Productivity of hired and family labour and determinants of technical inefficiency in Ghana's fish farms

Produktivita námezdní a rodinné práce a determinanty technické neefektivnosti na farmách chovu ryb v Ghaně

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Abstract: This paper examines the productivity of hired and family labour and determinants of technical inefficiency of fish farms in Ghana. A modified Cobb-Douglas stochastic frontier production function which accounts for zero usage of family and hired labour is employed on cross-sectional data of 150 farmers collected in 2007. The results reveal that family labour, hired labour, feed, seed, land, other costs and extension visit have a reasserting influence on fish farm production. Findings also show that family and hired labour used for fish farming production in Ghana may be equally productive. The combined effects of operational and farm specific factors (age, experience, land, gender, pond type and education) influence technical inefficiency although individual effects of some variables may not be significant. Mean technical efficiency is estimated to be 79 percent. Given the present state of technology and input level, the possibility of enhancing production can be achieved by reducing technical inefficiency by 21 percent through adoption of practices of the best fish farm.

Key words: Ghana, fish farms, technical inefficiency, hired and family labour, stochastic frontier

Abstrakt: Práce popisuje produktivitu námezdní a rodinné práce a determinanty technické efektivnosti na farmách chovu ryb v Ghaně. Byla zde použita modifikovaná Cobb-Douglasova stochastická mezní produkční funkce uvažující s nulovým využitím rodinné a námezdní práce, a to na vzorku údajů 150 farem získaných v roce 2007. Výsledky analýzy ukazují, že rodinná práce, námezdní práce, krmiva, osiva, půda a poradenské služby mají rozhodující vliv na objem produkce ryb. Získané poznatky rovněž ukazují, že produktivita rodinné a námezdní práce využité na produkci ryb na farmách může být stejná. Kombinovaný efekt obecných operačních a specificky faremních faktorů (věk, zkušenost, půda, gender, typ vodní nádrže a vzdělání) ovlivňuje technickou neefektivnost, ačkoliv individuální efekt některých proměnných nemusí být významný. Střední hodnota technické efektivnosti je odhadována na úrovni 79 %. Bereme-li v úvahu současný stav technologií a úrovně inputů, je zde možnost zvýšení objemu produkce, jíž může být dosaženo snížením technické neefektivnosti o 21 % aplikací postupů využívaných na nejlepších rybích farmách.

Klíčová slova: Ghana, technická neefektivnost, námezdní a rodinná práce, stochastické rozmezí

The fisheries sector has been an important contributor to the economic development of Ghana. It is a source of income, employment and supplies over 20 percent of the total protein intake in the country (Jacquet and Alder 2006). Estimated annual domestic supply (mainly from traditional marine fisheries) is 435 000 MT, which is about 40 percent less of what the country demands (Atta-Mills et al. 2004). It is estimated that Ghana spends over $125 million dollars a year to import fish products to supplement domestic production.

Coupled with the increasing demand as a result of the growing population and added competition from the industrial sector, the government embarked on fish farming campaign for sustainable fish production to supplement captured fisheries. This motivated the entry of both male and female farmers into the industry in the early 1980s. Predominantly, the dug-out pond system has been in use with few farmers adopting the concrete ponds. Race and cage ponds are still not properly developed in Ghana. Major inputs considered for production include: land, seed, feed and labour. Source of labour for fish farms in Ghana is mainly from family and hired labour, with family labour constituting the most important of total labour use. Nevertheless, due to inadequate resources, the industry has not seen any significant technological investment in infrastructure, capacity building and support systems since its inception. Moreover, since the capacity of extension service has eroded in recent years, even when improved technologies are available, they fail to reach the farmers. As the possibility of enhancing productivity of fish farms through technological innovations has hardly been possible, improvement in technical efficiency is of great concern.

Technical efficiency can be measured by different approaches. Pioneered by Kirkley et al. (1995), several research studies have employed the stochastic frontier production technique to assess efficiency of production in the fisheries and aquaculture production in many countries including Iran (Esmaeli 2006); Nepal (Sharma and Leung 1998); Hawaii (Sharma and Leung 1999); India (Sharma and Leung 2000); Malaysia (Iinuma et al. 1999); Philippines (Dey et al. 2000); Taiwan (Chiang et al. 2004); Spain (García del Hoyo et al. 2004); Morocco (Herrero 2005); England (Tingley et al. 2005); Nigeria (Kareem et al. 2008). Dey et al. (2005) estimate the levels and determinants of farm-level technical efficiencies in freshwater pond polyculture systems in China, India, Thailand, and Vietnam.

However, in order to avoid the problem of zero observation in the estimation of frontier production function, majority of these studies implicitly assume equal productivity and aggregate hired and family labour to determine their effect on production. Although Heshmati and Mulugeta (1996) separately consider hired and family labour variables in the frontier model, their study is limited to farmers who used positive values of these two sources of labour and discard cases with zero observations. Discarding parts of the observations appears to be unappealing since the available data does not seem to be fully utilised. Thus, some authors treat the zero-observation case by using values of one or an arbitrarily small number greater than zero for the key input concern. This procedure may result in serious bias estimators of the production function as notes by Battese (1997).

Against this backdrop, the study adopts the stochastic frontier approach to examine the effects of hired and family labour on fish farm production in Ghana, whilst technical inefficiency and their determinants are assessed. Guided by Battese et al. (1996) and Battese (1997), the study examines explicitly the effect of hired and family labour on production by setting the log-value of the zero-observation of these two sources of labour to be zero with dummy variables. This procedure ensures that efficient estimators are obtained using the full data set without introducing any bias.

MATERIALS AND METHODS

Following Farrell (1957), many different methods have been considered for the estimation of efficiency. Two major approaches that are widely used are the Data Envelopment Analysis (DEA) which involves mathematical programming, and the Stochastic Frontier Analysis (SFA) which uses econometric methods. This study adopts the stochastic frontier approach as it is preferred because of the inherent stochasticity involved (Aigner et al. 1977; Meeusen and Van den Broeck 1977). The SFA specifies output variability by a non-negative random error term (u) to generate a measure of technical inefficiency as considered also by advocates of the deterministic approach (Afriat 1972; Richmond 1974; Greene 1980) and a symmetric random error (v) to account for effects of exogenous shocks beyond the control of the analysed units which embodies variation in weather conditions, diseases, poaching etc, measurement errors and any other statistical noise. For a cross sectional data, the SFA model expressed in accordance with the original models of Aigner et al. (1977) and Meeusen and Van den Broeck (1977) has the form:

$$Y_i = f(X_i;\beta)\exp(\varepsilon_i) = f(X_i;\beta)\exp(v_i - u_i) \quad i = 1, \ldots, N \qquad (1)$$

where Y_i is the level of output for observation i. X_i is a vector of inputs and other explanatory variables associated with the i^{th} farm and β is a vector of unknown parameters of interest to be estimated. ε_i is the error term that is composed of two independent elements v_i and u_i such that $\varepsilon_i = (v_i - u_i)$. v_i is the noise error term, whilst u_i is a non-negative inefficiency error term. The condition that u_i is non-negative ($u_i \geq 0$) in model (1), guarantees that all observations lie on or beneath the stochastic production frontier.

Coelli et al. (2005) note that observed output can only lie above the frontier when the noise effect is positive and larger than the inefficiency effect i.e. if $\varepsilon_i \equiv v_i - u_i > 0$.

Estimation of parameters in (1) is underpinned by distributional assumptions concerning the two error terms. v_i is commonly assumed to be independently, identically and normally distributed with zero mean and constant variance, σ_v^2, $[v_i \sim N(0,\sigma_v^2)]$. However, different distributions have been assumed with varied specifications for the u_i in the literature (Aigner et al. 1977; Green 1980; Stevenson 1980). This study adopts a model by Battese and Coelli (1995) which specifies that the u_i's are non-negative random variables assumed to be independently distributed as truncation (at zero) of the normal distribution with mean, $Z_i\delta$ and variance, σ_u^2, such that the technical inefficiency effect is defined as:

$$U_i = Z_i\delta + W_i \qquad (2)$$

where Z_i is a $(P \times 1)$ vector of explanatory variables associated with the technical inefficiency effect which could include socioeconomic and farm management characteristics. Z_i may be specified to include both farm specific variables and some input variables as long as the technical inefficiency effects are stochastic (Battese and Coelli 1995). This idea is exemplified in (Coelli and Battese 1996; Battese and Broca 1997; Huang and Liu 1994; Ngwenya et al. 1997). δ is a $(1 \times P)$ vector of unknown parameters to be estimated and W_i's are random variables defined by truncation of the normal distribution with mean zero and variance, σ_u^2, where the point of truncation is $-Z_i\delta$ i.e. $W_i \geq Z_i\delta$. Battese and Coelli (1995) note that these assumptions are consistent with u_i being a non-negative truncation of $N(Z_i\delta, \sigma_u^2)$ distribution.

Consequently, the technical efficiency of the i^{th} farm, denoted by TE_i, is defined as the ratio of the mean of production for the i^{th} farmer, given the value of the inputs, X_i, and its technical inefficiency effect u_i to the corresponding mean of production if there were no inefficiency of production (Battese and Coelli 1988). This is expressed as:

$$TE_i = \frac{E(Y_i|X_i,u_i)}{E(Y_i|X_i,u_i=0)} = \exp(-u_i) \qquad (3)$$

The measure of TE_i has a value between one and zero, where one indicates a fully efficient farm and zero implies a fully inefficient farm. Considering the distributional assumption of the random errors, this study employs the maximum likelihood single-stage estimation procedure (Kumbhaker et al. 1991; Reifschneider and Stevenson 1991; Huang and Liu 1994) for the estimation of the parameters of models (1), (2) and the farm-specific TE_i in terms of the parameterization:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma^2} = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}$$

(Battese and Corra 1977). The parameter, γ is viewed to be bounded between zero and one. Thus, for $0 < \gamma < 1$, output variability is characterized by the presence of both technical inefficiency and stochastic errors.

Model specification

The stochastic frontier production function of first-order flexible Cobb-Douglas form is adopted for this study. This functional form is widely used in frontier production studies (e.g. Dawson and Lingard 1989; Kalirajan and Flinn 1983; Coelli and Battese 1996). In this study, the Cobb-Douglas model (4) is modified to permit explicitly, the productivity associated with hired labour (*HLabour*) and family labour (*FLabour*) and extension visit (*EV*). For more on this specification, see Battese and Coelli (1995); Battese et al. (1996) and Battese and Broca (1997).

$$\begin{aligned} LnY_i = {} & \beta_0 + \beta_1 DFL_i + \beta_2 Ln[\max(FLabour_i, 1 - DFL_i)] \\ & + \beta_3 DHL_i + \beta_4 Ln[\max(HLabour_i, 1 - DHL_i)] \\ & + \beta_5 Ln(Feed_i) + \beta_6 Ln(Seed_i) + \beta_7 Ln(Land_i) \\ & + \beta_8 Ln(Othercost_i) + \beta_9 DEV_i + v_i - u_i \end{aligned} \qquad (4)$$

where i and Ln are the i^{th} farmer and the logarithm to base e, respectively; Y denotes the quantity of fish harvested (in kilograms); *DFL* is a dummy variable equal to one if the number of family labour used is positive, zero otherwise; *FLabour* represents the number of family labour used (measured in man-days[1]); *DHL* is a dummy variable equal to one if the number of hired labour used is positive, zero otherwise; *HLabour* represents the number of hired labour used (measured in man-days). The expressions: $Ln[\max(FLabour_i, 1 - DFL_i)]$ and $Ln[\max(HLabour_i, 1 - DHL_i)]$ in model (4), account for zero usage of family and hired labour respectively by some farmers, whilst *DFL* and *DHL* account for intercept change. The estimator for the responsiveness of fish output to the use of hired and family labour could

[1]Man-days are computed according to the rule that one adult male, one adult female and one child (< 18 years) working for one day (8 hours) equal 1 man day; 0.75 man days; and 0.50 man days respectively. Battese et al. (1996) and Coelli and Battese (1996) also employ these ratios.

be bias without inclusion of *DFL* and *DHL* (Battese 1997). This study assumes that the marginal products and elasticities of output associated with other variables are the same for farmers who did not use either hired or family labour and those who did. *Feed* represents cost of feed used (in Ghana Cedi, GHC). This includes: commercial formulated feed (dizengoff and ranaan) and local manufactured feed such as fish meal, cereal bran and groundnut husk; *Seed* denotes quantity of fingerlings (fry) used (in kilograms); *Land* is the total area of ponds (in hectares) and it does not include farmyard and waste land. Ponds visited are assumed to have equal height of water level; *Othercost* denotes intermediate inputs (measured in GHC). It includes cost of chemicals, fertilizer, fuel, electricity, farm rent, maintenance, depreciation costs, etc; *DEV* is a dummy variable equal to one, if fish farm had at least one extension visit during the 2007 production year, zero otherwise. v_i and u_i are the random variables defined earlier.

The model for various operational and farm-specific variables hypothesised to influence technical inefficiencies in Ghana's fish farms is defined as:

$$U_i = \delta_0 + \delta_1(Age_i) + \delta_2(Experience_i) + \delta_3(Land_i) + \delta_4(Gender_i) + \delta_5(Pondtype_i) + \delta_6(Education_i) + W_i \quad (5)$$

where *W* is defined earlier; *Age* represents age of the primary decision maker; *Experience* denotes number of years engaged in fish farming by the decision maker; *Land* is total pond area and it is used as a proxy to capture size effect; *Gender* is a dummy variable which has the value of one, if farm decision maker is a male, zero if she is a female; *Pondtype* is a dummy variable which has the value of one, if the farm uses earthen pond, zero if concrete pond is used; *Education* represents the maximum level of formal schooling for a member of the household. Ranking of level of formal schooling in Ghana is outlined as: none ⇒ 0; primary level ⇒ 1; junior secondary/middle school level ⇒ 2; secondary level ⇒ 3; technical school level ⇒ 4; polytechnic level ⇒ 5; University (bachelor level) ⇒ 5; and University (graduate or above level) ⇒ 7.

Output and input variables considered in the stochastic frontier model and the relevant operational and farm-specific variables specified in the inefficiency model are summarised in Table 1. The Ox version 3.40 (windows) (C) J. A. Doornik 1994–2004, specifically, the SFAMB package (Brümmer 2003) is used to obtain the maximum likelihood estimates for the parameters.

Hypothesis test

The following hypotheses are investigated: (1) H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_6 = 0$, the null hypothesis that inefficiency effects are absent from the model at

Table 1. Summary of variables considered in the frontier and inefficiency models

Variable	Unit	Minimum	Mean	Maximum	Standard deviation
Output	kilogram	138	7 929	73 446	10 666
DFL	dummy	0	0.91	1	0.29
Family labour	man-days	0	281.60	960	166.54
DHL	dummy	0	0.52	1	0.50
Hired labour	man-days	0	187.20	1 620	249.66
Feed	Ghana Cedi	159.42	3 493.10	39 554	5 267.60
Seed	kilogram	29	471.51	4 356	691.02
Land	hectares	0.04	0.75	7	1.10
Other costs	Ghana Cedi	141.98	2277.90	36 233	4194
DEV	dummy	0	0.21	1	0.41
Age	years	28	49.84	71	9.32
Experience	years	2	7.23	25	3.91
Land	hectares	0.04	0.75	7	1.10
Gender	dummy	0	0.91	1	0.29
Pond type	dummy	0	0.93	1	0.25
Education	levels	0	4.24	7	1.29

DEV, DFL, DHL ≡ Dummies for extension visit, family labour and hired labour, respectively every level; (2) H_0: $\gamma = 0$, the null hypothesis that inefficiency effects are non-stochastic. Under $\gamma = 0$, the stochastic frontier model reduces to the traditional average response function; (3) H_0: $\delta_0 = \delta_1 = ... = \delta_6 = 0$, the null hypothesis specifies that simpler half normal distribution is an adequate representation of the data given the specifications of the generalised truncated-normal model; (4) H_0: $\delta_1 = ... = \delta_6 = 0$, the null hypothesis that farm specific factors do not influence the inefficiencies. Other important hypotheses of interest include: (5) H_0: $\delta_3 = 0$, the null hypothesis that there is no size effect; (6) H_0: $\beta_1 = \beta_3 = 0$, the null hypothesis that there is no intercept change; and (7) H_0: $\beta_9 = 0$, the null hypothesis that extension visit does not influence production. These hypotheses are tested using the generalised likelihood-ratio statistic, *LR*, which is specified as:

$$LR = -2[\ln\{L(H_0\} - \ln\{L(H_1\}] \quad (6)$$

where $L(H_0)$ and $L(H_1)$ are values of likelihood function under the null (H_0) and alternative (H_1) hypotheses respectively. *LR* has approximately a Chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with a degree of freedom equal to the number of parameters assumed to be zero in (H_0). Coelli (1995) proposes that all critical values can be obtained from appropriate Chi-square distribution. However, if the test of hypothesis involves $\gamma = 0$, then the asymptotic distribution necessitates mixed Chi-square distribution (Kodde and Palm 1986, Table 1).

Data and sampling technique

The study is conducted in Ghana, specifically in Ashanti, Eastern and Greater Accra regions. The study area is selected based on concentration of fish farms. A multi-stage sampling technique is employed for the data collection with the aid of a well structured questionnaire designed to obtain relevant socioeconomic characteristics, farming practices, output, inputs and price data. As a first stage in the data collection, a pilot test of the questionnaire was carried out to ensure that the respondents and the enumerators understood the questions and also to validate the suitability and the appropriateness of the questions and expected responses by respondents. The questionnaire was revised in the light of errors detected from the pilot survey. The second stage involved random selection of 50 fish farms from each region. Hence, a total of 150 fish farms were sampled for the study.

RESULTS AND DISCUSSION

The estimated parameters of the stochastic frontier model (4) and the inefficiency model (5) are presented below as *Frontier and Inefficiency model.*

Generalised likelihood ratio test (Table 2), which specifies that both the test for the absence of inefficiency effects and that inefficiency effects are not stochastic in the first and second hypotheses, respectively are strongly rejected as confirmed by the high value of $\gamma = 0.979$, which is statistically different from

Frontier model:

$$\begin{aligned} LnY = {} & \underset{(0.17)}{1.17^{***}} - \underset{(0.16)}{0.47^{***}}DFL + \underset{(0.\ 3)}{0.08^{***}}\, Ln[\max(FLabour, 1 - DFL)] - \underset{(0.18)}{0.45^{**}}DHL \\ & + \underset{(0.03)}{0.09^{***}}\, Ln[\max(HLabour, 1 - DHL)] + \underset{(0.03)}{0.10^{***}}Ln(Feed) + \underset{(0.04)}{0.01}\, Ln(Seed) \\ & + \underset{(0.05)}{0.60^{***}}\, Ln(Land) + \underset{(0.05)}{0.55^{***}}\, Ln(Othercost) + \underset{(0.02)}{0.09^{***}}DEV \end{aligned}$$

Log (Likelihood) = 90.954
Gamma (γ) = 0.979
VAR (u)/VAR (total) = 0.946

Inefficiency model:

$$\begin{aligned} U = {} & \underset{(0.33)}{-0.19} + \underset{(0.01)}{0.01}\, (Age) + \underset{(0.01)}{0.003^{***}}\, (Experience) + \underset{(0.02)}{0.21^{***}}\, (Land) - \underset{(0.11)}{0.031^{***}}\, (Gender) \\ & \underset{(0.11)}{-0.33^{***}}\, (Pondtype) + \underset{(0.02)}{0.03}\, (Education) \end{aligned}$$

**, *** ≡ statistically significant at levels of 0.05, and 0.01. Values in brackets below the estimated parameters are their corresponding standard errors.

Table 2. Hypotheses tests for model specification and statistical assumption

Null hypothesis	Log-likelihood value	Test statistics (λ)	Critical value ($\lambda^2_{0.001}$)	Decision
Testing the specification of technical inefficiency model				
1. H_0: $\gamma = \delta_0 = \delta_1 = \dots = \delta_6 = 0$	–	204.97**	25.37	reject H_0
2. H_0: $\gamma = 0$	–	75.31**	9.50	reject H_0
3. H_0: $\delta_0 = \delta_1 = \dots = \delta_6 = 0$	26.13	129.64	24.32	reject H_0
4. H_0: $\delta_1 = \delta_2 = \dots = \delta_6 = 0$	43.37	95.16	22.46	reject H_0
Other hypotheses test				
5. H_0: $\delta_4 = 0$	72.75	36.40	10.83	reject H_0
6. H_0: $\beta_1 = \beta_3 = 0$	80.66	20.58	13.82	reject H_0
7. H_0: $\beta_9 = 0$	82.30	17.30	10.83	reject H_0

Values with ** are test of one sided error from the Ox output. The correct critical value for the hypotheses involving γ are obtained from Table 1 of Kodde and Palm (1986, p. 1246).

zero. Hence, the traditional average (*OLS*) function is not an adequate representation for the data. The third hypothesis that the intercept and the coefficients associated with farm-specific variables in the technical inefficiency model are zero (that the technical inefficiency effects have a traditional half-normal distribution with mean zero) is strongly rejected. The fourth hypothesis, which states that all coefficients, except the constant term of the inefficiency model, are zero (hence, the technical inefficiency effects have the same truncated-normal distribution with mean equal to δ_0) is also rejected. This reveals that the combined effects of factors involved in the technical inefficiency model are significant in explaining the variation in production of fish farms in Ghana, although individual effects of some variables may not be significant.

Frontier model estimates

The expected coefficients for all inputs are positive, indicating that family labour, hired labour, feed, seed, land and other cost have positive influence on fish farming production in Ghana. The elasticity of output with respect to seed (0.01) is very small and insignificant. This means that a 1% increase in seed input may only increase production by 0.01%. MacPherson et al. (1990) note that one of the constraints in the fish farming industry in Ghana is overstocking of ponds with the view of compensating for fingerling mortalities. Pilley (1990) asserts that ensuring recommended stocking density is proper for successful grow-out. Thus, fish farmers in Ghana should be educated to adhere to pond stocking measures. Output elasticities for hired and family labour are both significant but not statistically different from each other ($\alpha = 0.05$). This revelation may indicate that the two types of labour are equally productive.

Intercept coefficient for family labour (*DFL*) and hired labour (*DHL*) are both estimated to be significantly negative. This implies that there could be bias estimators of the parameters in the frontier production function without inclusion of these dummies as confirmed by the rejection of the sixth null hypothesis (H_0: $\beta_1 = \beta_3 = 0$). The coefficient of variable *DEV* is estimated to be significantly positive (0.09). This indicates that output increased by 9% for farms who had at least one extension visit during the 2007 production year. This finding is confirmed by the rejection of the seventh null hypothesis (H_0: $\beta_9 = 0$) that extension visit does not influence production. Many studies have shown that contact with the advisory service is a positive factor in increasing agricultural productivity (Birkhaeuser and Feder 1991; Leavy 1991). Extension service in Ghana delivers information on new technologies to the farmers to enhance production. VAR (u)/VAR (total) is estimated to be 0.946, meaning that the one-sided inefficiency random error component dominates the measurement error and other random disturbances

Technical inefficiency model estimates

Estimated parameters in the technical inefficiency model reveal that the coefficient of age is positive but not significant. However, the coefficient of experience is estimated to be significantly positive, indicating that more experienced fish farmers are more technically inefficient in their production than possibly new farmers who are progressive and willing to implement new production systems.

A review by Lundvall and Battese (2000) establish a varied relationship between farm size and technical inefficiency in developing countries using the frontier production function. Contrary to the findings of Iinuma et al. (1999) and Dey et al. (2000), the coefficient of land in this study is estimated to be significantly positive, implying that fish farms that operate small pond are technically less inefficient than farms with large ponds. This is confirmed by the rejection of the null hypothesis (H_0: $\delta_3 = 0$) that there is no size effect. Nevertheless, using a translog model, Ngwenya et al. (1997) demonstrate an inverse relationship between farm size and technical inefficiency of wheat farmers in Eastern Free State of South Africa. However, an opposite observation is revealed when a Cobb-Douglas model is adopted in their study. Thus, care must be taking in explaining the finding in this study as it is possible that the modified Cobb-Douglas model considered does not appropriately capture a range of scale economics and hence it includes some scale inefficiency on the estimation.

The coefficient estimated for the gender dummy is significantly negative, indicating that farm decision makers who are males operate less inefficiently than their female counterparts. Fish farming requires labour for hard work. Women hire labour for pond construction, but fish feeding and pond management involve fairly continuous labour input. Coupled with division of labour that assigns domestic role to women in Ghana as note by Assibey-Mensah (1998), which allow little time to be spent on fish farms, contributes to inefficiency of production.

The coefficient of pond type dummy is also estimated to be significantly negative, implying that farmers who adopt the use of earthen pond for their operations tend to be less inefficient than concrete pond users. In addition to supplementary feed, fish farmers in Ghana rely on production of fish food through natural process by fertilization. Earthen ponds may provide a good medium for growth of live food. Pilley (1990) notes that most live food are rich in essential nutrients needed by fish for growth.

The coefficient of education in this study is surprisingly positive, suggesting that households with high level of formal education operate inefficiently in their production, although the relationship is weak. This is contrary to the finding of Battese et al. (1996) who obtained a positive relationship with technical efficiency and maximum years of formal schooling for a member of household. It may be necessary that formal education which enlightens farmers about the technical aspect of fish farming could be more important in Ghana to reduce inefficiency in the fish farming industry.

Technical efficiency

Technical efficiency estimated is depicted by the graph in Figure 1. It ranges between 0.16 and 0.99. About 29.3 percent of the farms have technical efficiency index above 0.90, whilst 48 percent of the farms have efficiency indices between 0.71 and 0.90. Thus about 77.3 percent of fish farms in Ghana have

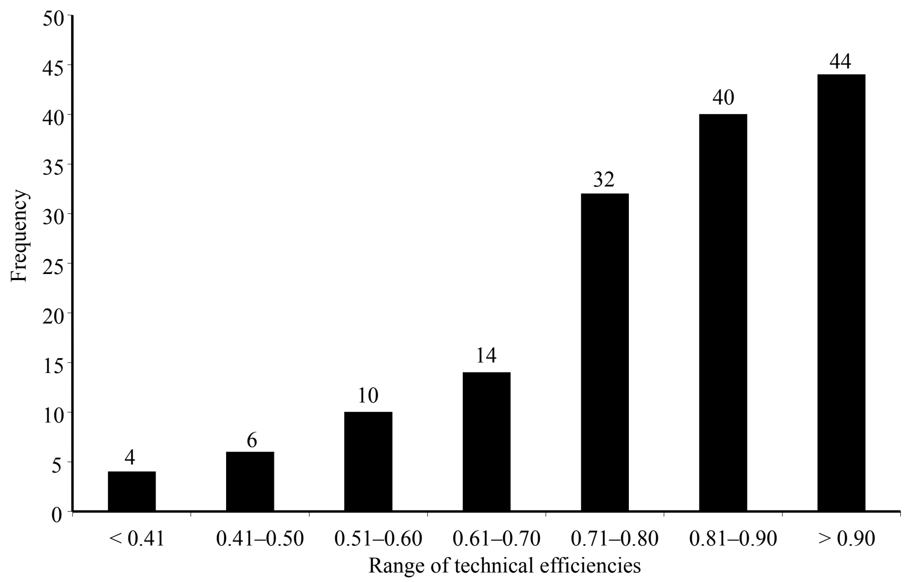

Figure 1. Frequency distribution of technical efficiencies

a technical efficiency index of 0.71 or above, whilst 22.7 percent of the farmers operate with efficiency level with indices between 0.16 and 0.70. The predicted mean technical efficiency is estimated to be 0.79. This indicates that on the average, fish farmers produced about 79 percent of the potential (stochastic) frontier output, given the present state of technology and input level. This means that about 21 percent of technical potential output is not realised. Therefore, the possibility of increasing fish farming production by an average of about 21 percent can be achieved in the short run by adopting the practices of the best fish farm.

CONCLUSION, POLICY IMPLICATION AND DIRECTION FOR FURTHER RESEARCH

The study finds that the values of coefficient estimated for all production inputs are positive. Results also reveal that although elasticity of output with respect to hired labour is slightly higher than the value obtained for family labour, the two sources of labour used for fish farming production in Ghana may be equally productive. Findings further show that extension visit to farms significantly enhanced fish farm production in the study area. The combined effects of factors involved in the technical inefficiency model are responsible for explaining the level and variations in production of fish farms in Ghana, although individual effects of some variables may not be significant. Results also suggest that small pond operators are less inefficient than farms with large ponds, however, the importance of this finding for policy purposes calls for further investigation. Mean technical efficiency is estimated to be 0.79, indicating that the realised output could be increased by about 21 percent without any additional resources.

Based on these findings, the study provides evidence to increase fish farm production through reduction in technical inefficiency by promoting and encouraging fish farmer's association to interact and exchange ideas between the old and young farmers and experienced and less experienced ones. Work of advisory service should be boosted by recruiting more agents for extension visits. Increased awareness about the benefits accruing from fish farming must be made to attract new entrants including women and young ones. Fish farming programs should be well integrated with the formal educational system at both basic and higher institutions to produce more fish farming experts. Orientation programs should be organised for existing fish farmers to ensure proper farming and management practices including pond stocking density measures. Government policy should also focus on ensuring easy accessibility of bank loans especially to young and small farms to expand their operations.

The study recommends further work to specify a stochastic frontier model which permits a more general structure. A more comprehensive study could also be considered using panel data to analyse technical change and time varying inefficiency.

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