A COMPARATIVE ANALYSIS OF TECHNICAL AND INPUT-SPECIFIC ALLOCATIVE EFFICIENCIES OF AQUACULTURE FARMS IN SOUTHWESTERN, NIGERIA

KOLAWOLE O.

Department of Agricultural Economics & Rural Development, Georg-August University, Goettinegn, Germany

Abstract

This paper comparatively examines technical and input-specific allocative efficiencies of aquaculture farms in Southwestern, Nigeria. Using a pre-tested and well structured questionnaire, a total of 160 farms were randomly selected from four states (Ondo, Ekiti, Oyo and Ogun states) across the region. The econometric applications of the stochastic frontier production models provide a measure of the technical efficiency of the farms. The returns-to-scale results shows that an average farm in Ekiti and Osun states exhibit increasing returns-to-scale while those in Ogun and Ondo exhibit decreasing returns to scale. Using estimates from the stochastic frontier production models, we computed the marginal value product and marginal factor cost for the variable inputs, to investigate input-specific allocative efficiency. The results show that none of the farms across the states optimally used the variable inputs considered in the study. Most farms were found to have either underused feeds or overused labour across the states. The estimated technical efficiency shows that about 11%, 18%, 22%, and 44% of outputs of the farms in Ogun, Ondo, Ekiti and Osun states are forgone due to inefficiency, respectively. We suggested that policies that address the improvement in the technical efficiency of the farms as well as, optimal input utilization will have a great implication on aquaculture development in the country.

Key words: aquaculture, technical efficiency, input-specific allocative efficiency, Nigeria

INTRODUCTION

Fish is regarded as the cheapest source of animal protein for many Nigerians. Presently, the domestic fish supply in the country stands at about 400 000 tons per year (Ogundari and Ojo, 2009). The majority of the fish supply within the country comes from the artisanal fisheries (Inoni, 2007), while the domestic supply is far below the demand because of the progressive increase in the country's population (Ojo et al., 2006). This necessitated the importation of frozen fish to offset the gap in the domestic demand.

The annual trade statistic from the Central Bank of Nigeria, shows that Nigeria expended over US $200 million annually on the importation of frozen fish to offset the under production in the country (CBN, 2006). Continued importation of frozen fish had been identified as one of the major sources of drain in the country's foreign reserves.

With a decrease in artisanal fish supply from ocean fisheries due to over-fishing and pollution, the concerns among policy makers is whether capture fisheries is capable of bridging the gap between the fish demand and supply in the country. Aquaculture in light of this development has been suggested as an alternative and sustainable source of fish protein in the country (Inoni, 2007; Fapohunda et al., 2005; Ojo et al., 2006; Ogundari and Ojo, 2009).

In Nigeria, aquaculture production is predominantly seen as an extensive land-based system, practiced at subsistence levels (Fagbenro, 2002). The current yield is put at 14 388 tons per year which offers a considerable potential for commercial aquaculture (Fagbenro and Adebayo 2005). Tilapias "*Oreochromis, Sarotherodon, and Tilapia* spp.", Clarid catfishes "*Clarias* and *Heterobranchus* spp" and the common/mirror carp "*Cyprinus carpio*" are the most widely cultured fish in the country. The technique of production ranges from homestead concrete pond, earthen ponds, and reservoirs to cages while this also varies across the regions in the country.

According to statistics by the Central Bank of Nigeria, the contribution of aquaculture to total fisheries production in the country increased from about 11% in 2003 to 21% in 2005 (CBN, 2006). This is an indication that aquaculture activity in the country is improving, although at a slower rate. Implication of this is that an expansion of aquaculture production across the country will play a significant role in ensuring sustainable fish production. Furthermore, aquaculture production is seen as a potential poverty and unemployment reduction instrument for the country.

The importance of efficiency as a means of fostering production in both developed and developing countries is well documented in the literature and widely recognized by researchers and policy makers alike (Ogundari, 2009). This suggests why there is proliferation in the number of efficiency studies which have often been used to raise policy debates that are applicable to aquaculture farms in the country during previous years (Awoyemi et al., 2003; Ajao et al., 2005; Fapohunda et al., 2005; Ojo et al., 2006, Kareem et al., 2008; Ojo and Ogundari, 2008; Ogundari and Ojo, 2009). However, these entire studies share a weakness as none has comparatively examined technical and input-specific allocative efficiencies of farms across the country. Neoclassical economic assumption suggests that estimating technical efficiency is a necessary but not a sufficient condition to globally assess the performance of farms.

To this end, the present study intends to provide such examination by comparing aquaculture farms across Southwestern Nigeria. Such analysis will provide agricultural policy makers in the country with a control mechanism for examining the performance of aquaculture farms.

MATERIALS AND METHODS

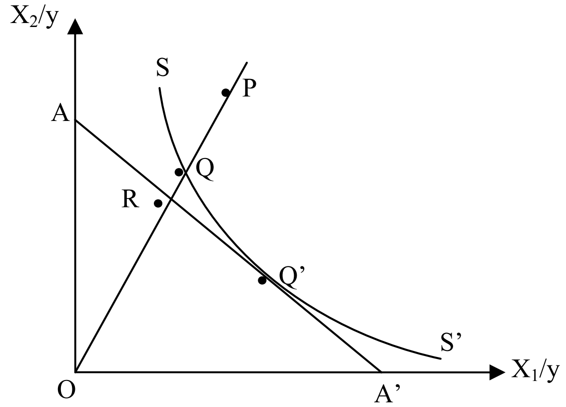
The study was carried out in four states across Southwestern, Nigeria. The states includes; Ekiti, Osun, Ondo and Ogun. Southwestern Nigeria has a total population of about 28 million people which is equivalent to about 20% of the country population (NPC, 2007). A tropical climate characterise the region with moderate temperatures year round, heavy rainfall during the rainy season (April to October) and dry wind during the dry season (November to March). While aquaculture production is quite popular because of the rapid need to boost animal protein supply, an extensive land-based system dominates the technique of fish production in the region

A multistage sampling technique is employed for the study. Two local government areas (LGAs) in each of the states with the highest prevalence of aquaculture farms were selected during the first stage. A successful identification of the LGAs is made possible by the fishery unit of the state's agricultural development program (ADP). The ADPs have the list of aquaculture farms in their respective states. The second stage involved a random selection of 20 farms from each LGA. A total of 40 farms were selected in each state. In all, 160 farms were interviewed with the aid of a pre-tested and well structured questionnaire administered through trained enumerators in 2006. Information collected includes; mature fish cropped (kg) and their price per kg in naira within the period under consideration. Information on quantity and prices of inputs used in naira was also collected. This includes: pond size (m^2), feeds (kg), labour (hours), numbers of fingerlings stocks, and costs of materials (including the cost of lime and fertilizer).

Farrell's (1957) literature introduced a method that helps shed light on the concept of efficiency in the production process. Farrell's measure of efficiency that embodies technical (TE) and allocative (AE) efficiencies can be explained by Figure 1. Let assume a situation where a firm exhibits constant returns to scale (CRS) with a production possibility set fully described by a unit isoquant SS' while considering two inputs x_1 and x_2 and one output y. If a given firm uses quantities of inputs defined by the point **P** to produce a unit of output of isoquant SS', the technical efficiency QP/OP in the context of physical inputs and output of that firm could be represented by the ratio of distance **QP** to **OP**. This ratio is defined as the amount by which all resources could be proportionally reduced without a reduction in output.

If information on the input prices is known and a particular behavioral objective such as cost minimization is assumed in such a way that the input price ratio is reflected by the slope of the iso-cost line **AA'**, the allocative efficiency OR/OQ of a firm operating at point **P** could also be derived as the ratio of **OR** to **OQ** from the unit isoquant plotted in Figure 1. This is defined as a reduction in production costs that would occur if production were to occur at the allocative (and technically) efficient point **Q'** instead of at the technically efficient (but allocatively inefficient) point **Q**. The product of the technical and allocative efficiencies provides a measure of cost (overall)

Figure 1: Technical and allocative efficiencies



Source: Coelli et al. (2005)

efficiency. Based on this concept, an analysis of technical and allocative efficiencies is not only a necessary condition, but it is also a sufficient condition to assess the production efficiency of aquaculture farms in Nigeria.

For the technical efficiency, we employed stochastic frontier production (SFP) models independently proposed by Aigner et al. (1977) and Meeusen and Van de Broeck (1977) for the study. The superiority of this model over the traditional least response model (OLS) is well documented in the literature. But the most significant of all this is that the SFP can be use to compute farm level technical efficiency which is quite important in the present study. By design, the SFP consists of two error components. One error term accounts for the statistical noise called (v_i) while another accounts for technical inefficiency called (υ_i).

Indexing the farms by *i*, the specification of the SFP model can be expressed as:

$$y_i = f(x_{ij}; \beta_j) \exp(v_i - \upsilon_i) \quad (1)$$

where: y_i is the output of the i-th aquaculture farm; x_{ij} is a vector of j-th inputs of i-th aquaculture farm and β_j is a vector of the parameters to be estimated. The first error term ν_i is assumed to be normally distributed as i.i.d ~ $N(0,\sigma_V^2)$. Traditionally, ν_i captured random factors beyond the control of the farmers such as weather variation. The second error term υ_i, captured general technical inefficiency associated with aquaculture production. For this study, we assumed that υ_i is distributed half-normally as i.i.d. $\sim N(0,\sigma_u^2)$. A higher value for υ_i implies an increase in technical inefficiency. If υ_i is zero the farm is technically efficient.

Following Battese and Coelli's (1988) proposition, we define technical efficiency (TE) as the ratio of the mean output for the i-th aquaculture farm, given the values of the inputs x_i and its technical inefficiency effect υ_i, to the corresponding mean output if there was no technical inefficiency in the production .

The definition can be expressed mathematically when y_i and x_{is} are in logarithm form as;

$$TE_i = \frac{E\left(Y_i \mid \mathbf{u}_i, X_i\right)}{E\left(Y_i \mid \mathbf{u}_i = 0, X_i\right)} = \frac{\mathbf{f}\left(X_j; \beta_j\right)\exp\left(\nu_i - \upsilon_i\right)}{\mathbf{f}\left(X_j; \beta_j\right)\exp\left(\nu_i\right)} = \exp\left(-\upsilon_i\right) \quad (2)$$

All estimates of equation 1 and 2 were obtained through maximum likelihood procedures in the computer program FRONTIER 4.1c (Coelli, 1996).

This study followed a neoclassical production theory approach to estimate input-specific allocative efficiency. Using a farm specific production function with the highest associated iso-profit line, we obtained a measure of input-specific allocative efficiency for the farms. The highest iso-profit line, is however determined when the marginal value product (MVP_x) of the inputs is equal to the marginal factor costs (MFC_x). According to Kalirajan and Obwona (1994) MVP_x is obtained when the slope of the production function (marginal product – MP_x) is equal to the ratio of the prices of the factor inputs (MFC_x) and that of output (P_y)[1]. Mathematically this can be expressed as;

$$MP_x = \frac{MFC_x}{P_y}$$

which is also equal to $MP_x \times P_y = MFC_x$ (3)

Based on the definition of Kalirajan and Obwona (1994) above;

$$MP_x \times P_y = MVP_x$$

while from Eqn.3; $MVP_x = MFC_x$ (4)

For this study, we expressed the derivation of the individual farm specific allocative efficiency for the variable inputs slightly different from the expression 3 to 4[2]. This is because of our choice of the Cobb-Douglas functional form[3] to represent the frontier model (equation 1).

The individual farm input specific allocative efficiency could be derived using the following expression because of the reasons outlined in foot note 1 as

$$\beta_j\left[Y_i / X_{ij}\right] = \frac{MFC_x}{P_y}$$

(here, $MP = \beta_j \times AP$, where $AP = Y/X$)

which is also equal to

$$\beta_j\left[Y_i / X_{ij}\right].P_y = MFC \quad (5)$$

[1]This assumption holds in principle for functional forms other than the Cobb-Douglas and translog functional forms. In the case of Cobb- Douglas or translog, the slopes serve as direct measure of elasticity.

[2]In accordance with economic theory, producers generally do not have the flexibility to adjust fixed inputs such as pond size and fingerlings with regard to aquaculture production. Based on this, the input specific allocative efficiency in the present study is computed for variable inputs where producers have the flexibility to adjust inputs such as labour and feeds. This however is a departure from the work of Inoni (2007).

[3]The Cobb-Douglas functional form is chosen because it is widely used in measuring a farm's efficiency for developing agriculture. Nevertheless, we tested this against the translog functional (TL) form; unfortunately our present dataset does not support the TL.

Where: β_j is the estimated input elasticities (that is the coefficient of the chosen Cobb-Douglas functional form); Y_i/X_{ij} is the average product of *j*-th input; MFC_x is the price of the factor input *j*; P_y is the price of the output; β_{ij} $[Y_i/X_{ij}]$ is equivalent to the marginal product (MP_x) of the input. The expression in equation 5 is the measure of the input-specific allocative efficiency employed for the study. This is calculated at individual sample points for all the aquaculture farms under investigation across each state.

For the economic interpretation, an input specific allocative efficiency (Eqn. 5), shows how farmers responded to price signals for output and inputs to allocate their resources (input-mix) in an optimal manner. For an optimal input utilization leading to an optimum production level, the marginal value product (MVP) of input x_j is expected to equate its marginal factor cost (MFC) (i.e., $MVP_x = MFC_x$). Whenever the MVP of an input x_j is greater than its MFC (i.e., $MVP_x > MFC_x$), it implied that x_j is under utilized in the course of production (i.e. not used sufficiently). Over utilization of the x_j is also observed when its MVP is less than its MFC (i.e., $MVP_x < MFC_x$). The implications of the last two scenarios signal a non optimum production level. Such characterizations implied a continued application of under-utilized inputs as well as a decreased application of over utilized inputs to ensure an optimum production level.

For this study, the Cobb-Douglas functional form is specified for the study for the reason stated in foot note 2. The Cobb-Douglas frontier functional form for the empirical analysis is expressed as:

$$\ln y_i = \beta_0 \prod_{j=1}^{J} \beta_j \ln x_j + \nu_i - \upsilon_i \qquad (8)$$

where, *ln* represents the natural logarithm; the subscript represents the i-th sample farmer; y_i represents the cropped fish (kg) for farmer *i*[4]; x_j represents pond size, feeds, labour, numbers of fingerlings-stocked and costs of materials; β_j represents the input coefficients while vi, and ui as earlier defined.

RESULTS AND DISCUSSION

The summary statistics of the variables included in the regressions show that an average farm in Ogun, Ondo, Ekiti, and Osun states cropped about 23 000 kg, 19 000 kg, 15 000 kg, and 13 000 kg, respectively of fish per year. For the inputs, the analysis showed that an average farm in Ogun state obtained about 341 m^2 of pond size, 4 400 kg of feeds, 1 300 hours of labour, 34 800 numbers of fingerlings stocked, and ₦ 48 000 costs of materials. Likewise, an average farm in Ondo state obtained about 260 m^2 of pond size, 3 100 kg of feeds, 910 hours of labour, 26 000 fingerlings stocked, and ₦ 32 000 costs of materials. Also, for an average farm in Ekiti state we observed; 210 m^2 of pond size, 2 510 kg of feeds, 968 hours of labour, 14 560 fingerlings stocked, and ₦ 33 000 as the costs of materials. On the other hand, an average farm in Osun state obtained; 194 m^2 of pond size, 2 240 kg of feeds, 893 hours of labour, 14 100 fingerlings stocked, and ₦ 28 485.56 as the costs of materials.

Presented in Table 1 are the results of the point estimates of input elasticities of farms across the states. All the estimated coefficients had a positive sign and were significantly different from zero. This suggests that the production functions monotonically increased with input level for the farms. The returns to scale (RTS), computed as the summation of the input elasticities, shows that a joint increased of all the inputs by 1% increased the output by 0.88%, 1.33%, 1.15%, and 0.92% for farms in Ogun, Ekiti, Osun, and Ondo, respectively. The implication of this is that an average farm in Ekiti and Osun states exhibits increasing returns-to-scale while those in Ogun and Ondo exhibit decreasing returns-to-scale.

The result of the input specific allocative efficiency shows that none of the farms across the states appeared to have efficiently allocated any of the variable inputs considered[5] (MVPx = MFCx). Nevertheless, we observed that 90%, 85%, 60%, and 70% of the farms in Ogun, Ondo, Ekiti, and Osun states, respectively, appeared to have under-used feeds. Also 93%, 70 %, 88%, and 55% of the farms in Ogun, Ondo, Ekiti, and Osun states, respectively, appeared to have over-used labour. The economic interpretation of the results is that for an optimum production level to be achieved, an average farms in the study areas must increased the use of feeds and decrease the use of labour. The observation that feeds are underutilized is contrary to the finding of Inoni (2007) while our observation that labour is overutilized is in conformity with author's finding. Nevertheless, it must be stressed that the present study and that of Inoni (2007) are carried out in different region of the country and at the differ-

[4]We are aware that some of the farms produced more than one species of fishe. With regard to the farms with different species, y_i is obtained by simply aggregating the total revenue from each species and dividing this by the sum of the prices of the species.

[5]We must point out here that delta equation was used to the standard error of the computed ratio (MVP/MFC). The ratios across the farms were found to be significantly different from zero.

Tab. 1: Estimates Regression of the Stochastic Frontier Production model

Variables	Parameters	Frontier ML estimates			
		Ekiti	Osun	Ogun	Ondo
Constant	β_0	2.614^a (3.95)	5.039^a (2.49)	4.115^a (3.74)	1.851^b (1.98)
ℓn Pond Size	β_1	0.149^b (2.17)	0.267^b (1.98)	0.223^a (2.79)	0.311^a (3.64)
ℓn Feeds	β_2	0.368^c (1.97)	0.295^b (2.26)	0.187^b (2.02)	0.209^b (2.12)
ℓn Labour	β_3	0.123^a (2.54)	0.169^a (6.31)	0.149^b (1.99)	0.003^a (3.82)
ℓn fingerlings stocks	β_4	0.305^c (1.96)	0.297^a (2.75)	0.283^b (2.36)	0.146^b (2.38)
ℓn costs of capital	β_5	0.387^a (5.93)	0.124^c (1.97)	0.142^a (3.28)	0.252^b (2.04)
Variance parameters					
Sigma square	σ^2	0.445^a (3.46)	0.319^a (8.35)	0.523^a (3.96)	0.464^a (3.09)
Gamma	γ	0.821^a (5.85)	0.803^a (3.07)	0.941^a (6.24)	0.894^b (2.36)
Log likelihood	LL	–47.954	–68.251	–60.298	–55.892
Returns-to-scale (RTS)		1.332^a (2.38)	1.153^a (5.07)	0.882^a (2.86)	0.921^a (3.17)
Technical efficiency					
Minimum		0.246	0.127	0.581	0.295
Maximum		0.811	0.763	0.982	0.927
Average		0.784	0.565	0.892	0.816
Standard deviation		0.017	0.035	0.013	0.028

Figures in parentheses are t-ratio; Upper subscripts a, b and c denote variables that are significant at 1%, 5% and 10% level of significance, respectively

ent time period which might also responsible for the observed result of the *feeds*.

One possible reason for the observed allocative inefficiency most especially for the variable inputs *feeds*, across the farms can be attributed to the credit constraints of the farms. This observation was made known to us by the majority of the interviewed farmers across the states. Liefert (2005), in his study of the allocative efficiency of material inputs in Russian agriculture stressed the significant influence of credit constraint on optimal input utilization in Russian agriculture. He concluded that improving access of farmers to credit will improve the allocation of resources among Russian farmers. This however, is applicable to the current situation of aquaculture farms in southwestern Nigeria.

Tab. 2: Frequency of the computed allocative efficiencies for variable inputs

Decisions	Feeds		Labour	
	freq.	%	freq.	%
Ogun state				
$MVP_x > MFC_x$	36	90	3	7
$MVP_x < MFC_x$	4	10	37	93
Ondo state				
$MVP_x > MFC_x$	34	85	12	30
$MVP_x < MFC_x$	6	15	28	70
Ekiti state				
$MVP_x > MFC_x$	24	60	5	12
$MVP_x < MFC_x$	16	40	35	88
Osun state				
$MVP_x > MFC_x$	28	70	18	45
$MVP_x < MFC_x$	12	30	22	55

Another reason which can be attributed to allocative inefficiency with regard to *feeds* can be traced to accessibility and high cost. High costs and accessibility to traditional inputs such as feeds among others have been documented in the literature as a serious bottleneck to the development of aquaculture in Nigeria (Ojo et al., 2006; Inoni, 2007; Ogundari and Ojo, 2009).

The summary statistics of the point estimates of the technical efficiency scores for the farms is presented in the lower part of Table 1. The results show that an average farm in Ogun, Ondo, Ekiti and Osun obtained an average technical efficiency of 0.892, 0.816, 0.784 and 0.565, respectively. The results suggest that an average farm in Ogun, Ondo, Ekiti and Osun states could scale up their present level of output by approximately 11%, 18%, 22%, and 44%, respectively, to reach the frontier level of the most efficient farm across individual states. Comparatively, it is implied that less than 20% of the current output of the farms in Ogun and Ondo states is forgone as a result of inefficiency as compared to more than 20% in Ekiti and Osun states.

A possible explanation for the significant level of inefficiency observed in this study can be attributed to a number of factors. This includes: economic (e.g., credit, high cost of inputs), technical (e.g., lack of information on aquaculture techniques and inadequate management strategies), ecological and institutional factors (e.g., lack of capital). Ogundari (2009), in a study of the meta-analysis of technical efficiency studies in Nigerian agriculture, observed that over the years, extension activities play a major significant role in the level of the technical efficiency of farms in the country. This observation equally applies to the present study considering the fact that observations in the study apply to all facets of Nigerian agriculture including aquaculture. Right and timely dissemination of the needed techniques of production and management could help scale up the output of aquaculture production in the country even at the current input usage.

CONCLUSION

The findings show that an assessment of farm-level technical and input specific-allocative efficiencies can provide the needed performance indicator of aquaculture farms in the Southwestern Nigeria.

While the results have implication on sustainable fish production in Nigeria, effort must be made to address the inefficiency inherent in aquaculture production in the country as highlighted in the study. Therefore, any measure aimed at improving the economic efficiency of cultured fish production in Nigeria should address allocative inefficiency as well as, improve the technical efficiency of the farms.

We suggested that policy options for improving the economic efficiency of the farms should follow closely the combination of the following approaches; policies that will improve the provision of credit to facilitate the timely accessibility of farmers to needed inputs should be pursued. A government program that will improve farmers' accessibility to the inputs at a subsidized rate should also be considered. A credit delivery system without the bureaucratic bottlenecks will improve the allocative technical efficiencies of the farms.

Finally, the role of effective extension activities in fish production, preservation, and processing cannot be ruled out for the expansions of fish production. Additionally, its sustainability is crucial in the fulfillment of the millennium development goal (MDG) of food security in the country.

ACNKOWLEDGEMENT

An earlier version of this paper was presented at the International Institute of Fishery and Trade Conference held NhaTrang, Vietnam, during 22–25 July 2008. The author gratefully acknowledges the comments of the participants during the conference.

REFERENCES

AIGNER D.J., KNOW-LOVEL C.A., SCMMIDT P. (1977): Formulation and estimation of stochastic frontier production models. Journal of Econometrics, 6: 21–32.

AJAO A.O, AMAO J.O., WILLIAMS S.B. (2005): Determinants of technical inefficiency of fish farms in Oyo State Nigeria. Journal of Sustainable Development, 2 (2): 33–39.

AWOYEMI T.T, AMAO J.O., EHIRIM N.C. (2003): Technical efficiency in aquaculture in Oyo state Nigeria. Indian Journal of Agricultural Economics, 8 (4): 812–819.

BATTESE G.E., COELLI T.J. (1988): Prediction of farm-level technical efficiencies with a generalized frontier production function and panel data. Journal of Econometrics, 38: 387–399.

CBN (2006). Central Bank of Nigeria Annual Report and Statement of Account for the year ended 31st December, 2005. Abuja, Nigeria.

COELLI T.J. (1996): A Guide to Frontier Version 4.1c: A Computer Program for Stochastic Frontier Production and Cost Function Estimation. Working paper, Dept. of Econometrics, University of New England, Armidele, Australia.

FAGBENRO O.A. (2002): Tilapia: fish for thought. 32nd Inaugural Lecture, Federal University of Technology, Akure, Nigeria.

FAGBENRO O.A., ADEBAYO O.T. (2005): A review of the animal and aqua feed industries in Nigeria. In: Moel J., Matthias Halwart M. (eds.): A synthesis of the formulated animal and aqua feed industry in sub-Saharan Africa, pp. 25–36. CIFA Occasional Paper No.26, FAO, Rome.

FAPOHUNDA O.O., OJO S.O., BALOGUN A.M. (2005). Analysis of productivity of bio-technical factors and technical efficiency of aquaculture production in Ondo State. Nigeria Journal of Animal and Vertinary Advances, 4 (5): 535–539.

FARRELL J.M. (1957): The measurement of productive efficiency. Journal of the Royal Statistical Society, Series A, 120, Part III: 253–290.

INONI O.E. (2007): Allocative efficiency in pond fish production in Delta state, Nigeria: A production function approach. Agricultural Tropical et Subtropica, 40 (4): 127–134.

KALIRAJAN K.P., OBWONA M.B. (1994): A measurement of firm- and input-specific technical and allocative efficiencies. Applied Economics, 26: 393–398.

KAREEM R.O., DIPEOLU A.O., AROMOLARAN A.B., AKEGBEJO S. (2008): Analysis of technical, allocative and economic efficiency of different pond systems in Ogun state, Nigeria. African Journal of Agricultural Research, 3 (4): 246–254.

LIEFERT W. (2005): The allocative efficiency of material input use in Russian Agriculture. Comparative Economic Studies, 47: 214–223.

MEEUSEN W., VAN DEN BROECK J. (1977): Efficiency estimation from Cobb-Douglas production functions with composed error. International Economic Review, 18: 435–444.

NPC (2007). National Population Commission preliminary report on 2006. National and Housing Population Censor exercise in Nigeria. Abuja, Nigeria.

OGUNDARI K., OJO S.O. (2009): An examination of income generation potential of aquaculture farms in alleviating household poverty: Estimation and policy implications from Nigeria. Turkish Journal of Fisheries and Aquatic sciences, 9 (1): 39–45.

OGUNDARI K. (2009): A Meta-Analysis of Technical Efficiency Studies in Nigerian Agriculture. Paper presented at the International Association of Agricultural Economists 2009 Conference, August, 16–22, Beijing China.

OJO S.O., AFOLABI J.A., FAGBENRO O.A. (2006): Profitability and technical efficiency of Artisanal fisheries production in Nigeria. Journal of Sustainable Tropical Agricultural Research, 19: 23–30.

OJO S.O., OGUNDARI K. (2008): Fighting Poverty and Unemployment with Efficient Fish Farming in Nigeria. Book of Abstracts of the Tropentag 2008 – Competition for Resources in a Changing World New Drive for Rural Development. 7 – 9 October, 2008, University of Hohenheim, Germany.

OJO S.O., FAGBENRO O.A., FAPOHUNDA O.O. (2006a): Productivity and technical efficiency of aquaculture production in Nigeria – A stochastic frontier production function approach. World Aquaculture, 37 (3):18–23.

Received for publication on September 29, 2009
Accepted for publication on June 6, 2010

Corresponding author:

Kolawole Ogundari
Department of Agricultural Economics & Rural Development
Georg-August University
Platz Der Goettinger Sieben 5
37073, Goettinegn, Germany
e-mail: ogundarikolawole@daad-alumni.de