APPLICATION OF THE STOCHASTIC PRODUCTION FRONTIER TO THE MEASUREMENT OF TECHNICAL EFFICIENCY OF FISH FARMING IN UMUAHIA METROPOLIS, ABIA STATE, NIGERIA

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Abstract
The study examined the factors that affect fish production among fish farmers who use pond for their fish production in Umuahia Metropolis, Abia State. Thirty six respondents were sampled from a list of fish farmers derived from Abia State Agricultural Development Programme Office. The Cob Douglas stochastic production function was used to determine factors that affect fish production as well as the factors that affect the technical efficiency of fish production. Pond size (p=0.05), capital input (p=0.01), labour input (p=0.05) and fertilizer used (p=0.05) were the major factors that determined fish production while species of fish stocked (p=0.1), number of ponds (p=0.1), distance (p=0.1) and educational status (p=0.1) determined the technical efficiency of fish production. The mean technical efficiency of fish production by use of pond in Abia State, Nigeria is 62%, implying that there are yet about 38% of chances for improvement on the technical efficiency of production. Given the existing technology of the fish producers, proper management that bears in mind the use of improved fish species, maintenance of number of ponds and increased education of the fish producers on current techniques of production are policy measures that could help improve on the technical efficiency of fish production in the study area.
Keywords*: Fish production, Frontier, Technical efficiency, Pond, Factors, Abia State*
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Introduction

Nigeria with an annual output of over 635,379 tones of fish is acclaimed as one of the largest fisheries producers in Africa (FMAWR 2008). Fish is a vital component in food and nutritional security of developing countries and with the world population growing; the need for more food including fish is expected to increase. Nigeria is still trailing behind with the current low animal protein intake per head per day of 10g compared to FAO recommended 36g (FMAWR, 2008). This scenario has not changed over time and the steady rise in population throughout the world presupposes a great need for increased protein food resources and enhancing of biological value of different products. Anene (2004) had suggested the exploration of alternative source of animal protein supply with emphasis on fish farming as a means of increasing output. Omonyinmi (1999) had earlier reported that protein sources from fish are better than most of its rivals like beef, etc because besides its relatively cheaper rate, it contains an anti-cholesterol oxidant and above all, does not compete with man for other grain and vegetables as most other livestock do and yet has more protein materials than most of its rivals.

According to Onuoha (2009), fish provide throughout the tropics a cheaper source of first class proteins for human consumption and for this reason; most countries have turned their attention to the development and exploitation of their fisheries resources as a means of providing their citizens with the much needed protein. However, the government structures seem to have fundamentally failed in integrating this in the farm economy in some ways. It has been reported that about 79.85% of the annual fish demand in Nigeria is supplied through importation of fish from outside the country (Onuoha, 2009). This reveals the need for indigenous development of fisheries to enable the resuscitation of our domestic economy. Nwanna (2002) had also observed that the low production in fish is associated with discouraging government policies towards aquaculture development, low private and organized sector participation, shortage of skilled labour, inadequate fish feed and lack of credit facilities to farmers among others. Nlewadim (2005) on another hand opined that the fisheries sub-sector in the country had never received fair share of financial efforts channelled to the Agriculture sector in previous years. Data from various banks showed that a large proportion of loans channelled into fisheries were actually to industrial fisheries which contributes less than 3% of local fish landing. Another error of the government is that many of those who headed the various ministries of agriculture were not fisheries technocrats and implementation machineries of government are in the hands of officials who are based in Lagos, Abuja or the state capitals while the rural communities where practitioners dwell are neglected. These seem to have relegated fisheries to the background (Nlewadim, 2005).

Fish has a great potential of helping the citizenry breach the protein gap and thus help Nigerians achieve food security. This is because, they exhibit enormous diversity as far as their number, morphology, habitats, biology, behaviour etc are concerned (Gupta and Gupta, 2006). This study designed to examine the technical efficiency of fish farmers among other things would help stimulate growth in this emerging enterprise in the State.

Materials and Methods

Theoretical Framework

Several techniques have been developed for the measurement of production efficiency (Farell, 1957). The two most popular approaches for efficiency measurement were the parametric stochastic frontier and non-parametric mathematical programming approach popularly referred to as the data envelopment analysis (DEA) (Aigner *et al*., 1977; Meeusen and Van den Broeck, 1977; Charnes *et al*., 1978). The stochastic frontier production frontier function was independently proposed by Aigner *et al*. (1977) and Meeusen and Van den Broeck (1977). Research has proved that estimation by the stochastic frontier production function makes it possible to find out whether the deviation in technical efficiencies from the frontier output is due to farm specific factors or due to external random factors (Igwe, 2004; Onyenweaku *et al*,. 2005; Okoye, 2006).

The stochastic frontier model according to Aigner *et al*., (1977) can be generally represented as:

$Y_i = f(X_i;B) \exp(V_i - U_i)$ where i = 1,2,...n ... (1)
Where Y = output of the ith farm
X_i = vector of functions of actual input quantities used by the ith farm
B = vector of parameters to be estimated
$V_i - U_i$ = the composite error term
Vi accounts for random error not under the control of the farmers while Ui is the non-negative random variable associated with technical inefficiency.

In the context of the stochastic frontier equation above, the technical efficiency defined as the ratio of the observed output to the corresponding frontier output conditional on the levels of inputs used by the farmer is mathematically expressed as:
$TE = Y_i/Y_i*$ ... (2)
$= f(X_i;B) \exp(V_i - U_i) / f(X_i;B) \exp(V_i)$ ... (3)
$= \exp(-U_i)$ ... (4)
Where Y_i = observed value of output and Y_i* = the frontier output

The frontier production function is estimated by the Maximum Likelihood Technique. Any farmer who is fully technically efficient will have the value of one. Thus farmers having values lying between zero and one are described as being technically inefficient.

Study Area
The study was conducted among farmers who use pond in raising their fish. List of fish farmers were derived from the Agricultural Development Programme Office. Abia State is an agrarian state. Although many are involved in semi-commercial crop farming activities particularly in their rural communities, fisheries and other livestock activities are gradually being recognized and practised by some of the inhabitants.

Abia State is one of the five South Eastern states of Nigeria created in August 1991 from the old Imo State. The state occupies a landmass of 7620 square kilometres and Umuahia is the capital. The state occupies an area of about 6420 km^2 with about 2.6 percent of the population of Nigeria; has an average population density of 364 persons per square kilometre with 63 percent (63%) involved in agricultural production and an average household of 6 persons per family (World Bank, 2000; NPC Report, 2006).

The State is situated in the south east zone of Nigeria and is bounded by six states: Rivers in the south, Cross River in the North East, Akwa Ibom in the South East, Anambra in the North West, Imo State in the West and Ebonyi in the North East. Geographically, lies within latitude $4^o 45^1$ N and $6^o 17^1$ N of the equator and longitude 7^o 00 E and 8^o 00 E of the Greenwich Meridian and has a tropical climate that is humid all year round, with the rainy season that starts from March-October and dry season that occurs from November-February (FOS, 1999). The state has a tropical climate with two seasons, the rainy season and dry season. The Rainy season lasts from April to October while the dry season is from mid November to March. Two rainfall peaks are observed, at lower peak which occurs during August – September, with the dry spell in August

(August break). The higher peak is usually followed by three to four months of dry season, which is characterized by dry harmattan winds. The people of the study area are predominantly farmers and mainly located in the rural areas.

Data Collection and Analysis

Data collection involved the use of questionnaire complimented with interview schedule. A list of fish farmers from Abia State Agricultural Development Programme constituted the sampling frame. Thirty six respondents were randomly chosen from the sampling frame containing the list of fish farmers within Umuahia Metropolis which lies within part of Umuahia North and Umuahia South Local Government Areas of Abia State. Given that the fish farmers are not uniformly spread across the Local Government Areas and not too many, thirty six respondents were randomly drawn from the list. The frontier 4.1 was used for the analysis.

The model adopted for analysis was the Cob Douglas production frontier having been proven by researchers to be the best for agricultural production studies. The implicit form of the model is specified as:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, (V_i - U_i)$ ... (5)

Where

Y = Output of fish in kilogramme

X_1 = Pond size in squared metres

X_2 = Capital input in naira

X_3 = Quantity of fingerlings in numbers

X_4 = Labour input in hours

X_5 = Feed intake in kilogrammes

X_6 = Fertilizer in naira

Vi = Symmetric error term accounting for random variations in output due to factors beyond the farmer

Ui = Non-negativity random variable representing economic inefficiency in production relative to the stochastic frontier

$Exp(-Ui) = b_0 + b_1 Z_1 + b_2Z_2 + b_3Z_3 + b_4Z_4 + b_5Z_5 + b_6Z_6 + b_7Z_7 + b_8Z_8 + e$ ... (6)

Where:

Z_1 = Species

Z_2 = Number of Ponds

Z_3 = Stocking density

Z_4 = Distance

Z_5 = Education

Z_6 = Farm experience in years

Z_7 = Extension contact in numbers

Z_8 = Membership of Cooperatives

b_0 = Constant

$b_1 – b_8$ = Parameters to be estimated

e = error term

Results and Discussion

Determinants of Fish Production using Pond

The determinants of fish production in the study area are presented under production factors in Table 1. Pond size was significant at 5% level and positive in sign as expected. This means that farmers with ponds with relatively bigger sizes were producing more fish than those with smaller pond size. As the stock size increases, the space where the fish is housed is also expected to increase.

Capital input variable was also significant and positive in sign. As more capital is invested in pond fish rearing, there is increased fish production by farmers. Capital input significantly determined fish produced in the pond at 5% level in the study area. The more infrastructural facilities available to the farmer, the higher would his fish output become. For instance, for a farmer who owns a preservation facility such as cold room, his technical efficiency of production is expected to increase. Similarly, farmers who own boreholes would be technically efficient as their water need of the farm is met with ease and so increased technical efficiency is expected.

Labour input also affected fish production. A significant level of 5% observed in the study area among fish producers indicated that labour activities necessarily determine increased fish production. Fish will not thrive well in fouled water and so ensuring that the water is not toxic or fouled for survival of the fish besides feeding and sorting activities constitute labour activities required to achieve increased fish production.

Fertilizer variable determined fish production at 5% level. The sign of the estimated variable was positive. Fertilizer is required for the growth of the phytoplanktons and other plants on which the fish also feed on.

However, feed intake was not as highly significant as was expected. It was significant at 10%. Fish production is more than giving the fish adequate food requirement. It entails ensuring that a fish friendly environment needed for their survival is also not compromised.

Factors Affecting Technical Efficiency of Fish Production

Species, number of ponds, distance and education of the farmers are among the factors that affected technical efficiency of fish in the study area as shown under the efficiency factors in Table 1. Species variable was significant at 10% level indicating that farmers with more than one variety of fish were not as technically efficient as those with one type of fish species.

Similarly, number of ponds was significant at 10% but was negative. This implies that only the fish farmers who rear different types of fish in different ponds were more technically efficient than the others. The more ponds the farmers have, the lower their technical efficiency of production. This is contrary to a priori expectation because fish farmers are expected to have more ponds to give room for sorting and other activities to go on such as breeding activities. The variation is however due to the fact that many of the fish farmers are small scale and are still struggling to understand the basic techniques needed to achieve improved technical efficiency.

Distance and education variables respectively were positive as expected but were significant at 10%. Given that many of the marketers who are the clienteles to the farmers buy their produce at the farm gate, the farmers therefore stand to increase the price they sell their produce should they travel to sell to the buyers. Thus, with increased distance the technical efficiency of fish production is expected to increase.

Education on the other hand is expected to increase efficiency. The more educated the farmer becomes the more equipped he is to make the best of the technology available to him for increased technical efficiency. The importance of education to increasing technical efficiency of production has been observed by Igwe (2004), Onyenweaku *et al.* (2005) and Effiong (2005).

A further analysis of the spread of level of technical efficiency of fish production was done. This is presented in table 2. Result show that about 33% of the farmers were producing fish under a technical efficiency level of less than or equal to 0.40. This gives indication of the level of inefficiency that exists among this group of farmers. Although that over 20% were above 90%, the presence of technical inefficiencies was observed among the fish farmers in the study area. The result of the frontier analysis indicates a mean technical efficiency of 0.62. This implies that an average farmer in the area has a chance of about 38% gap to close up in order to become technically efficient.

Table 1: Maximum Likelihood Estimate (MLE) for Fish Production Using Pond

Factors	Parameters	Coefficients
Production Factors		
Constant term	β_0	-10.9427 (6.4857***)
Pond size	β_1	0.3012 (2.8240**)
Capital input	β_2	0.5196 (5.6405***)
Quantity of Fingerlings	β_3	0.9470 (0.3334)
Labour input	β_4	1.1067 (2.7357**)
Feed intake	β_5	0.5025 (1.5835*)
Fertilizer	β_6	0.1328 (2.4666**)
Efficiency Factors		
Constant	b_0	-0.6585 (-0.6974)
Species	b_1	0.3667 (1.8029*)
Number of ponds	b_2	-0.1289 (-2.2411*)
Stocking density	b_3	0.1256 (0.1961)
Distance	b_4	-05795 (2.2921*)
Education	b_5	0.1073 (2.0562*)
Farm Experience	b_6	-0.0055 (-0.1045)
Extension contact	b_7	-0.1644 (1.3425)
Membership of Cooperative	b_8	0.6532 (0.2237)
Sigma-squared	σ^2	0.2627 (1.4353)
Gamma	γ	0.4845 (1.3033)
Log Likelihood Function		-22.1480

Source: Field Survey, 2006

N/B. ** and * means significant at 5% and 10%

Table 2: Percentage Distribution of Efficiency Levels of Pond Fish Producers

Range	Frequency	Percentage
0.21 – 0.30	3	8.34
0.31 – 0.40	9	25.02
0.41 – 0.50	2	5.56
0.51 – 0.60	2	5.56
0.61 – 0.70	6	16.68
0.71 – 0.80	3	8.34
0.81 – 0.90	3	8.34
0.91 – 1.00	8	22.24
Total	**36**	**100**

Source: Field Survey, 2006

Conclusion

Data collected from thirty six sampled pond fish producers showed that fish production in the study area is influenced by farm size, capital input, labour input and fertilizer used. Number of ponds and education level of the fish farmers are among the variables that determined technical efficiency of the farmers. Thus, fish farming as a growing industry in Abia State can be improved upon by educating the farmers through the available extension services which could help equip the farmers on the knowledge of the number of ponds that can make for efficient use of their resources given the available technology among others. In this way, technical efficiency of the farmers could be improved upon by about 38%.

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