08, cost of labour as ₦ 43,684.12, and other operating expenses as ₦ 39,184.12. The operating expenses include; cost of fertilizer (₦ 5,700) and transportation (₦ 26,684.12).

Using equation 1, we computed gross margin of ₦206, 732. 34 per annum per farm. Implication of this is that, an approximately GM /kg of ₦ 151.84 /kg was obtained from the analysis. Further analysis shows, an average total revenue per kg of ₦ 229.02 was realized, while, an average total variable costs per kg of ₦ 77.18 was also obtained from the analysis.

Hence, an overview of the distribution of GM across the farms is presented in the Table 2. The distribution shows that, about 14% of the farms recorded GM less than ₦ 201,000 per annum, about 83% recorded GM between ₦ 201,000- ₦ 250,000 while about 3% recorded GM greater than ₦ 250,000.

However, the result of the GM so far shows that, aquaculture production is a profitable investment considering the size and positive GM obtained from the analysis. Therefore, investment in aquaculture farms will ensure sustainable income generation, capable of helping household to break out of vicious cycle of income poverty. This result, however, is in agreement with the findings of Kareem *et al* (2008a), which reported an average profit of ₦ 204,079 and ₦161,789 for concrete and earthen ponds respectively for a study conducted on aquaculture farms in Ogun state (Ogun state is one of the neighboring to the study area).

Table 2: Distribution of gross margin across the farms

Gross Margin	Frequency	Percentage
1000-50,000	5	4.17
51000-100,000	7	5.83
101000-150,000	3	2.50
151000-200,000	2	1.67
201000-250,000	100	83.33
>250,000	3	2.50
Total	**120**	**100**

Result of the hypotheses: The result of various proposed hypotheses for the study is presented in Table 3. The first hypothesis of restricting the cross-product of estimated coefficients in trans-log to zero resulted in LR statistic of 17.3. With the tabulated, chi-square (χ^2) of 24.38 at 5% level with 15 degrees of freedom, the restriction did not result in a significant loss of fit, so the Cobb-Douglass was accepted (first row).

The second hypothesis specifies that the inefficiency effects are absent from the model is strongly rejected. This implied technical inefficiency cannot be rule out in the production process of the aquaculture farms under study (second row).

The third hypothesis specifies that the coefficients of the inefficiency model were zero. This hypothesis is strongly rejected (third row). The implication of this is that, included variables explain technical efficiency of the farms as expected.

Result of Productivity Analysis: The estimated parameters of the variables included in the regression are presented in Table 3. The estimates, serve as direct measure of input elasticity (a measure of resources productivity of factor inputs).

All estimated coefficients were positive and significantly different from zero with exception of cost of labour, which is insignificant at 5%. Implication of this is that, the output of the farms monotonically increased in inputs level.
Also, the returns to scale (1.160) computed as the sum of the elasticities is presented in Table 5. The computed value of 1.160 implied 1% joint increased in the inputs increases the output by 1.16%. The implication of this is that, an average aquaculture farm from the study, exhibits increasing returns to scale. Hence, output of an average aquaculture farm from the study area needs to be enlarge by allocating more of the variable resources involved in the production process that is enlarging the scale of operation in order to move the aquaculture farms to economically optimum level of production. This observation is in conformity with the RTS obtained in studies related to aquaculture farms in Nigeria. This include: Fapohunda *et al* (2005) and Ojo *et al* (2006).

Table3: Results of the likelihood ratio tests of the stochastic production frontier model

Null hypotheses	$LL(H_0)$	$LL(H_a)$	LR	$\chi^2(0.95)$	Decision
Production function is Cobb-Douglas :$\beta_{jk}=0$	-32.41	-23.72	17.38	24.38	Accept
Absence of inefficiency effects: $\gamma=0$	-46.11	-32.41	27.40	14.85*	Reject
$\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6=0$	-68.15	-32.41	35.74	11.91*	Reject

*This value is obtained from Table 1 of Kodde & Palm (1986) which gives critical values for tests of null hypothesis involving values of the boundary of the parameter space.

Table 4: Estimated results of the Cobb-Douglass Stochastic Production Function Frontier

Variables	Parameters	Average OLS	Frontier ML
General Model			
Constant	β_0	2.086*(3.947)	0.194*(3.725)
Pond size(M^2)	β_1	0.126* (8.321)	0.120*(8.751)
Feeds(kg)	β_2	0.029* (2.164)	0.034*(2.943)
Cost of Fingerlings(₦)	β_3	0.289* (3.361)	0.589*(3.521)
Cost of Labour (₦)	β_4	0.039 (1.628)	0.287 (1.132)
Other costs (₦)	β_5	0.146*(2.461)	0.030*(3.987)
Inefficiency Parameters			
Constant	φ_0	0	2.841*(3.94)
Age(yrs)	δ_1	0	1.075 (1.04)
Experience(yrs)	δ_2	0	1.373 (1.25)
Educational level(yrs)	δ_3	0	-0.036*(3.03)
Extension	δ_4	0	-0.012* (6.94)
Stocking density	δ_5	0	-0.842* (2.18)
Credit	ψ	0	-0.272* (2.79)
Variance Parameters			
Sigma-Squared	σ^2	0.351	0.726*(7.617)
Gamma	γ	0	0.731*(19.246)
$\gamma/[\gamma + (1-\gamma)\pi/(\pi-2)]$	γ^*	0	0.597*(5.83)
Log likelihood	llf	-46.11	-32.41
Mean TE			**0.806**

*Figures in parentheses are t-ratio, * Estimate is significant at 5% level of significance*

Table 5: Elasticity of production and returns to scale

Variables	X_1	X_2	X_3	X_4	X_5	*RTS*
Elasticity	0.120	0.034	0.589	0.387	0.030	***1.16***

X_1= Pond size (m^2); X_2 =feed (kg); X_3=cost of fingerlings (₦); X_4 =cost of labour (₦); X_5 = other costs (₦).

Technical efficiency analysis: To investigate the presence of technical inefficiency among the aquaculture farms, here we discuss first, the estimated gamma (γ) in the lower part of Table 4.
From the analysis, we obtained 0.731 of γ, which was found to be significant at 5%. The implication of this is that, inefficiency effects are highly significant among the aquaculture farms (a confirmation of the earlier finding under the results of hypotheses).
Further analysis, revealed that about 60% (γ^* in the lower part of Table 4) of deviation of observed output from the frontier can be attributed to the inefficiency effect among the aquaculture farms.
Confirming this observation further is the result of the estimated technical efficiency scores (for brevity this is not presented in table form). The estimated technical efficiency ranged between 0.815 and 0.968 with an average of 0.806. This value, however, suggests that approximately 19% of the cropped fish for an average farm from the study were forgone due inefficiency in the production process. This finding is in conformity with the technical efficiency obtained in the following study related to aquaculture farms in Nigeria. The studies include, Ojo *et al* (2006) with an average TE of 0.83 and Kareem *et al* (2008b) with an average TE of 0.88.

Determinants of Technical efficiency: Presented in the lower part of Table 4 is the result of the determinants of the technical efficiency (TE). The result shows that; extension, years of schooling, stocking density, and credit significantly increased the TE, while age of the farmers and years of experience decreased the level of TE from the study. The result of the determinants of technical efficiency most especially the years of schooling and age from this study is in line with study of Kareem *et al* (2008b).
The implication of this finding is that policy variables such as numbers of extension contacts, years of schooling, stocking density and credit plays a significant role in explaining the differences in technical efficiency among the farmers.

Marginal effects of inefficiency variables: Presented in Table 6 is the result of the marginal effects of inefficiency variables (z_k) on the estimated technical efficiency. While the marginal effect of variables such as education, extensions, stocking density, and credit have positive marginal effects on TE, other variables such as age and years of experience have negative effects as expected. The implication of this is that education, extension, stocking density, and credit are associated with a higher technical efficiency. Extension has highest marginal effects of 8%. That is, an increase in the present numbers of extension contacts will increase technical efficiency of the farms by 8%. In similar way, a unit increase in credit, education level, and stocking density will increase the technical efficiency of the farms by 5%, 3%, and 1% respectively.

Table 6: ***Marginal effect of inefficiency variables***:

Variables (z_k)	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
Marginal effects	-0.000016	-0.043	0.030	0.082	0.010	0.051

Z_1 =age; Z_2 =experience; Z_3 = education; Z_4 = extension Z_5 = stocking density ; Z_6 = credit

CONCLUSIONS AND POLICY IMPLICATIONS

This study, empirically examined the potential inherent in aquaculture production in alleviating households' income poverty in the country, as well as, resource productivity of aquaculture farms in Nigeria. However, with an average TE > 0.80 and RTS of 1.16 coupled with GM > ₦ 200, 000, the implications is that, the significant level of profit observed among the aquaculture farms is synonymous to the improve efficiency environment highlighted from the study.

We therefore draw the following policy implications from the study: aquaculture production is a profitable investment considering the size of the estimated gross margin obtained from the study. Hence, policy variables such as extension, years of farmers education, and credit are expected to serve as needed impetus that will further improve the efficiency environment of the aquaculture farms across the study. These are expected to generate a large increase in the profit, as well as, overall performance of the sector if strengthen as variable of policy concern for sustainable fish production in the country.

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