

Technical efficiency of catfish (*Clarias gariepinus*) production in Bayelsa State, Nigeria: a stochastic approach

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ABSTRACT

This study employed the Translog form of Stochastic Frontier Production Function in empirical analysis of technical efficiency of catfish production in Bayelsa State, Nigeria. A multi-stage sampling technique was used to select three (3) Local Government Areas (Yenagoa, Ogbia and Kolokuma-Opokuma) purposively based on their predominance in commercial catfish farming and randomly five (5) communities each from the 3 LGAs. Eight (8) catfish farmers in each community were randomly selected making a total number of one hundred and twenty (120) catfish farmers. The translog production function was used in analyzing the data. The findings revealed that four inputs significantly determined the production efficiencies of the farms in the area. Fish feeds had the greatest estimated coefficient of (0.98). This was followed by capital (0.66), labour (0.13) and pond size (-0.07) respectively. Significant inefficiency determinants recorded were age, farming experience, sex, pond type and number of ponds. The mean efficiency of the farms was 92%. The study concluded that efficient use of resources of the factors can be improved by training existing staff or employing more skilled labour, and also through utilization of the capital on high quality feed among other managerial improvement strategies such as capital expansion.

Keywords: Efficiency, Catfish Production, Stochastic Approach

INTRODUCTION

In Nigeria, the production of food has not increased at the rate that can meet the increasing population. While food production increases at a rate of 2.5%, food demand increases at a rate of more than 3.5% due to high rate of population growth of 2.83% (Ojo and Fagbenro, 2010). The apparent disparity between the rate of food production and demand for food in Nigeria has led to a food demand supply gap thus leading to a widening gap between domestic food production and

total requirement, an increase resort to food importation and high rates of increase in food prices and as a result, wide spread hunger and malnutrition are evident in the country (Ugwumba and Chukwuji, 2010). The growth of a country's population is usually accompanied by increase in the demand for the basic necessities of life including water, food and shelter. This is the case with the unrestricted increase in the demand for protein rich food items of animal origin especially. The Food and Agriculture

Organization (FAO, 1991), recommended that an individual takes 35 grams per caput of animal protein per day for sustainable growth and development. However, the animal protein consumption in Nigeria is less than 10 grams per person per day, which is a far cry from the FAO minimum recommendation (Onoja and Achike, 2011).

The major animal protein sources in the country include cattle, goat, sheep, poultry and fish. Out of these sources fish and fish products provide more than 60% of the total protein intakes in adults especially in the rural areas (Adekoya and Miller, 2004). Therefore, the importance of the fishing industry to the sustainability of animal protein supply in the country cannot be over-emphasized (Ugwumba and Chukwuji, 2010). Regrettably, the supply of food fish has been on the decline. This is due to consistent declines from the country's major source of food fish, the artisanal fisheries, from 90% in 1990 (Tobor, 1990) down to 40% in 2006 resulting to about 300,000 metric tonnes Global Agriculture Information Network (GAIN, 2007). The shortfall is said to be abridged by the importation of 680,000 metric tonnes annually consuming about ₦50 billion in foreign exchange (Odukwe, 2007). Therefore, increasing fish production in Nigeria requires embarking on pond fish farming. This has prompted the Federal Government of Nigeria to package the Presidential Initiative on fisheries and aquaculture development in 2003 to provide financial and technical assistance to government programmes and projects encouraging fish production (Ugwumba and Chukwuji, 2010). Similarly, the Bayelsa State government created a fisheries component in their Agricultural Development Programme with many technologies to support fish farmers in order to compliment the Federal Government effort.

Regardless these efforts of Government, fish production has remained low in Nigeria (Ozigbo *et al.*, 2014) This has been attributed to inadequate supplies from the local fish farmers due to the use of poor quality fish seeds, inadequate information, high cost of feeds, traditional techniques, small size of holdings, inefficiency in resource use, poor infrastructural facilities, lack of credit, high cost of industrial feed, lack of extension agents, lack of veterinary doctors and lack of fish production equipment and low capital investment (Adeogun *et al.*, 2007; Inoni, 2007; Ugwumba and Nnabuike, 2008; Adinya and Ikpi, 2008; Adinya, Offem, and Ikpi, 2011; Madubuike, 2012).

There are indications that the development of efficiency of fish farming in Nigeria can be a bridge towards solving this problem of nutritional imbalance and low income especially among farmers in the country (Emokaro and Ekunwe, 2009; Ojo and Fagbenro, 2010). This may not be unconnected with low efficiency of fish farms in Nigeria. An underlying premise behind most of the work of efficiency is that if farmers are not making efficient use of existing technologies, then efforts designed to improve efficiency would be more cost effective than introducing new technologies as a means of increasing agricultural output (Effiong, 2005; Ike, 2008). More recently researchers have applied the use of the translog Stochastic Frontier Production Model (SFPM) in estimating efficiency of resource-use for specific agricultural enterprises (Tijani, 2006; and Boshirabadi, Villano and Fleming, 2008).

Related studies on fish farming viability in the past such as Emokaro, Ekunwe and Achille (2010), Kassali and Mariama (2011), and Kudi, Bako and Atala (2008) conducted research works on profitability of fish farming. Nevertheless there is need for further studies

on technical efficiencies of the fish farming enterprises. Hence the need for this study is primarily designed to ascertain the technical efficiencies of catfish farmers. The broad objective of this study is to identify any gaps that may exist in the current level of technology employed by catfish farmers in Bayelsa State, Nigeria, through the use of the appropriate econometric technique in the estimation of the efficiency of resource-use among catfish farmers. This is expected to provide empirical evidence of gaps that may exist in the farmers' current level of technology. These gaps would serve as policy intervention points which would assist in enhancing the productivity and profitability of the farmers, as well as an authority to gear up their current level of output so as to bridge the current shortfalls in local supplies and manage their scarce resources efficiently.

This study therefore was designed to specifically: identify factors that influence technical efficiency of catfish farmers; determine the factors influencing farm level inefficiency among the farms surveyed; and ascertain major determinants of technical efficiency of catfish farmers in the study area.

RESEARCH METHODOLOGY

Study Area: The study area is Bayelsa State, Nigeria. Bayelsa State was created on October 1, 1996 out of Rivers State. The state is geographically located within Latitude 04° 15' North, 05° 23' South and longitude 05° 22' West and 06° 45' East (BYSG, 2008; Alagoa, 1999). It shares boundaries with Delta State on the North, Rivers State on the East and the Atlantic Ocean on the West and South, National Bureau of Statistics, NBS (2012). Its land area is about 21,110 square kilometres, with a population estimated at 1,703,358, National Population Commission (NPC, 2006). More than three quarters of this area is covered by water, with a moderately

low land stretching from Ekeremor to Nembe. The area lies almost entirely below sea level with a maze of meandering creeks and mangrove swamps (NBS, 2012). Bayelsa State is divided into three (3) Agricultural zones constituting the eight (8) Local Government Areas (LGAs). The 3 Agricultural Zones includes Brass (3 LGAs), Yenagoa (3 LGAs) and Sagbama (2 LGAs). Brass consists of Nembe, Brass and Ogbia. Yenagoa consist of Yenagoa, Kolokuma/Opokuma and Southern Ijaw. Sagbama consist of Sagbama and Ekeremor.

Sampling Method: Multi-stage sampling technique was used for this study. Firstly, three (3) Local Government Areas (Yenagoa, Ogbia and Kolokuma-Opokuma) were purposively selected due to the predominance of commercial catfish farmers in these areas. The second stage involves the random selection of five (5) communities each from the three LGAs making 15 communities. Furthermore, eight (8) catfish farmers in each community were randomly selected making a total number of one hundred and twenty (120) catfish farmers. The primary data were collected with the aid of structured sets of questionnaire, administered through personal interviews and observation.

Data Collection: Primary data for this study was obtained through a sampling frame of 1000 registered fish farmers from the Ministry of Agriculture and Natural Resources and Bayelsa State Agricultural Development Programme (BSADP).

Data Analysis : The empirical translog production function was specified following Christensen, Jorgenson and Lau (1973) and Boshwabadi, Villano and Fleming, (2008) thus:

$$\ln Y_i(k) = \beta_0(k) + \sum_{j=1}^4 \beta_j(k) \ln X_{ij}(k) + \sum_{j=1}^4 \beta_{jj}(k) \ln^2 X_{ij}(k) + \sum_{j=1}^4 \beta_{ji}(k) \ln X_{ij}(k) \ln X_{is}(k) + V_i(k) - U_i(k) \dots\dots\dots(1)$$
where j represents the j -th input ($j = 1, 2, \dots, 4$) of the i -th firm ($1, 2, \dots, N_k$) in the k -th group

($k=1, 2, \dots, 5$); $\beta_{ij}(k) = \beta_{ji}(k)$ for all j and k ; Y_i represents the number of fish output from each farm unit (count); $X_i 1$ is the value of capital employed in Naira; $X_i 2(k)$ represents the quantity of feed fed in kilogrammes/pond; $X_i 3(k)$ represents the total amount of labour in mandays; and $X_i 4(k)$ the pond size (m^2). All variables are mean-corrected to zero, which implies that the first-order estimates of the model represent the corresponding elasticities. Estimated values of β in Equation 1 above indicate the elasticities of the inputs or their relative importance in the output of fish in the farms studied. Error term (V_i) is assumed to be independently and identically distributed and captured random variations due to factors beyond the control of fish farmers in the area. The error term (U_i) captures technical inefficiency in the production systems. This term is assumed to be firm specific, nonnegative random variables assumed to be independently distributed. The technical inefficiency effects, (U_i) are assumed to be a function of some explanatory variables (Z_s) and an unknown vector of coefficients (δ). The ratio of the observed output of any farm relative to the potential output estimated by equation 1 gives the total efficiency (TE) of that farm.

If $U_i = 0$, the farm is 100% technical efficient. Maximum likelihood estimates of the parameters were estimated using Frontier 4.1c developed by Battese and Coelli (1995) and Coelli (1996). The following inefficiency variables (Z_s) were estimated: farmers age (years); educational level (years); farming experience (number of years spent in catfish farming); sex (dummy 0 = male, 1 = female); volume of credit accessed (in Naira); pond unit (dummy: 0 = concrete, 1 = earthen); pond feeding system (dummy, extensive = 0, intensive = 1); and water supply system (dummy; stream water = 0, tap water = 1).

RESULTS

Table 1 shows the results of the Maximum likelihood Estimates of stochastic frontier (translog function) analysis. The estimates of the parameters of the production function are positive decrease function to the factors except for pond size (-0.0685) which is negatively significant at 1% probability level. Similarly, all the four (4) inputs used in the model are statistically significant at varying degrees of probability. They include capital, feeds, labour and pond size.

Table 1: Maximum Likelihood Estimation (MLE) of Stochastic Frontier Production Function for Catfish Farmers in the study area.

Variable	Parameter	Coefficient	Standard error	t-ratio
Constant	β_0	-4.618	0.8010	-5.766***
Ln(Capital) X_1	β_1	0.656	0.1612	4.068***
Ln(Feeds) X_2	β_2	0.9839	0.09802	10.038***
Ln(Labour) X_3	β_3	0.1325	0.0777	1.706*
Ln(Pond size) X_4	β_4	-0.0685	-0.0265	-2.583***

Source: Data Analysis Based on Field Survey (2014) using Frontier 4.1c Programmed

*, **, *** stand for level of significance at 10%, 5%, and 1%, respectively

Table 2 shows results of the estimated coefficient of age of the farmers, which is negative and statistically significant at 10% probability level. Coefficients of other variables such as educational level and sex

were positive, while experience in fish farming, pond type and number of ponds were negative and statistically significant at 1% probability level.

Table 2: Parameter Estimates of the Inefficiency Model

Variable	Parameter	Coefficient	Standard error	t-ratio
Constant		0.511	0.107	4.764***
Age of farmer (years)	Z ₁	-0.00364	0.00211	-1.727*
Education level (years of schooling)	Z ₂	0.00548	0.00398	1.377
Experience in fish farming (years)	Z ₃	-0.0163	0.00346	-4.713***
Sex	Z ₄	0.1022	0.0236	4.320***
Pond type	Z ₅	-0.0830	0.03600	-2.306***
Number of ponds	Z ₆	-0.0204	0.00479	-4.269***
Variance parameters				
Sigma-squared	δ^2_s	0.0122	0.00240	5.087***
Gamma	Γ	0.5619	0.1206	4.659***
Log-likelihood function	Llf	123.09		

Source: Data Analysis Based on Field Survey (2014) using Frontier 4.1c Programme

*, **, *** stand for level of significance at 10%, 5%, and 1%, respectively.

Table 3 shows results of technical efficiency estimates. It reveals that, technical efficiency of sampled farmers is less than (1.00). The results further show a range of technical efficiency of the farmers, with most efficient

farmers having a technical efficiency of 0.99, (99%) while the least efficient farmers has a technical efficiency 0.68, (68%) with a mean technical efficiency of 0.92 (92%).

Table 3: Ranges of Technical Efficiency Estimates

Efficiency level	Frequency	Percentage
0.60 – 0.69	4	3.3
0.70 – 0.79	16	13.3
0.80 – 0.89	12	10.0
0.90 – 1.00	88	73.3
Total	120	100.0
Minimum	0.68	
Maximum	0.99	
Mean	0.92	

Source: Field Survey (2014) Analysis output from Frontier 4.1c.

DISCUSSION

Maximum likelihood results of stochastic frontier (translog function) analysis shows that feed is the most important factor in catfish production with an estimated coefficient of 0.98 implying that a 10% increase in the quantity of feeds would increase output of catfish by 9.8%. The result therefore agrees with the findings of Onoja and Achike (2011) which found out that feed administered had the greatest elasticity (1.59%) and is very necessary for the growth, health and output size of fish to be sold. Capital is the second most significant factor in catfish production with a positive estimated coefficient of 0.66 which is statistically significant at 1% level of probability. The implication is that, a 10% increase in capital invested would increase output of catfish by 6.6%. This is an indication that capital as a factor of production is very vital in catfish production in the study area. This result is in conformity with the findings of Issa, *et al* (2014) which found out that capital is one of the important factors in catfish production and the contribution of capital towards technical efficiency of the farms were increasing maybe through the proper use of capital resource in the business. Labour is also a significant input in catfish with an estimated coefficient of 0.13 which is statistically significant at 1% probability level. It implies that 10% increase

in the use of labour in catfish production would increase output by 1.3%. This result is in consonance with the findings of Adegeye and Dittoh (1985) which found out that labour is one of the important factor of production. The estimated coefficient for pond size (-0.07) is statistically significant at 10% probability level and negatively related to the total output. Highly significant gamma statistic indicates the presence of a high systematic inefficiency and implies that 100% of the variation in fish production could be attributed to inefficiencies.

The estimated coefficient of age of the farmers in Table 2 found to be negative and statistically significant at 10% probability level indicates that as the catfish farmers are advanced in age, they are likely to be technically efficient compared to younger farmers. The result is in contrast with the findings of Adeogun *et al* (2012) which showed that age and education had significant impact on technical inefficiency that is decrease in technical efficiency in Lagos State. Education level has a negative coefficient but not statistically significant even at 10% probability level, this implies that although farmers are literate but not technically efficient. The result is in contrast with the findings of Emokaro and Ekunwe (2009) who reported in their study of catfish efficiency in

Kaduna State of Nigeria. The coefficient of farm experience was found to be negative and statistically significant at 1% probability level. This implies that as the catfish farmers get more experienced; they are likely to be technically efficient compared to inexperienced farmers. This result agrees with the findings of Taphee, (2014), Ajibefun and Abdulkadir (2004), and Ajibefun *et al.*, (2002) that found out that efficiency level of farmers was significantly affected by farming experience. The estimated coefficient of sex was found to be positive and statistically significant at 1% probability level. This indicates that sex has a negative effect on technical efficiency but significant. Pond type has a negative coefficient and statistically significant at 1% probability level. This implies that farmers with concrete ponds have the potential to increase farm output; this could be due to easy maintenance of concrete ponds in terms of management. The estimated coefficient of number of ponds of catfish farmers was found to be negative and statistically significant at 1% probability level. This implies that farmers with relatively large number of ponds have the potential to increase farm output. Similar study on determinants of output and profitability of aquaculture fish farming in Delta State, Nigeria only showed age, educational attainment and farming experience as important variables that determine output (Ike and Chuks-Okonta, 2014). The result of log likelihood showed that capital, feeds, labour and pond size are important factors in catfish production as they were statistically significant at 1%.

Technical efficiency of less than (1.00) of sampled farmers in Table 3.0 implies that catfish farmers in the study area are producing below the maximum frontier output. The range of technical efficiency shows that the most efficient farmer has a technical

efficiency of 0.99, that is, (99%) while the least efficient farmers has a technical efficiency 0.68, that is (68%) with a mean technical efficiency of 0.92 that is, (92%). The mean technical efficiency of 92% implies that on the average, the farmers were able to achieve about 92% optimal outputs from a given set of inputs under given technology. The mean TE of 92% indicates a reasonable average level of technical efficiency on the average farm. This was higher than the results of Penda *et al.* (2013), in a study conducted in Benue State, which revealed that the mean technical efficiency was 61.9% and Oguoma *et al.* (2010) in a study carried out in Imo State with a mean technical efficiency of 75.49%.

CONCLUSION AND RECOMMENDATIONS

This study employed the Translog form of Stochastic Frontier Production Function in empirical analysis of technical efficiency of catfish production in Bayelsa State, Nigeria. Maximum likelihood of stochastic frontier (translog function) showed that fish feed is the most important factor in catfish production followed by capital, labour and pond size in that order as they significantly determine the production efficiencies of the farms in the area, while significant inefficiency determinants were age, farming experience, sex, pond type and number of ponds. The mean farm efficiency of the farms studied leaves room for farm efficiency improvement in the state in order to bring the fish farmers to the frontier of their technology. The study concluded that efficient use of resources of the factors can be improved by training existing staff or employing more skilled labour, and also through utilization of the capital on high quality feed among other managerial improvement strategies such as capital expansion.

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