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An Analysis of Price Efficiency of Catfish Grow-out in Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The objective of this was to estimate the price efficiency of catfish grow-out production in Nigeria using parametric stochastic frontier and cost functions. A sample of 143 fish farmers using flow through system were purposively selected from the twenty Local Government Areas in the State for the interview. Data regarding input-output relations and socio-economic properties of farms were collected for the production season of 2012-2013. Price efficiency measures were derived for this sample by employing parametric stochastic frontier analysis (SPF). Finally, socio-economic factors affecting efficiency levels are estimated with a Tobit estimation procedure. The analysis shows that the mean price efficiencies are found to be 36.0%, 70.0% and 62.08% for plastic, fibre and concrete tanks respectively. These scores indicated that the inefficiencies in fish production are not trivial for farmers using concrete and fibre but trivial for plastic indicating considerable allocative inefficiency. Analysis of the role of various socio-economic factors on productive efficiency shows that the size of the farm, age, education, experience and machinery were found to be important determinants of price efficiency. A policy implication of this study is that there are more potential for farmers to increase fish production and net profit.

Keywords: Catfish; grow-out; parametric stochastic frontier.

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1. INTRODUCTION

Aquaculture is a diverse sector traversing a range of aquatic environments spread across the world. In Nigeria, aquaculture industry has grown tremendously in the past two decades with a reported production of farmed catfish of over 200,000 metric tonnes at a growing rate of 20% per year [1]. This development was catalyzed by different arrays of production systems. Due to the rapid development of technologies and culture systems in aquaculture sub-sector, there is greater flexibility in the choice of technology and culture system among catfish growers in Nigeria. Among the production systems is Flow Through System (FTS) which is a relatively new technology for holding and growing catfish in Nigeria. This system comes in an array of models, capacities and efficiencies. Flow-Through is a culture system in which the water supplied to the pond is used once only and then discharged with or without primary treatment (depending on stocking density and waste output). This translates to an increased level of control, which can provide a basis for improved risk management. Theoretically, introducing modern technologies can increase aquaculture productivity and production. However, in areas where there is inefficiency in which the existing inputs and technologies are not efficiently utilized trying to introduce new technologies may not have the expected results. Obviously, the level of farmers' price efficiency has paramount implications for country's choice of development strategy.

Price efficiency measures firm's success in choosing optimal proportions, i.e. where the ratio of marginal products for each pair of inputs is equal to the ratio of their market prices. In Nigeria, empirical works on the farm level of price efficiency is limited and knowledge of farmers' production situations remains inadequate particularly in fish production. Hence, given the case of Nigeria that have scarce resources to undertake new investments on modern agricultural technologies, improving the price efficiency of farmers is indispensable i.e. there is a wide room for increasing fish productivity and production in these areas by improving price efficiency of farmers at the existing resources (decreasing cost of production through improvement in the management practices).

There exists very little literature dealing with price inefficiency in fish production. A large body of literature exist dealing with technical efficiency in major crops, such as cereals (rice, wheat and maize) and cash crops (cotton and sugarcane) and some extended their research to estimate price efficiency as well, there is little of such study in fish production in Nigeria. The study aims to measure the possibilities of productivity gains by enhancing the efficiency of fish farmers and providing guidance to various stakeholders on how to increase fish production by identifying the extent by which fish production efficiency could be raised with the available technology and resource base in Nigeria.

Equally important is to examine the principal factors that affect price efficiency of farmers, since these factors can be influenced by public policies. In order to provide policy implications, the efficiency measurements will be decomposed into only price efficiency using stochastic efficiency decomposition frontier analysis.

2. THEORETICAL FRAMEWORK

A large literature exists on measurement of productivity, both in the general economics and agricultural economics. The agricultural economics literature started with [2] and continued with [3-8] and most recently [9,10].

In his seminar paper [11] used the concept of efficiency postulated by [12] and the radial type of efficiency measure considered by [13] to introduce the foundation for efficiency analysis. He differentiated between technical and allocative efficiencies. A firm is technically efficient if it uses the minimal possible combination of inputs for producing a certain output (input orientation). Allocative efficiency, or price efficiency, refers to the ability of a firm to choose the optimal combination of inputs given input prices.

2.1 Parametric Approach

This section presents briefly the details of the parametric technique used in this study. It follows the [14] cost decomposition procedure to estimate technical, allocative and economic efficiencies as used in many earlier studies [15-17]. The firm's technology may be represented by a stochastic production frontier as follows:

$$Y_i = f(X_i; \beta) + \varepsilon_i \tag{2.1}$$

Here in equation (2:1), Yi denotes output of the ith producer; X_i is a vector of actual input quantities used by the ith producer; β is a vector of parameters to be estimated and ε_i is the composite error term defined as:

$$\varepsilon_i = v_i - u_i \tag{2.2}$$

by following [18, 19], it is assumed that v_is are independently and identically distributed N(0; $\sigma^2 v$) random errors, independent of the u_is and u_is are non-negative random variables, associated with technical inefficiency in production. They are assumed to be independently and identically distributed and truncations (at zero) of the normal distribution with mean μ and variance $\sigma^2 u$ ($|N(\mu, \sigma^2 u)|$). Estimators for β and variance parameters $\sigma^2 = \sigma^2 v + \sigma^2 u$ and $\gamma = \sigma^2 u / \sigma^2$ are obtained by the maximum likelihood estimation of equation (2:1). Equation (2:1) yields after subtracting v_i from both sides:

$$\hat{Y}_i = Y_i - v_i = f(X_i, \beta) - u_i \tag{2.3}$$

where $\hat{Y}_i$ is the observed output of the ith firm, which is adjusted for the stochastic noise captured by v_i. For a given level of output $\hat{Y}_i$, the technically efficient input vector for the ith firm, X_i^t, is derived by simultaneously solving equation (2:3) and the input ratios $X_1 / X_i = k_i$ ($i > 1$), where k_i is the ratio of observed inputs, X_1 and X_i. The dual cost frontier may be written in a general form as follows, by assuming that the production function in equation (1) is self-dual (e.g., Cobb-Douglas):

$$C_i = h\,(W_i, \hat{Y}_i; \alpha) \tag{2.4}$$

Here in equation (2:4), C_i is the minimum cost of the *i*th firm with the output level $\hat{Y}_i$, W_i is a vector of input prices for the *i*th firm, and α is a vector of parameters. The economically efficient input vector for the *i*th firm, X_i^e, can be derived by applying Shephard's lemma:

$$\frac{\partial Ci}{\partial WK} = X_k^e \quad (Wi, \hat{Y}i; \psi) \qquad k = 1, 2, \ldots, m \text{ inputs} \tag{2.5}$$

where ψ is a vector of parameters. Then, the observed, technically efficient and economically efficient costs of production for the *i*th firm are given as $W_i^{'}X_i$, $W_i^{'}X_i^t$ and $W_i^{'}X_i^e$, respectively.

From these cost measures, one may compute technical (TE) and economic efficiencies (EE) for the *i*th firm as follows:

$$TE_i = \frac{W_i^{'}X_i^t}{W_i^{'}X_i} \tag{2.6}$$

$$EE_i = \frac{W_i^{'}X_i^e}{W_i^{'}X_i} \tag{2.7}$$

By using equations (2:6) and (2:7), one may derive the allocative efficiency (AE) as follows (Farrell 1957):

$$AE_i = = \frac{W_i^{'}X_i^e}{W_i^{'}X_i^t} \tag{2.8}$$

2.2 (Socio-economic) Factors Affecting Efficiency

The next important step of the efficiency analysis is to determine the socio-economic factors that have effects on the estimated efficiency levels. For this purpose, one may regress the estimated efficiency scores on a set of socio-economic factors that are suspected to be important determinants of (in) efficiency. A tobit regression model is more appropriate since the values of the dependent variable (efficiency scores) should lie within a certain interval (0 - 1). This two-step procedure, which first estimates the efficiency scores and then regresses these scores on a set of independent factors, is criticized by some researchers [20,21]. They assert that the socio-economic factors should be included directly in the first step, which is the estimation of an efficient frontier. Despite these criticisms, the two-step procedure has kept its popularity.

3. DATA AND EMPIRICAL ANALYSIS

3.1 Study Area

The study focuses exclusively on fish farmers in Lagos State, Nigeria. The State is selected on the basis of its importance in aquaculture production. Lagos State is located between approximately latitude 6° 24′ and 6° 31′ North of the equator and longitude 3° 16′ and 3° 27′ East of the Greenwich Meridian. The State is bounded in the East and North by Ogun State, in the West by Republic of Benin and in the South by Atlantic Ocean. Lagos State covers an area of 3,677Km^2 with a total population of 9,013,534 million [22]. It has the highest population density in Nigeria of 2,451 persons per square kilometer. Lagos State is endowed with enormous water resources. The State has a coastline of about 180 km bordering the Atlantic Ocean which is the major water resource for the country. There is also a network of lagoon system beginning with Badagry lagoon from the western end bordering Republic of Benin through the Lagos and Epe lagoon and finally terminating at Lekki lagoon at the eastern end. Lagos state, which is also known as the state of "Aquatic splendour", has numerous rivers together with flood plains, creeks, and lagoon. The water bodies encompass an area of about 790 km^2, which is approximately 22% of the total area of Lagos State [23]. These water bodies have great potentials for fish production. In a similar vein, there is about 147,877ha of swamp, which is more suitable for aquaculture.

3.2 Data, Description of Variables and Analytical Technique

The efficiency of each fish farm was estimated using primary and secondary data. Data were collected purposively from all the fish farmers in all the twenty local Government Areas in the State. The sampling frame of all the fish farmers were generated from the census data of Lagos State Agricultural Development Authority (LSADA), Catfish Fish Farmers Association (CAFAN) of Lagos State and complemented with snowball techniques. Data regarding input-output relations and socio-economic properties of farms were collected for the production season of 2012 – 2013 from 143 pond operators. The main analytical technique used in the study was stochastic production frontier. Duncan Multiple Range Test (DMRT) was used to compare a population mean more than two population means.

3.3 Empirical Model

For the efficiency analysis, while fish yield (kg/Naira) is the output (Y - dependent) variable, X_1, unit price of fish seed (Naira), X_2, price of labour (hour/Naira), X_3, price of chemical fertilizer (kg/Naira), X_4, price of organic manure (kg/Naira), X_5, piece of feed (kg/Naira), X_6, price of land (ha/Naira), X_7, price of machinery (hour/Naira) which is calculated by dividing the total yearly machine expenses (maintenance-repair, gas-oil and rental expenses) by total machine hours, and X_8, price of other inputs (Naira). In this model, a Cobb-Douglas function is used to represent the production technology by the producers. This is because the Cobb-Douglas function has been the most commonly used function in the specification and estimation of production frontiers in empirical studies. It is attractive due to its simplicity and because of the logarithmic nature of the production function that makes econometric estimation of the parameters a very simple matter. Also, the specification allows for a non-negative random component in the error term to generate a measure of technical inefficiency, or the ratio of actual to expected maximum output, given inputs and the existing technology.

It is true, as [24] pointed out, that this function may be criticized for its restrictive assumptions such as unitary elasticity of substitution and constant return to scale and input elasticities, but alternatives such as translog production functions also have their own limitations such as being susceptible to multicollinearity and degrees of freedom problems. Kopp and Smith (1980) suggested that functional specification has only a small impact on measured efficiency. Furthermore, [26] pointed out that if an industry is not characterized by perfectly competitive producers, then the use of a Cobb-Douglas functional form is justified. Considering the Nigeria fish farm industry which is not perfectly competitive, the use of this functional form is justified. It can be argued that the fish industry in Nigeria is characterized by (a) non-homogeneous products, (b) buyers are not price takers (c) there is no perfect information on both sides of the market, that is buyers and sellers do not possess complete information with respect to the quality and nature of the product and the prevailing price. Also, since the product is not homogeneous, different prices exist in the industry. Prices are charged on arbitrary basis and (d) inefficient firm cannot be totally eliminated from the industry.

3.4 Price Efficiency of Inputs

This study follows the stochastic frontier production to examine price efficiency of inputs, using the firm specific production function. The structural equation is stated in equation below:

$$\mathrm{Ln}Y_i = \beta_o + \sum_{i=1}^{8} \beta_j\, Ln(X_{ij}) + V_i - U_i \qquad \text{(i)}$$

$$\ln Y_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + \beta_8 lnX_{8i} + (V_i + U_i) \qquad \text{(ii)}$$

The choice of the Cobb-Douglas is based on the fact that the methodology requires that the function be self –dual as in the case of cost function in which this analysis is based on the inefficiency model (U_i) is defined by: $U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i}$

Where Z_1, Z_2 and Z_3 represent age, educational level and farming experience. These socioeconomic variables are included in the model to indicate their possible influence on the cost efficiency of the farmers to be estimated.

The variance of the random error, σ^2v and that of the cost inefficiency effects σ^2u and the overall variance of the model $ó^2$ are related as follows: $\gamma = \sigma^2u/ \sigma^2v + \sigma^2u$. The gamma ($\gamma$) measures the total variation of total cost of production from the frontier cost which can be attributed to cost inefficiency [27]. The estimate for all the parameters of the stochastic frontier cost function and the inefficiency model are simultaneously obtained using the program FRONTIER version 4.1 [28]. The test for the presence of cost inefficiency using generalized likelihood-ratio statistics λ defined by: $\lambda = -2 \ln (H_0/H_a)$.

Where: H_0 is the value of the likelihood function for the frontier model in which parameters restriction specified by the null hypothesis, H_0 are imposed; and H_a is the value of the likelihood function for general frontier model. If the null hypothesis is true then ë has approximately a mixed chi-square distribution with degree of freedom equal to the number of parameters excluded in the unrestricted model. The interpretation of allocative efficiency depends on the assumptions made about a farmer's behaviour. It was assumed that cost minimization is the basis on which a farmer's allocation decision is taken to obtain a given level of output and the allocative inefficiency is a farmer's inability to equate the ratio of marginal products of inputs to the ration of their respective prices [11,29]. Where profit maximizing behaviour is assumed, allocative inefficiency can be defined as the failure to equate the marginal value product of inputs to their prices [14,30,31] have assumed profit maximizing behaviour and have defined. In the Data Envelopement Analysis model, however, the behavioural assumption is more subtle as the allocative efficiency is the proportion by which the costs of the levels of inputs on farm can be reduced without any loss in output. Thus, an efficiency score of 0.8 implies that the farm could reduce its costs by 20 % by choosing a more cost-efficient input mix.

4. RESULTS AND DISCUSSION

4.1 Farming Practices

An array of culture systems is used around the world and in Nigeria various containment or holding facilities are common to fish culture. The current FAO reporting system for aquaculture classifies production only by environment, making it difficult to obtain the relative importance of each culture system in the respective regions. There major systems were identified from the study area. The systems can be differentiated by the rearing vats (concrete, plastic and fibre tanks), the size (fingerling or juvenile) of the fish stocked, type of feed used (floating or pelleted) and harvesting strategy (partial or total). For the purpose of analysis, efficiency differential was measured based on the rearing facilities adopted by the fish farmers (Fig. 1).

Descriptive analysis shows differences in the distribution of the rearing facilities. The dominant system was concrete tank growers which accounted for 42%, plastic tank growers were 31% while the fibre tank growers were relatively small 27%. There were high variation in the output among sample farmers depending on the inputs and management practices adopted. Average outputs of fish were 16899 kg, 42171 kg and 20335 kg for fibre, plastic and concrete tanks respectively. The age, educational status and experience of the catfish growers were very close with no significant difference. Farm size was slightly different and significant. Labour utilization among the growers were similar but shows no significant difference. The output (F = 20.55) and yield (F = 5.69) per hectare differs significantly. This could be attributed to different stocking capacity.

4.2 Price Efficiency

The maximum likelihood estimation of equation (3:1), which is the stochastic production frontier, was done by using the Frontier 4.1. The results of this estimation are presented in Table 2. The signs of the estimated coefficients of input variables for all the culture systems were positive as expected. That means an increase in each input leads to an increase in output. While the coefficients of fuel and land area were found to be significant in among the farmers using concrete and fibre tanks respectively, the coefficients of seed, feed and fuel were significant in farmers using plastic tank. Moreover, the estimated variance parameter was also significantly different from zero. This implies that a big part of the variation in fish production output stems from inefficiency effects. By making use of the estimated stochastic production frontier of Table 2, it is possible to derive for the rearing facilities various dual cost frontiers, which was given as follows:

$$Ln\ Y_i = 2.898 + 0.195X_1 + 0{:}281X_2 + 0.092X_5 + 1.041X_6 + 0.101X_7 \sim \varepsilon i$$

$$Ln\ Y_i = 3.094 + 0.155X_1 + 0.054X_2 + 0.373X_5 + 0.308X_6 + 0.030X_7 \sim \varepsilon i$$

$$Ln\ Y_i = 3.820 + 0.624X_1 + 0{:}355X_2 + 0.456X_5 + 0.408X_6 + 1.284X_7 \sim \varepsilon i$$

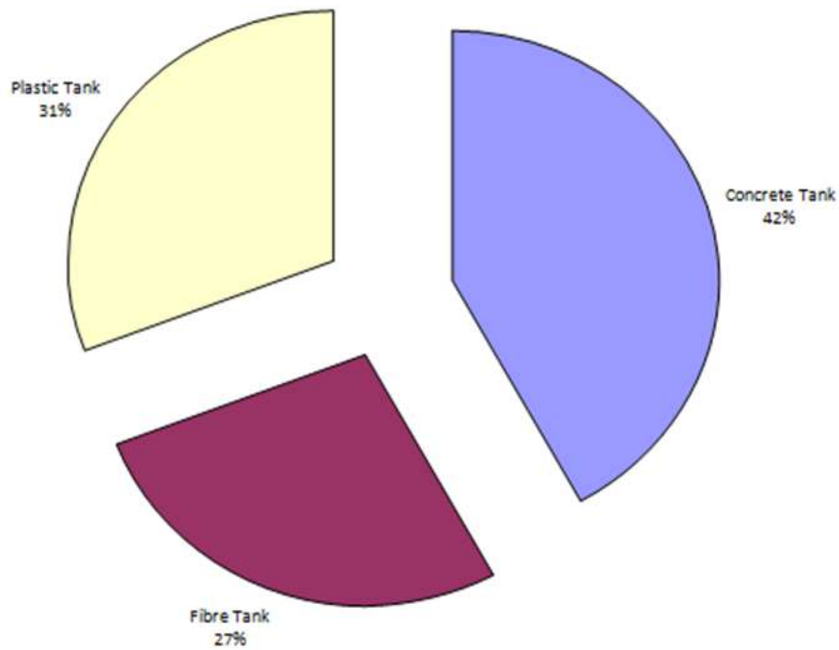

Fig. 1. Percentage distribution of fish farmers using various rearing tanks

Table 1. Summary statistics of socioeconomic and farm characteristics

Socioeconomic/farm characteristics	Fibre tank	Plastic tank	Concrete tank	F
Age (Years)	44.410[a]	45.364[a]	43.600[a]	0.44
Education (Year of schooling)	15.2308[a]	15.0455[ab]	14.2333[b]	3.10
Experience (Years)	5.1833[a]	5.5227[a]	5.0769[a]	0.20
Average farm size (ha)	0.5778[b]	0.7624[b]	1.0822[a]	6.03*
Average pond area (ha)	0.3301[a]	0.5523[a]	0.5542[a]	2.40
Number of farm labour	3.1667[a]	3.1364[a]	3.0513[a]	0.32
Output (kg)	16899[b]	42171[a]	20335[b]	20.55*
Yield (kg/ha)	132443[b]	579473[a]	101115[b]	5.69*

Author's calculation

Table 3 presents the summary statistics and the frequency distributions of the estimated price efficiency (AE) indices for the various rearing facilities using the parametric approach. The mean price efficiency indices were estimated as 36.0%, 70.0% and 62.08% for plastic, fibre and Concrete tanks respectively, under CRS. These scores indicated that the inefficiencies in fish production are not trivial for farmers using concrete and fibre but trivial for plastic indicating considerable allocative inefficiency. Another observation from Table 2 is that the majority of producers fell within the range of 0 - 20%, and 21 - 40% for plastic users and 81 - 100% for concrete and fibre price efficiency indices, respectively. In faba bean production, cost inefficiency was confirmed by the significant gammas values of 0.57 and 0.58 in Dongola and Ed-abba, respectively. This indicated that about 57% and 58% in the total faba bean production costs are caused by differences in costs efficiencies [32].

Table 2. Price efficiencies of fish farmers based on rearing facilities in the study area

	Parameter	Concrete tank	Fibre tank	Plastic tank
		Coefficient		
Constant	βo	2.898**	3.094	-3.82
Ln (*Seed*)	β_1	0.195	0.155	0.624**
Ln (*Labour*)	β_2	0.122	-0.179	0.068
Ln (*Chemical fertilizer*)	β_3	-	-	-
Ln (*Organic manure*)	β_4	-	-	-
Ln (*Feed*)	β_5	0.281	0.054	0.335**
Ln (*Land area*)	β_6	0.092	0.373**	0.452
Ln (*Other input - fuel*)	β_7	1.041**	0.308	0.408**
Ln (*Capital inputs*)	β_8	0.101	0.03	1.294
Price (Allocative) inefficiency model				
Constant	δo	12.881**	7.530**	5.672**
Educational level	$\delta 1$	-4.055	1.008**	-0.009
Pond area	$\delta 2$	0.048	0.674**	0.05
Age	$\delta 3$	-1.496	-2.172**	1.021
Machinery	$\delta 4$	0.823	-0.507	-0.882
Experience	$\delta 5$	-0.322	1.157**	-39
Fish farm management	$\delta 6$	-1.381	0.547	-0.44
Water management index	$\delta 7$	-1.653	-1	0.173
Feed management index	$\delta 8$	-0.088	-1.128	-0.354
Primary activity	$\delta 9$	0.529	-0.768	0.219
Variance parameters	σ^2	0.053	0.094	0.457
	γ	0.008	0	1
Log (likelihood)		1.676	-9.233	-13.977

Author's calculation

Table 3. Frequency distribution of price efficiency of fish farmers in Nigeria

Price efficiency	Plastic tank	Fibre tank	Concrete tank
0 – 20	17	1	2
21 – 40	10	2	8
41 – 60	9	13	5
61 – 80	4	7	5
81 – 100	4	16	10
Max	0.98	1.00	1.00
Min	0.10	0.00	0.20
Mean	0.36	0.70	0.62

Author's calculation

4.3 Socio-economic Factors Affecting Efficiency Levels

The effects of socio-economic characteristics were studied according to their coefficients signs. A negative sign reduce allocative inefficiency or increase allocative efficiency and a positive sign increase allocative inefficiency or decrease allocative efficiency. The model in equation (ii) was estimated with a Tobit estimation procedure. The result of this estimation is stated in Table 2. Education has a negative but insignificant effect on efficiency levels for farmers using concrete and plastic tanks while it was positive and significant for culture system fibre tank. The negative relationship between education and efficiency implies that farmers with high school or higher education work more inefficiently compared to farmers with lower education levels. Although this may look peculiar at first sight, an explanation for that could be as follows: producers with lower education levels concentrate more on fish production as the core business compared to producers with higher education levels, who may have additional activities. Yet this effect is not significant.

The impact of education on efficiency levels has been largely examined in previous literature. Interestingly, these studies mostly show that there does not seem to be a significant relationship between education and efficiency especially in developing countries as it has been shown in this paper. However, there are also a few studies like [33] which find, on the contrary, a positive and significant relationship between the education level of corn producers in Nepal and efficiency.

Another result from Table 2 is that farm size represented by pond area has a positive and significant effect on efficiency levels only for farmers using fibre tank, suggesting that large farms on average operate more efficiently than small farms. This result is not very surprising considering the fact that small producers have very limited marketing opportunities compared to large producers. One other advantage of large producers is usually that they have a lower labor price per unit of output. Machinery deployed for fish farming activities were found to be insignificant on efficiency level for all the culture systems considered. While the sign was negative for farmers using fibre and plastic, it was however positive for concrete tank.

The age of the producer has a positive but insignificant effect on efficiency levels for fish farmers with plastic while it was negative in concrete tank (insignificant) and fibre (significant). Variables for age are negative and significant at 5% in the two localities, suggesting that younger farmers, who are less than 50 years, are more efficient than the older ones. The reason for this is probably that the age variable picks up the effects of physical strength as well as farming experience of the household head. Although farmers become more skillful as they grow older, the learning by doing effect is attenuated as they approach middle age, when their physical strength starts to decline. Liu and Zhung, [35-37] made similar conclusions. An earlier study by [38] also finds a positive relationship between the age of corn producers in Ethiopia and efficiency but this effect is significant in their case. Experience of the producers in fish farming depicts a positive and significant effect on efficiency level in fibre tank while it was negative and insignificant for other culture systems. This implies that and experienced fish farmer can be more productive and efficient but farmers with less experience can also be more efficient if given adequate training and back up with extension support facilities.

4.4 Marginal Effect

Table 2 shows the calculations of inputs elasticities of fish producers in the State. A 1% increase in the price of fish seed will increase the fish yield by 0.2%, 0.16% and 0.62% in concrete, fibre and plastic tank respectively. Concerning the labour, a 1% increase in labour will increase fish yield by 0.12% in concrete tank and 0.07% in plastic tanks. Conversely, it will reduce fish yield by 0.18% in fibre tank users. This reveals that labour supply is inelastic. This may be probably due to shortage of labour at periods of peak demand. Presently, people preferred to use motorcycle (*Okada*) for commercial business than to go into farming in Nigeria. The use of fertilizer and organic manure were not common with flow through system. In case of fish feed, a 1% increase in fish feed will increase fish output by 0.28%, 0.05% and 0.034% in concrete, fibre and plastic tanks users. The marginal effect of land was equally positive on fish yield. A 1% increase in land will increase fish yield by 0.09%, 0.37% and 0.45% in concrete, fibre and plastic tanks users respectively. For other input such as fuel, a 1% increase in the price of fuel will increase fish yield by 1.04% in concrete tanks. This implies that fish yield is slightly elastic with respect to fuel. The same 1% increase in fuel will also increase fish yield by 0.31% and 0.41% in fibre and plastic tanks. A 1% increase in capital will increase fish yield by 0.1%, 0.03% and 1.29% in concrete, fibre and plastic tank users respectively.

5. CONCLUSIONS

This paper provides estimates on the levels and determinants of price efficiency among catfish growers using flow through system rearing of fish in Nigeria. The study was aimed at identifying potential way of increasing productivity while minimizing costs at different intensity level of fish production. On the average, mean allocative efficiency were found to be 36.0%, 62.0% and 70.0% for farmers using plastic, concrete and fibre tanks respectively. The findings demonstrated that there are considerable inefficiencies in fish production among the catfish growers in the country. In this respect, there is a lot of room for improvement to operate at fully productive efficiency levels. In order to get some idea how to improve the productive efficiency, the role of various socio-economic factors on efficiency were examined. Firstly, pond area was positive and significant effect on efficiency, implying that there is room to increase efficiency by exploiting economies of size. The attention of policy makers to mitigate the existing level of food deficiency and poverty by improving agricultural productivity should not stick only to the introduction and dissemination of modern agricultural technologies but they should also give due attention towards improving the existing level of inefficiency of fish farmers.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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