EFFICIENCY ANALYSIS OF FISH PRODUCTION IN BENUE STATE, NIGERIA: AN APPLICATION OF STOCHASTIC FRONTIER COST FUNCTION

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ABSTRACT

The study examined efficiency analysis of fish farmers in Katsina Ala Local Governemnt Area of Benue state, Nigeria. Descriptive statistics and stochastic frontier cost function were used to realize the objectives. Primary data were collected from 80 fish farmers with the use of well structured pre-tested questionnaire for the study. Multistage random sampling procedure was employed to sample the respondents. The stochastic frontier cost function revealed that cost of feeds and cost of labour were statistically significant at 1% level of probability. The average cost efficiency estimates of fish farmers was found to be 1.83, this implies that the respondents were 83% spending above the cost minimization level. The inefficiency model reveled that training on fish farming and education level of the respondents were statistically significant and negatively related to inefficiency, which means that these variables enhances their cost efficiency. But duration of raising fish to table size increases cost inefficiency. The major constraints to fish production are; inadequate finance/funds, seasonality of fry, and shortage of fingerlings Programmes that encourage those of school-going age and training on fish farming are expected to raise productivity and efficiency in fish farming, even awareness has to be created on fish varieties with shorter duration in order to enhance cost efficiency of the farmers in the study area.

Keywords: Efficiency, Fish production, Stochastic Frontier Cost Function.

INTRODUCTION

In Nigeria, fish production is not only important as a source of fish protein, but also can be used to bring about institutional changes. These changes can offer access to production assets and resources which can help to empower the poor and directly promote their livelihoods (Obiekezie, 1999). Aquaculture increases the income of the rural populace, creates employment opportunities and reduces poverty. Small-scale farmers operate fish farms as part and parcel of the ecosystem. The ponds are either owned individually, communally or by cooperative organizations. Most farmers in this category stock their ponds with wild fish from water in their environments (Lawal, 2002). Animal protein sources such as beef, mutton and chicken presently are beyond the reach of an average income earner (Samson, 1997). Hence many people now settle for fish as a cheap source of animal protein. The demand for fish globally and particularly in Nigeria has been on the increase with supply not meeting up with the demand (Food and Agricultural Organization of the United Nations [FAO], 2004). Current projected fish demand in Nigeria is estimated to be at 2.66 million tonnes per annum. However, data on domestic fish supply in the country showed that average domestic supply of fish was 620,000 tonnes which was augmented by fish importation of about 740,000 tonnes valued at US$594.4 million hence leaving a deficit of 1.3

million tonnes (Federal Department of Fisheries [FDF], 2007). Nigerians are high fish consumers with a total current consumption of about 1.2 million tons/year, out of which about 650 000 tons is imported. This makes Nigeria the highest importer of fish and fishery products in Africa. The composition of the imports is largely mackerels, sardinella, hakes, herrings and croakers caught off the coasts of the Eastern Central Atlantic countries of Senegal and Mauritania and from the North Sea. The exporting countries are Spain, the Netherlands, Russia, Denmark, the Irish Republic and, to some extent, USA. Value of imports is over US$ 400 million. In 2005, the values of fisheries imports was $432 503 000 and the value of exports was 568 270 000 (FAO, 2007). Nigeria is a net importer of fish to bridge the wide gap between local supply and demand. In a bid to address the demand/ supply gap in fish, governments have at various times come up with policies and programmes. Among them are Nigerian Institute of Fisheries Research (NIFRI), New Bussa, Nigeria Institute for Oceanography and Marine Research (NIOMR), Victoria Island, Lagos and recently Presidential Forum on Fisheries. The Abuja declaration on sustainable fishing and aquaculture in 2005 and recent programmes aimed at improving aquaculture in Nigeria. These programmes have contributed to the way that aquaculture development is facilitated. It has been observed that these policies and programmes have not been consistent. As identified by Idachaba (2000), inconsistent policies are a major source of poor performance of Nigerian agriculture. Thus, the changes in policies and the limited capacity of the Nigerian aquaculture sector to match domestic demand raised a number of pertinent questions both in the policy circles and among researchers. For example, what are the factors explaining why domestic fish production lags behind the demand for the commodity in Nigeria?

Central to this explanation is the issue of efficiency of the fish farmers in the use of available resources or technology. Ajibefun (2006) opined that efficiency of production is central to raising production and productivity in the African agriculture. The whole issue of the appropriate balance in emphasis between efficient choice of technology and efficient use of the chosen technology has received less attention in the developing agricultural economies. The process of producing fish requires resources like feeds, fingerlings, labour, water, pond, etc. These resources are being used by the fish farmers to get table size fish. But for a fish farming to be profitable, the fish farmer or fish farm operator must be able to combine these resources optimally. Cost minimization is one of the objectives of a farm-firm or a producing unit. Other objectives are input minimization, profit and output maximization (Olayide & Heady, 1982). The cost incurred on these resources and the ways they are being utilized determine the level of profit of the fish farmer. Aquaculture research and development in Nigeria have concentrated on several tilapia species and on the African catfish. This is partly due to the ease of their culture and ability to achieve the desirable size within very short period. Clarias such as the African catfish (*C. gariepinus*) have overtaken tilapia as major culture species in Nigeria (FAO, 1999).

Other fish species identified as cultivable in Nigeria are *Heterobranchus species, Heterotis niloticus, Heteroclarias (*a hybrid of *Clarias species* and *Heterobranchus species)* and example of exotic species popularized and accepted for fish culture in Nigeria is *Cyprinus carpio* (common carp). Research is still going on the development of the culture of more fish species.

Research Questions

The following research questions guided this study:

(i) What are the socio-economic characteristics of the fish farmers?
(ii) Are the fish farmers cost efficient?
(iii) What are the factors influencing cost inefficiency of fish farmers?
(iv) What are the constraints faced by the farmers in fish production in the study area.

Objectives of the Study

This study examined cost efficiency analysis of fish production in Katsina Ala Local Government Area of Benue State, Nigeria.The specific objectives are to:

Specific Objectives:

(i) describe the socio-economic characteristics of fish farmers,
(ii) estimate the cost efficiency in fish production,
(iii) identify factors influencing cost inefficiency and
(iv) ascertain the constraints faced by the farmers in fish production in the study area.

LITERATURE REVIEW

Studies conducted either in Africa including Nigeria and other continents have identified several factors influencing the productive efficiency of either food crop farmers or livestock farmers. Some of these studies are hereby reviewed, for the purpose of this study, in this section. Obwona (2000) estimated a translog production function to determine technical efficiency differentials amongst small- and medium- scale tobacco farmers in Uganda using a stochastic frontier approach. The results showed the efficiency level of tobacco farmers ranged between 44.5% and 98.1% on a scale of 100% efficiency with mean technical efficiency of 78.4%. He further estimated the factors influencing technical efficiency differentials explained by socio economic variables and institutional factors, the results indicated that family size, education, credit accessibility and extension services contributed positively towards the improvement of efficiency.

Chaovanapoonphol *et al.* (2005) estimated Stochastic Frontier Production Function (SFPF) using the survey data collected from 656 rice farmers in the Upper North of Thailand in 2004. The results indicated average technical efficiency of rice farmers was 79 percent and also found that factors affecting the technical inefficiencies of rice farmers were land, amount of loans used for major rice production, experience, formal education and age. The estimated elasticity of mean rice output with respect to land is 0.801, estimated at mean input levels.

Ajibefun *et al.* (2002) used the translog stochastic frontier production function methodology to estimate the level of technical efficiency of smallholder food crop farmers in Oyo State of Nigeria. The results revealed that the inefficiency effects of the smallholder croppers were significant. The technical inefficiency varied widely, ranging from 19% to 95%, with a mean value of 82% indicating that the farmers are 82% efficient in the use of their production input. Age of farmers, farming experiences, level of education, size of farm holdings as well as the ratio of hired labour to total labour use, were factors that significantly influenced the level of technical efficiency. The results showed that the technical inefficiency of farmers increases with age; farm size and the ratio of hired labour to total labour, while the level of technical inefficiency tends to decline with years of experience and level of education. The results also indicated an increasing return-to-scale parameter 1.17, (i.e significantly different from

1). Ogundele and Okoruwa (2006) in their study, "technical efficiency differentials in rice production technologies in Nigeria," estimated technical efficiency following the maximum likelihood estimation using data from 302 farmers. The findings indicated that there was no absolute differential between the two groups (local and improved) of farmers. The average technical efficiency for the two groups were corresponding high (>0.90), which indicated that there is little opportunity for increased efficiency, about 10%, given the present state of technology. The variables that tend to contribute to technical efficiency are hired labour, herbicides and seeds. Ojo (2003) examined the productivity and technical efficiency of poultry egg production in Nigeria using the stochastic frontier production function analysis using data from 200 farmers. The results showed that poultry egg production was in the rational stage of production (stage II) as depicted by the returns to- scale (RTS) of 0.771. The technical efficiencies of the farmers varied widely between 0.239 and 0.933 with a mean of 0.763. He further observed that only location of farm (nearness to urban centre) positively affected technical efficiency while increase in the other socio-economic variables i.e. age, experiences and education led to decrease in technical efficiencies.

Ajibefun (2006) used the translog stochastic frontier production function to analyze and link the level of technical efficiency of Nigeria small scale farmers to specific farmer's socio- economic and policy variables. The results show that while farmers' socio – economic and policy variables significantly influenced the level of technical efficiency; education has the highest marginal effect. The highest mean technical efficiency of 0.77 occurs among group of farmers within 7-12 years of schooling (secondary school education group) while the least mean technical efficiency (0.54) occurs within the category of farmers with years of schooling within 1-6 years. It implies that technical efficiency has a direct relationship with years of schooling.

Ehirim and Onyekea (2002) in their study "a stochastic frontier approach to technical efficiency in aquacultures in Oyo State, Nigeria. The study revealed that an average relative inefficiency index of 24% was found using Cobb- Douglas functional model and a total return to scale of 1.12 was recorded, which shows an increasing return–to–scale (IRS). It implies that an additional increasing of 0.12% of output will be recorded if there is an increasing in 1% use of all these input resources like capital, labour and chemical. Ali and Flinn (1989) examined farm- specific profit efficiency for 120 rice farmers in Pakistan. A translog stochastic profit frontier was estimated by maximum likelihood. The findings showed that education had a significant role in reducing profit inefficiency. In addition, off- farm employment and difficulties in securing credit (credit inaccessibility) to purchase fertilizer increased profit inefficiency. Abdulahi and Huffman (2000) applied a stochastic translog profit frontier to examine production efficiency for 256 rice farmers in Northern Ghana in 1992-93. The results showed a negative and statistically significant relationship between access to credit and profit inefficiency. It means that farms lacking credit to purchase fertilizer tended to experience higher profit inefficiency. Ogundari (2006) applied stochastic Cobb-Douglas profit frontier model to examine the determinants of profit efficiency among the small-scale paddy rice farmers in Nigeria. The results showed that the profit efficiency of the paddy rice farmers were positively influenced by (age, educational level, farming experiences and household size) but negatively influenced by the price of fertilizer /kg. The average profit efficiency estimated was 0.60 on 1.0 scale.

CONCEPTUAL FRAMEWORK

A theoretical framework can be thought of as a map or travel plan. At the start of any research study, it is important to consider relevant theory underpinning the knowledge base of the phenomenon to be researched. Theory relevant to this study is the theory of production. Production is the process of transforming set of inputs to output (Adegeye and Dittoh, 1985). The economic theory of production provides the analytical framework for most empirical research on productivity and efficiency. Productive efficiency means the attainment of a production goal without waste. Beginning with this basic idea of "no waste", economists have built up a variety of theories of efficiency. The fundamental idea underlying all efficiency measures, however, is that of the quantity of goods and services per unit of input. Consequently, a production unit is said to be allocatively inefficient if too little output is being produced from a given bundle of inputs. There are two basic methods of measuring efficiency—the classical approach and the frontier approach. The classical approach is based on the ratio of output to a particular input, and is termed partial productivity measure. Dissatisfaction with the shortcomings of this approach led economists to develop advanced econometric and linear programming methods for analysing productivity and efficiency. The frontier measure of efficiency implies that efficient firms are those operating on the production frontier. The amount by which a firm lies above its cost minimization frontier is regarded as the measure of inefficiency. The earliest work on the frontier approach dates back to Farrell (1957).

The production function stipulates the technical relationship between inputs and output in any production schema or processes (Olayide & Heady, 1982). In their own view, Adegeye and Dittoh (1985) explained production function as the relationship between factors of production or inputs and product (or output).

METHODOLOGY

The Study Area

Katsina Ala Local Government Area (L.G.A) is one of the 23 local government areas of Benue State, Nigeria. The State is located in the middle belt of Nigeria, approximately between latitudes 6.3°N to 8.1°N and longitudes 8°E to 10°E. The state is blessed with two major rivers namely River Benue and river Katsina-Ala. She has a total land area of about 32, 866.25 square kilometers. (BNARDA, 1998; 2000). She is referred to as the "food basket of the nation" because of the abundance of agricultural resources in the state. According to the 2006 census by the National Population Commission, Katsina-Ala Local Government Area has a population of about 224,718 people (Nigerian Muse, 2007). The local government has twelve council wards.

Method of Data collection

Multistage random sampling procedure was employed to sample the respondents. Katsina-Ala Local Government Area (L.G.A.) has twelve council wards. Four council wards were randomly selected from the LGA namely, Ikurav-Tiev I, Ikurav-Tiev II, Michje and Mbacher. From each council ward, 20 fish farmers were randomly selected totaling 80 fish farmers for the study. The selection was done through the village agricultural extension agents (VAEAs). Primary data were collected through the use of structured questionnaire. Information collected include socio-economic characteristics of the respondents, the resources (labour, feed, etc.) used in fish production, and constraints faced by the fish farmers in fish production.

Method of Data Analysis

Descriptive statistics (frequency and percentage) to achieve objectives (i) and (iv) and Cobb-Douglass Stochastic Frontier Cost Function was used to achieve objective (ii), while inefficiency effects model was used to realize objective (iii).

Cobb-Douglass Stochastic Frontier Cost Function

Cobb-Douglass Stochastic frontier cost function is derived analytically and defined as follows: $Ln\,C_i = \beta_0 + LnY_i\beta + Lnx_i\beta + (V_i+U_i)$, $i=1,\ldots,N$,

Where C_i is the cost of production of the i-th fish farm; X_i and Y_i is a kx1 vector of (transformations of the) input prices and is a output of the i-th farm, respectively; Ln = natural logarithm, Y_i = the total output of fish in naira, X_1 = the price of the feed in naira, X_2= the price of fingerling in naira, X_3= the price of labour in naira, X_4= the price of transportation in naira, X_5= the price of water supply in naira, and X_6= the price of fertilizer in naira. β is an vector of unknown parameters; the V_i are random variables which are assumed to be iid $N(0, \sigma_v^2)$, and independent of the U_i which are non-negative random variables which are assumed to account for the cost of inefficiency in fish production, which are often assumed to be $|N(0, \sigma_u^2)|$.

Inefficiency Effects Model

Inefficiency effects model is defined by

$$U_i = \delta_0 + \sum \delta j Zji$$

Where:

δ = a (5x1) vectors of unknown parameters to be estimated. δ_1= Age of farmer in years δ_2 =Education level of farmer in years, δ_3= farming experience in years, δ_4 = household size in number, δ_5 = training on fish farming, and δ_6 = gestation period (number of months to harvest).

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

The result of the study in table 1 shows that persons aged 20 years and below constituted 1.2%, those aged, between 21-60 years (the economically active population), constituted 92.5%, while those aged 60 years and above constituted 6.2%. The mean age of the respondents was 44.59 years. This implies that fish farming in the area is being practiced by economic active people. Male dominated fish farming in the study area which constituted 67.5% of the respondents. The finding also shows that 68.8% of the respondents were married, 17.5% were single, 6.2% were divorced and 7.5% were widow/widower. This implies that labour was largely supplied by household members of the respondents in fish farming. Majority (30.0%) of the respondents had tertiary education, 27.5% had primary education, 22.5% had secondary education and 20.0% had no formal education. Majority (62.5%) of the respondents had 5 years and below experience in fish farming, 28.7% had between 6-10 years of fish farming experience, 5.0% had between 11-15 years of fish farming experience and 3.8% had 15 years and above in fish farming experience.

Maximum Likelihood Estimates of Stochastic Frontier Cost Function

Table 2 shows that the significance of sigma squared ($\delta^2 = 2.71$) at 1% level of probability, which indicates a good fit of the specific distributional assumption of the model. Also the estimate d gamma ($\gamma=0.37$), which is the ratio of variance of farm specific cost efficiency to the total variance of the cost and it was significant at 1% level. This implies 37% of the variance in the cost of raising fish among fish farmers was due to inefficiency. The maximum likelihood estimates (MLE) of the cost function show that price of feed and price of labour were significant at 10% level of probability as revealed by the t-ratio 1.72 and 1.83 respectively.

The inefficiency effect model shows that **education** had an inverse and statistically significant influence on cost efficiency. This implies that an increase in level of education will reduce cost inefficiency. This indicated consistent enhancement of efficiency in fish farming. Our results are consistent with those of several other researchers (Ali and Flinn, 1989; Wang *et al*., 1996; Seyoum *et al*., 1998; Abdulai and Huffman, 2000; Rahman, 2002; Obwona, 2006, Hyuha *et al.,* 2007). Thus, programmes to encourage those of school-going age are expected to raise productivity and efficiency in fish farming. **Training on Fish Farming** was inversely significant at 1% level of probability with t-ratio of -8.81. This indicates that an increase in the number of training attended by fish farmers on fish farming will enhance the cost efficiency level of the farmers. This is accordance with the *a priori* expectation. This shows that the training of farmers on techniques involved in fish farming by subject matter specialist (SMS) in fisheries and aquaculture of Benue Agricultural and Rural Development Authority(BNARDA) and the presence of the Department of Fisheries and Aquaculture in the University of agriculture might have helped in training the farmers. Enhancing these programmes will further help in reducing the cost inefficiency of the farmers. **Duration** (i.e. gestation period) was positively significant at 1% level of probability as seen in table 2. This is in line with the *a priori* expectation. The result shows that an increase in the duration of the production would make the farmers to be cost inefficient, but a reduction in the duration of raising fish to table size will enhance cost efficiency. It implies the less the duration period the more profit the farmers make.

Cost Efficiency Estimates of the Respondents

Table 3 present the cost efficiency indices of the fish farmers. The results show that majority of the respondents (37.5%) operated within the cost efficiency above 1.90. The result further revealed that 23.8% had their cost efficiency ranged between 1.31-1.60 while 20.0% had theirs ranged between 1.01- 1.30. The mean cost efficiency of fish farming was found to be 1.83. This implies that the fish farmers were spending 83% above the minimum cost.

Production Constraints faced by the Respondents

Table 4 shows that inadequate funds or finance (97.5%) was the major problems experienced in fish production. The implication of this result is that procurement of productive inputs like feeds, fingerlings, labour, and even adjustment of farm size may be hampered. This result agrees with the findings of Lawal (2002) and Otubosin (1980) that lack of funds is a major constraint to fish production. Seasonality of fry was also a major hindrance to fish farming in the study area. Shortage of fingerlings is also major challenge to fish farming as seen in table 4 and figure 1. The existence of only few hatcheries in the study area further compounded the problem. This situation often made them to turn to the wild environment and uncertified sources for fingerlings which are associated with low productivity, low performance and pathogenic infestation. It also revealed that fish farmers spent a lot of money on transportation especially transporting fingerlings from outside the study area. This will increase the production cost and consequently have effect on their profit. Other problems identified by the farmers include lack of water supply, unavailability of quality feeds, high cost of fertilizer, disease control and high mortality. All these constraints contributed to making the fish farmers to be cost inefficient.

CONCLUSION

The cost efficiency of fish farmers in the study area was 1.83, which implies that the respondents were 83% spending above the cost minimization level. The stochastic frontier cost function revealed that price of feeds and price of labour were statistically significant at 1% level of probability. The inefficiency model reveled that training on fish farming and education level of the respondents were statistically significant and negatively related to inefficiency, which means that these variables enhance their cost efficiency. But duration of raising fish to table size increases inefficiency, that is, the longer the period the more cost inefficient the fish farmers are in the study area. Many of the respondents were married which accounted for 68.8%. They were constrained by inadequate finance/funds, seasonality of fry, and shortage of fingerlings, among others in fish production.

POLICY RECOMMENDATIONS

The following recommendations:

(i) Government and non-governmental organizations (NGOs) should focus more on programmes, policies and interventions that encourage those of school-going age to develop passion for profitable fish farming in the study area.

(ii) Training on fish farming should also be aggressively pursued in the area the study area and

(iii) Proactive measures on creation of much needed awareness have to be initiated on the available fish varieties with shorter duration (i.e. maturity period) with intention to enhance cost efficiency of the farmers in the study area.

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Table 1: Frequency Distribution of Respondents by their Socio-Economic Characteristics

Characteristics	Frequency	Percentage
Age (Years) Mean = 44.59		
≤ 20	1	1.2
21 – 40	32	40.0
41 – 60	42	52.5
≥ 60	5	6.2
Sex		
Male	54	67.5
Female	26	32.5
Marital status		
Married	55	68.8
Single	14	17.5
Divorced	5	6.2
Widow/widower	6	7.5
Occupation		
Primary	9	11.2
Secondary	71	88.8
Total	80	100.0
Level of Education (Mean = 8.96 years)		
No formal education	16	20.0
Primary	22	27.5
Secondary	18	22.5
Tertiary	24	30.0
Farming experience (years)		
≤ 5	50	62.5
6 – 10	23	28.7
11 – 15	4	5.0
≥ 15	3	3.8
Household size		
≤ 5	13	16.2
6 – 10	36	45.0
11 – 15	22	27.5
≥ 15	9	11.2
Pond type		
Concrete	35	43.8
Earthen	45	56.2
Access to credit		
Yes	17	21.2
No	63	78.8
Number of ponds (Mean = 1.79)		
≤ 2	66	82.5
3 – 4	12	15.0
> 4	2	2.5

Source: Computed from Field Data, 2010

Table 2: Maximum Likelihood Estimates of the Parameters in the Cobb-Douglas Stochastic Frontier Cost Function

Variables	Coefficient	t-ratio
Cost function		
Constant	1.77	0.52
Total revenue	0.04	0.40
Price of feed	0.46	1.72*
Price of fingerling	0.43	1.60
Price of labour	0.06	1.83*
Price of transportation	-0.10	-0.40
Price of fertilizer	-0.01	-0.100
Inefficiency effect model		
Constant	-2.76	-0.90
Age	0.36	0.47
Education	-0.68	-6.81***
Experience	0.31	0.75
Household size	-0.25	-0.43

Duration (gestation period)	1.33	8.79***
Training on fish farming	-3.77	-8.81***
Access to credit	0.24	0.50
Sigma squared	2.71	6.33***
Gamma	0.37	3.15***
Log likelihood function	-153.41	

***, * means significant at 1% and 10% respectively

Source: Computed from Field Data, 2010.

Table 3: Distribution of the Respondents by Cost Efficiency Estimates

Cost efficiency index	Frequency	Percentage
- 1.30	16	20.0
1.31- 1.60	19	23.8
1.61 – 1.90	15	18.8
≥ 1.91	30	37.5
Total	**80**	**100.0**
Mean efficiency	1.84	
Minimum efficiency	1.01	
Maximum efficiency	3.53	

Source: Computed from Field Data, 2010.

Table 4: Production Constraints Faced by Fish Farmers

Constraints	Frequency	Percentage
Inadequate fund/finance	78	97.5
Unavailability of quality feed	9	11.2
High cost of fingerlings	31	38.8
High cost of fertilizer	35	43.8
Shortage of fry	42	52.5
Seasonality of fry	46	57.5
Diseases control	55	68.8
High mortality	54	67.5
Inadequate water supply	71	88.8

Source: Computed from Field Data, 2010