ECONOMETRICS OF FISH PRODUCTION IN THREE LOCAL GOVERNMENT OF ADAMAWA STATE, NIGERIA

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Abstract: The study was on econometrics of fish production in Adamawa State. The objectives of the study were to determine the influence of socio-economic characteristics of farmers on their technical efficiency, input utilization among fish-farmers and to identify problems associated with fish production in the study area. Data were collected using structured questionnaires retrieved from 70 respondents using snowball sampling technique. The data generated from the questionnaire were analyzed using descriptive statistics, and stochastic frontier production function. The results of the production analysis showed that the variance of parameter (γ) and sigma square (δ^2) of the production function were significant at 1% level. Feeds, water and fuel were significant at 1% level and labour was significant at 5% level, while pond size and number of fingerlings indicated no significant relationship at 1% level. The mean technical efficiency index was 0.83 with minimum and maximum technical efficiency of 0.73 and 0.99 respectively. The study identified feeds supply, water, market outlet, power supply, technology, capital as problems associated with fish farming. The study therefore recommends that feed prices should be subsidized, fish farmers' cooperative societies be formed and Power supply should be improved.

Keywords: Econometrics, fish, problems, production, stochastic.

Introduction

Hunger and malnutrition remain first amongst the most devastating problems facing the world's poor especially in Africa. The Food and Agricultural Organization (FAO) State of Food Insecurity Report (2000) estimated that 799 million people in 98 developing nations, Nigeria inclusive are not getting enough food to live normal, healthy and active lives. Food demand and in particular the demand for fish, has continued to rise, and it is forecasted that expanding population and changing eating habits will make a doubling of food output imperative in the near future. Fish culture contributes to poverty alleviation as it provides employment to millions of people, both in the sector itself as well as in support services. It also generates income to farmers involved and as price for most food commodities fall, fish prices are expected to rise reflecting the significant gap between its demand and supply. Fish farming becomes an attractive and important component of rural livelihoods in situations where increasing population pressures, environmental degradation or loss of access, limited catches from wild fisheries (Agriculture and Rural Development, 2005 and FAO, 2014).

Meanwhile, studies confirm the viability and profitability of aquaculture in Nigeria even in the present economic settings. However, the production of private investment in aquaculture has not been rightly demonstrated by the establishment of demonstration farms which have failed to convince the private sector that aquaculture is a profitable business. Government's investment has been inconsistent and evidence of inadequate planning and lack of adequate commitment abound in every aquaculture business embarked upon. It is now left for private sectors to determine the profitability of the business themselves (Igun, 1997). Intensive aquaculture yield more output from a given production unit, which is achieved through the use of technology and high degree management control. With the world fish coming under increasing pressure, natural aquatic resources alone are highly unlikely to be able to satisfy the growing demand for fish and fisheries products. As a result, fish farming is currently described by the FAO as the only fish unit which still offer high growth potential. Based on the technology and demand, there are today virtually no technical limitations to the global trade in fish and fisheries products (Agriculture and Rural Development, 2005).

A number of empirical studies have identified the sources of technical inefficiencies in addition to predicting technical efficiencies for the farms. One of the earliest empirical studies in stochastic frontier production function was an analysis of sources of technical inefficiency in the Indonesian weaving industries (Pitt and Lee, 1983). The study estimated a stochastic frontier production by the method of maximum likelihood and the predicted technical efficiencies were then regressed upon some variables including size, age and ownership structure of each firm and they were shown to have some significant effect on the degree of technical inefficiencies in the firms. Subsequent empirical studies have investigated the sources of technical inefficiencies in different industries using two stages analytical method. However, recent studies have questioned the theoretical consistency of this two stage analytical techniques and proposed the use of stochastic frontier specifications which incorporate models for the technical inefficiency effects and simultaneously investigate all the parameters involved (Ajibefun and Daramola, 1999). Considering a farm using N inputs (X_1, X_2, ---, X_n) to produce a single out-put Y. Efficient transformation of input is characterized by the production of F(x) which shows the maximum output obtainable from various input vectors. The stochastic frontier production function assumes the presence of technical inefficiency of production and may be expressed as:

$$Y_i = \exp (X_i\beta = V_i - U_i) \text{ ……..} (1)$$

Where: Y_i = Out-put of the i^{th} farm; X_i = Vector of inputs; β = Vector of parameter to be estimated; V_i = symmetric random error that is assumed to account for measurement error and other factors not under the control of the farmers; U_i = account for technical inefficiency in production; exp = exponential function

This method looks at the error term of the regression model as composed of two parts V_i and U_i. The V_i is the "*white nose*'' and covers random effect on production outside the control of the decision unit. It is symmetrically independently and normally distributed with zero mean and constant variance ($\delta^2 v$). The U_i is an asymmetrical

component which measures technical inefficiency and is assumed to be the result of behavioural factors which come under the control of the decision unit (Apezteguia and Garate, 1997). It is non-negative, half normal and is independently distributed with zero mean and constant variance (δ^2u) (Tadesse and Krishnamoorthy, 1997).
The (δ^2v) and (δ^2u) are the variance of the parameters V and U, respectively.
Therefore the overall variance for models (δ^2) is given as;

$$\delta^2 = \delta^2v + \delta^2u \text{ ……. (2)}$$

Then $\lambda = \delta u/\delta v$ …… (3)

Or;

$\gamma = \delta^2u/\ \delta^2$(Jondrow *et al.*, 1982) ……. (4)

Where: λ or γ total variation of output from the frontier which can be attributed to technical efficiency (Battese and Corra, 1977). The technical efficiency of an individual firm is defined in terms of the ratio of the observed output (Y_i) to the corresponding frontier (Y_i*) given the technology that is;

$$T E = Y_i/Y_i^* \text{ ……. (5)}$$

So that,

$$0 \leq Y_i / Y_i^* \geq 1$$

That is;

$$0 \leq TE \geq 1$$

This model is such that the possible production Y_i is bounded above by the stochastic quantity, $f_i(X_i,b) \exp(V_i)$, hence the term stochastic frontier the modeling and estimation of stochastic frontier production function in agricultural economics studies have generated much interest over the years and there have been considerable research effort to extend and apply the use of this method in analyzing agricultural data (Ojo and Imoudu, 2000). The objectives of the study were to determine the influence of socio-economic characteristics of fish farmers, input utilization among fish-farmers and to identify problems associated with fish production in the study area.

Materials and Methods

The study was conducted in three Local Government Areas of Adamawa State, Nigeria, namely: Yola South, Yola North and Girei. The study area lies between Latitude 7^0 and 11^0 North of the Equator and between Longitude 11^0 and 14^0 E of the GMT (Adebayo, 1999). The wet season commences in April and ends in late October, while the dry season starts in November and ends in April. The mean annual rainfall of the area is about 1000mm (Adebayo, 1999).
The study area falls within the Northern Guinea Savannah Zone with land mass of 2,310.05 km^2 and a population of 522,849 (NPC, 2006). The area is bounded by Fufore, Song and Demsa Local Government areas to the south and east, to the north and to the west, respectively. The major occupation of the people is crop farming, animal rearing and fishing. There are a lot of fishing activities in the study area as one of the major rivers in Nigeria (Benue). Two major dams (Njuwa and Gerio) attached to the rivers are located within the study area. One commercial farm (Gessedaddo) is also located within the area, where fish is produced in large scale. The peak period of fish harvest from natural water bodies is in August-October while in April-May it drops to its lowest in which the dams occasionally open at this time. Major species of fish around are Cat fish and Tilapia. They are mostly harvested using common fishing gears (nets and hooks). Most fish-farmer harness period of low fish output from natural source for their harvest.
Data for this study were derived from primary source which were collected with the use of structured questionnaires administered on 70 fish farmers in the study area using snowball technique; this is where the respondents are used to identify other respondents because of the difficulty in identifying fish farms and fish farmers in the study area. Descriptive statistics (ranking) and stochastic frontier production function model were used to analyse the data.

Stochastic frontier production function model

The Stochastic Frontier Production Function Model comprises a production function of the usual regression type with a composite disturbance term equal to the sum of two error components (Aigner *et al.*, 1977; Meeusen and Van den Broeck, 1977). One error component represents the effect of statistical noise (e.g. Weather, topography, disruption of supply, measurement error, etc.), while the other error component captures the systematic influence that are unexplained by the production and are attributed to technical inefficiency. The Stochastic Frontier Production Function Model specified by the Cobb-Douglas functional form is defined as:

$$LnY_i = f(X_i) + V_i - U_i \text{ ……. (6)}$$

i=1, 2, ----------, N

Where: Y_i = the output of the i^{th} firm, X_i = the vector of input quantities of the i^{th} firm and is the vector of unknown parameters.
The V_i account for random factors such as risk, weather and measurement error, while the U_i is due to technical inefficiency (Son *et al.*, 1993)

The empirical model that was used in this study is specified as:

$$LnY_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \text{---} + \beta_6 LnX_6 + V_i - U_i \text{ ……. (7)}$$

Where: Y_i = Total output of i^{th} farmer in kg; X_1 = Size of the Pond in meter cube (m^3); X_2 = Amount of feed in Kg/production cycle; X_3 = water supplied in litres/production cycle; X_4 = Number of fingerlings/production cycle; X_5 = Labour inputs in mandays/production cycle; X_6 = Fuel used in litres/production cycle; V_i = Random error (white noise) which is assumed to be independently and normally distributed as N~(O, δ^2v) independently of U_i; U_i = inefficiency effects which is assumed to be non-negative half normal distribution N (O, δ^2u)

The inefficiency model was given as:

$$U_i = \delta_0 + \delta_1 + LnZ_1 + \delta_2 LnZ_2 + \delta_2 LnZ_2 + \text{----------} + \delta_5 LnZ_5 \text{ …….. (8)}$$

Where: U_i = Technical inefficiency of the i^{th} farmer; Z_1= Years of experience of the i^{th} farmer; Z_2= Years of formal education; Z_3= House hold size; Z_4= Age of farmers; Z_5= Number of contact of the farmer with extension workers

The parameters of the stochastic frontier production function effect and the inefficiency were simultaneously estimated using the Maximum Likelihood Technique (MLE) from a computer programme FRONTIER 4.1 developed by Coelli (1994). This was used to determine

the input utilization among fish farmers and also to determine the influence of some socio-economic characteristics of fish farmers on their technical efficiency.

Result and Discussion

The Maximum Likelihood Estimate (MLE) of the parameters of the stochastic frontier model of fish farmers as presented in Table1 contained the estimates of the parameters for the production function, the inefficiency model and the variance parameters of the model. The variance parameters of the stochastic frontier production function are represented by sigma squared (δ^2) and gamma (γ). The sigma squared in Table1 is 0.037 and significantly different from zero at one percent level. This indicated a good fit and correctness of the distribution form assumed for the composite error term. Gamma indicates that the systematic influence of the explained variables by the production function is the dominant sources of random error. The gamma estimate of 0.81 showed the amounts of the variation resulting from technical inefficiencies of the farmer. This means that about 81 percent of the variation in farmers output was due to technical efficiency. This implied that the ordinary least square estimate (OLS) will not be adequate in explaining the inefficiencies on aquaculture; hence the specification of a stochastic frontier production function was justified. Typical of the Cobb-Douglas production function, the estimated coefficient for the specified function can be explained as the elasticities of the explanatory variables.

The production elasticity of pond size was positive and statistically significant at 5%. This implied that pond size positively influences the output of fish farmers in the study area. An increase of one percent in pond size will result to an increase in output of fish by 0.30%. This is because the larger the size of pond, the more fingerlings it will contain.

The production elasticity of feeds supply was positive and statistically significant at 1%. This depicts that feeds supply positively influence the output of fish farmers. A 1% increase in feeds will result to an increase in output by 7.10% depending on the quality of feeds used. This implies that the feed conversion ratio is high.

The production elasticity of water was positive and statistically significant at 1%. This shows that water can positively influences the output of fish farmers in the study area. An increase of 1% in water will result to an increase in output by 0.43%. Water is very important in fish production as it supplied them with oxygen for breathing and also, they live in an aquatic habitat. The production elasticity of number of fingerlings was negative but statistically significant at 10%. The implication is that, the number of fingerlings will negatively affects the output of fish farmers in the study area. A 1% increase in the number of fingerlings will lead to decrease of output by 0.41%. Increase in fingerlings in a pond will exceed the carrying capacity of the pond, competition for feeds and space, and cannibalism will inhibit their growth.

The production elasticity of fuel was positive and statistically significant at 1%. The assertion is that fuel has a positive and significant influence on the output of fish in the study area. 1% of fuel use will result to an increase 0.44% output. Fuel ensures the availability of fresh water in the pond thereby replacing contaminated with fresh water and/or pumping oxygen into the water. However, labour input was found to be statistically insignificant at the conventional level.

Table 1: Maximum likelihood estimate of parameters of stochastic frontier production function for fish farmers

Variables	Parameters	Coefficients	T Values
Constant	β_o	0.71***	5.1348
Pond size	β_1	0.30**	2.0314
Feeds supply	β_2	7.10***	4.2861
Water	β_3	0.43***	3.5465
Number of Fingerlings	β_4	-0.41*	-1.7257
Labour	β_5	0.10	0.5107
Fuel	β_6	0.44***	3.4611
Inefficiency model			
Constant	δ_0	0.57**	2.0315
Experience	δ_1	-0.38	-0.3160
Formal Education	δ_2	-0.71***	-3.7931
Household Size	δ_3	-2.53***	-14.4302
Age	δ_4	-0.21	-0.8328
Visit by Extension Worker	δ_5	-3.28***	-2.4873
Variance Parameter			
Sigma squared	δ^2	0.037***	3.3746
Gamma	γ	0.81***	4.1948

Source: Computer output from frontier analysis, 2013; * Significant at 10 percent; ** Significant at 5 percent; * Significant at 1 percent**

Sources of disparity in technical inefficiency (TI) among fish farmers

The existence of technical inefficiency provides a good ground to find out the sources of inefficiencies among fish farmers in the study area. Variations in TI of fish farmers may arise from managerial decisions, farmers' characteristics and existing technology. Socio-economic variables were considered and estimated in the model and result was presented in Table 1 The signs and coefficient in the inefficiency model are interpreted in the opposite way such that a negative sign means the variable increases efficiency and vice versa. The result of the inefficiency model shows that the coefficients for farming experience and age were not statistically significant.

The coefficient for formal education was estimated to be negative but statistically significant at 1% level. This implied that an increase in formal education will result to an increase in output. The more relevant education one attained, the more knowledge he/she acquire to adopt new innovations aquaculture. The coefficient for household size was also estimated to be negative but also statistically significant at one percent level. This means that an increase in household size will also result to an increase in output. The study reveal that fish farmers use mostly family labour hence, family size affects labour in pond management. The coefficient for visit by extension worker was estimated to be negative and statistically significant at 1% level. This depicts that an increase in visit by extension worker will result to an increase in output. This is so, because innovations in aquaculture are being delivered by extension workers. This finding is in agreement with (Olagunju *et al.*, 2007; Aihonsu and Shittu, 2007; Filli, 2011) which indicate that household size, age, experience, educational level, workshop and training being the major factors associated with fish farming.

Technical efficiency

Table 2 shows the frequency distribution of the Technical Efficiency (TE) of farmers. From the Table 2, 17% fall within the TE range of 0.70 and below, 6% fall within the TE range of 0.71-0.75, 34% fall within the TE range of 0.76-0.80, while 20% and about 23% fall within 0.81-0.85 and > 0.85, respectively. This shows that majority (75%) of the fish farmers are having a relatively higher TE. The

mean technical efficiency of fish farmers was 0.79 (79%). This shows that majority of fish farmers are have relatively higher TE. The mean TE of fish farmer was 0.79 (79%). This confirms that fish farmers are not fully efficient as their observed output is 21% less than the maximum output. This can be increased by 21% through improved resource allocation with no additional cost. The mode of the technical efficiency was 0.78 (78%) meaning that majority of the farmers had technical efficiency of 78%.

Table 2: Frequency distribution of technical efficiency (TE) of fish farmers

Range of TE	No. of Respondents	Percentage
0.70	12	17.14
0.71 – 0.75	4	5.71
0.76 – 0.80	24	34.29
0.81 – 0.85	14	20.00
> 0.85	16	22.86
Total	**70**	**100.00**
Minimum 0.54		
Maximum 0.89		
Mean 0.79		
Mode 0.78		

Source: Computer output from frontier analysis, 2013

Problems of fish farming

Table 3 shows that inadequate feed supply ranked first as the major problem faced by fish farmers in the study area. This affects 23% of the respondents. Water supply ranked second affecting 15% of the respondents; while lack of good market outlet ranked third as it affects 14% of the respondents. Sources of fingerlings, power supply, technology, capital, co-operatives and awareness affected 12%, 11%, 10%, 9%, 3% and 1% of the respondents respectively. Drugs and labour did not constitute serious problems as they affected less than 1% of the respondent each. The problems identified agreed with the studies conducted by (Spaulding and Blasco, 1997; Assiah, 1997; Olagunju *et al.*, 2007; Filli 2011). They also observed that feed supply, lack of capital, access to fingerlings, market information, water supply and inadequate information were the major problems associated with aquaculture.

Table 3: Distribution of respondents based on problems associated with fish farming

Problem	Frequency	Percentage
Inadequate Feeds	32	23.19
Inadequate Water supply	21	15.21
Inadequate Market outlet	19	13.78
Insufficient Fingerlings	16	11.59
Inadequate Power supply	15	10.87
Inadequate Technology	14	10.15
Inadequate Capital	13	9.42
Inadequate Cooperatives	4	2.90
Lack of Awareness	2	1.45
Inadequate Drugs	1	0.73
Inadequate Labour	1	0.73
Total	**138***	**100.00**

Source: Field Survey, 2013; *Multiple responses

Conclusion

Based on the result of this study, it can be concluded that pond size, feeds supply, water, and fuel were positive and statistically significant at various levels signifying that any increase in this variables will lead to increase in output and fish farmers have the potential of raising their production efficiency by 21% through improvement in resource allocation. Inadequate feeds supply, inadequate water, inadequate market outlet, inadequate power supply, inadequate technology and insufficient capital were predominant problems.

On the basis of the findings of this study, the following recommendations were made for improvement of fish production, motivation on technical efficiency among fish farmers and policy making in fishery sector:

1. The government and other assisting agencies should provide better means of subsidizing the prices inputs to reduce the cost of production.
2. Training on new technology and awareness on fish production should be geared up, so as to improve production.
3. Fish farmers should form themselves into cooperatives groups to enable them get assistance from government and donor agencies so as to improve their production efficiency.
4. Though capital intensive, fish farmers are encouraged to sink boreholes for themselves so as to have adequate water supply to their ponds.

Fish production in the study area will receive a boost on the basis of the recommendation of this study.

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