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Research Note

EFFICIENCY IN POND FISH PRODUCTION THE CASE OF CREDIT AND CONTACT FARMERS UNDER MYMENSINGH AQUACULTURE EXTENSION PROJECT

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ABSTRACT

This paper uses a deterministic Cobb- Douglas production function to estimate efficiency of pond fish farms from Mymensingh, Bangladesh. We consider estimation of farm specific technical. allocative and economic efficiency using average and frontier production function which accommodates endogenous inputs because exogenous variables are beyond the control of the farms. Farm specific technical and allocative efficiency are estimated separately for both credit and contact farmers. Empirical results show that the mean level of technical efficiency for the credit and contact farmers are J8.*84*'~ and 98.79 respectively. Both categories of fish farms are technically. allocatively and economically efficient.

I. INTRODUCTION

Efficiency is a very important factor of productivity growth especially in developing agriculture where resources are very scarce. The crucial role of efficiency in increasing' agricultural output has been widely recognized by the researchers and policy makers. Technical inefficiency is not the only inefficiency. If the producers make mistakes in allocating inputs. the resulting inefficiency is labeled as allocative inefficiency. It always associated with some behavioral objective like profit maximization or cost minimization. Mistakes in allocation of resources and production of suboptimal level output increase cost and decrease profit. Consequently, identification of the inefficient producers is very important, especially for government policy designed to promote efficient utilization of resources. Considerable effort has been devoted to the analysis of farm level efficiency in developing countries. An underlying premise behind much of this work is that if the farmers are not making efficient use of existing technology. then effort designed to improve efficiency would be more cost effective than introducing new technologies as a means of increasing agricultural output (Belbase and Grahowski. 1885).

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Most of the empirical literature dealing with farm efficiency in developing countries has heen concerned exclusively with the measurement of technical efficiency (Huang and Bag]. 1984: KKalirajan. 1981. 1984: Lingard. Castillo and Jayasuria 1983; Kalirajan and shand. 1986: Shapiro and Muller. 1977; Rawlins, 1985; Philips and Marble 1986: Taylor and Shonkwiler. lytib. Dev and Hossain. 1995). By focussiin only on technical efficiency. these studies have ignored the gains in output that could be obtained by also improving allocative efficiency.

There are only a few studies that go beyond the measurement of technical efficiency in developing countries aericulture. These include the studies by Taylor. Drummond and Games (198G). which analyzed technical and economic efficiency for a sample Brazilian farmers; Bailey et at.. (1989) which measured technical, allocative and scale inefficiency for a sample of Ecnadorean milk producers; and Ali and Chaudry (1990) which examined technical, allocative and economic efficiency for a sample of Pakistani crop farmers; Bravo Ureta and Evenson (1994) which measured technical, allocative and economic efficiency of cotton and casava production by peasant farmers in eastern Paraguay.

The purpose of this paper is to contribute to the efficiency literature in developing country a"riculture in the context of pond fish farming by quantifying the level oftechnicaL allocative and economic efficiency for a sample of credit and contact farmers under Mymensingh Aquaculture Extension Project in Bangladesh. Section II discusses the analytical framework and data: while experimental results are discussed in the third section. The last section deals with some concluding remarks.

II. ANALYTICAL FRAMEWORK AND DATA

Efficiency as defined by the pioneering work of Farrel, is the ability to produce a given level of output at lowest cost. Efficiency can be estimated by separately estimating technical and allocative efficiency from a production frontier using farm survey data or by combining farmer with experimental data. Technical efficiency is defined as the ratio of farmer's actual Output to the technically maximum possible output at the given level of resources, allocative efficiency is expressed as the ratio of the technically maximum possible output at the farmer's level of resources to the output obtainable at the optimum level of resources and economic efficiency is simply the product of technical and allocative efficiencies. Deterministic production frontier was used to determine the efficiency of the pond fish farmers. Following Aigner et al.. (1977) and Meeusen and Van Den Broeck (1977) deterministic frontier production function was used to determine the efficiency of the pond fish production of the respondent farmers. The essential idea behind the deterministic model is that the error term is only U. Cobb-Douglas production function was used to calculate required coefficient for analysis of technical. allocative and economic efficiency. The deterministic production frontier in Cobb-Douglas specification can be written as:

$$Y = f(X)\, e^{u}, \qquad U \leq 0 \qquad (1)$$

and in the Cobb-Douglas form,

$$\log y = a + \sum_{j=1}^{n} \beta_j \log x_j + u, \qquad U \leq 0 \qquad (2)$$

the random disturbances (u) are assumed to follow a one sided distribution (e.g., truncated normal, gamma, exponential, etc.) and to be independently and identically distributied. In addition the set of inputs (x_j) are assumed to be independent of the disturbances.

Corrected ordinary least squares (COLS) regression is chosen as the most convenient means of estimating equation (2). That is, as a first step, OLS is applied to (2), yielding best linear unbiased estimates of the βj coefficients. The intercept estimate is then corrected by shifting the function until no residual is positive and one is zero. Greene (1980) has shown that a consistent, though biased, estimate of α, which imposes the sign uniformity on the residuals, will be generated by this procedure.

The empirically estimated Cobb-Douglas production function was specified in the present study as :

$$\text{Log}(y) = \log a + b_1 \log x_1 + b_2 \text{Log} x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5$$

Where y = return from pond fish farming (Tk. hectare/ year)

a = constant or intercept.

x_1 = cost of labour (Tk. /Hectare/year)

x_2 = cost of feed (Tk. /Hectare/year)

x_3 = cost of fertilizer (Tk. /Hectare/year)

x_4 = cost of manure (Tk. /Hectare/year)

x_5 = cost of fingerlings (Tk. /Hectare/year)

b_1, b_2, b_3, b_4, b_5, = co-efficient of the respective variables.

In order to estimate an efficient frontier, farm level data on input and output quantities are required. However, it is often the case that input and output quantity data are unavailable. Data are often available, however, on farm output revenues and input expenditures. Therefore in this study a common approach is used (Revenues and Expenditures data) as proxies for output and input quantities. This approach was also used by Ali and Chaudhry (1990).

To determine technical, allocative and economic efficiency deterministic production frontier method was used. The coefficient of the parameters were calculated by ordinary least square methods. From the deterministic production function coefficients, farm specific technical efficiency (TE_j) is measurd as follows:

$TE_j = AGR_j / MGR_j$

Where,

AGR_j = jth farmer's actual gross revenues and

MGR_j = jth farmers maximum possible gross revenues

MGR_j is measured by substituting the jth farmer's level of resources into the estimated deterministic frontier production function.

Farm specific allocative efficiency (AE_j) in use of variable input (i)

$AE_{ij} = MGR_j / OGR_{ij}$

Where,

OGR_{ij} is gross revenues at the optimum level of the ith input with all other inputs remaining at the level at which they were used by the jth farmer. Farm specific optimum input level was calculated by using MVP/MFC = 1 principle.

The allocative efficiency (AE_j) of all inputs on the jth farm was estimatied,

$AE_j = MGR_j/OGR_j$

Where,

OGR_j is the jth farmer's gross revenue at the optimum level of all variale inputs.

Farm specific economic efficiency (EE_j) was estimated using the following equation:

$EEj = TE_j . AE_j$

Where,

EE_j = Economic efficiency of jth farmer.
TE_j = Technical efficiency of jth farmer.
AE_j = Allocative efficiency of jth farmer.

Sources of Data

The data for the present study were collected from the credit and contact farmers under the Mymensingh Aquaculture Extension Project (MAEP) of Government of Bangladesh with financial and technical assistance provided by Danish International Development Agency (DANIDA). Its actual rural aquaculture support services started from June, 1990. The phase-1 project was confined within six thanas of Mymensingh district namely, Fulbaria, Ishwargonj, Gouripur, Trishal, Mymensingh Sadar and Muktagacha. In addition to these six thanas, the 2nd phase of the project was started in July, 1993 for a period of 7 years in another 20 thanas of Mymensingh, Kishorganj, Netrokona, Sherpur, Jamalpur, Tangail and Gazipur Districts.

The 1st phase of the Aquaculture Extension project (AEP) was a pilot or model to demonstrate the viability of an intensive extension and support programme which is expected to increase fish production through aquaculture in a given area in a relatively short period of time. The target beneficiaries of the project are the landless and marginal men and women farmers and pond operators who demonstrate a sincere interest in achieving higher aquaculture yields and sustainable income from their own or leased ponds. The project has emphasized to involve women as beneficiaries of the project. The basic strategy of the project is. through a relatively concentrated effort, to provide knowledge about semi-intensive pond aquacultw¯e to the pond opreator in the project area. The main theme is to establish an intensive extension programme in the project area for increasing fish production. The extension programme is based on already known technologies. Establishment of village type hatcheries on a private basis has been supported through training, technical assistance and credit.

The project aims at achieving improved aquaculture techniques through well trained and experienced village youths and establish high yielding aquaculture models for target pond resources. through intensive and constant technical assistance contacts. pond culture production demonstration and through infusion of credit. The project works with three types of farmers as follows - i) Demonstration Farmers. ii) Credit Farmers and iii) Contact Farmers. The Demonstration Farmers receive technical and financial support from the MAEP generally for a period of one year. The demonstration farmers were not considered while only credit and contact farmers were included in the present study. The Credit Farmers receive technical and financial support from the project. The credit farmers consist of poor. landless or marginal men and women. They may be labourers, unemployed youth or people who are already involved in small fisherises activities. Among the credit farmers at least 30 percent must be women. The contact farmers receive technical assistance but no financial assistance. The contact farmers consist of only sincere pond operator. Farmers may be either target as well as non target. The only criteriaon is that they own or operate a pond and are willing to follow project guidelines.

The data set for the present study was collected through field survey from the farmers of lshwaraanj Thana under the project involved in pond fish culture sinnce 1991. There were 75 credit farmers in the whole thana and 125 contact farmers in the five unions. Out of 75 credit farmers and 125 contact farmers 30 credit farmers and 30 contact farmers were selected randomly which constituted 40 percent of total credit and 24 percent of total contact farmers.

III. EMPIRICAL RESULTS

Table I shows the basic characteristics of the sample fish farms. The average family size is for the credit farm 6.83 persons and that for the contact farm is 5.77 persons. For the credit farm the average age of the farm operator is 35 years and his average years of schooling is 5.7

years. While for the contact farm, the average years of the farm operator is 34 years and his average years of schooling is 7.7 years. The average size of the pond of the credit and contact farms are 0.15 ha and 0.10 ha, respectively. Most of the farmers (56 percent and 53.3 percent of the credit and contact farmers, respectively) have small pond size (up to 0.15 ha) while 33.3 percent and 30 percent of credit and contact farmers, respectively, have medium size pond (0.16 to 0.30 ha). On the other hand, 10 percent and 16.7 percent of credit and contact farmers, respectively, have large ponds (above 0.30 ha). The per ha per year use of variable inputs for pond fish culture was higher for the credit farmers than for the contact farmers.

Table 1. Basic characteristics of the sample ponds farms, 1996

Description	Value	
	Credit Farm	Contact Farm
No. of households	30	30
Average ponds sige	0.15	10
Average family size	6.83	5.77
Education level of operator	5.7	7.7
Average age of operator	35	34
Percentage distribution of Ponds :		
Small (up to 0.15 ha)	56.7	53.3
Medium (0.16 to 0.30 ha)	33.3	30.0
Large (Above 0.30 ha)	10.0	16.7
Input use (per ha per year) :		
Labour (man-days)	376	238
Fingerlings (no.)	17851	14599
Feed (kg)		
Rice bran	3106	2850
Oil cake	266	225
Green vegetationer	5317	2099
Fertilizer (kg)		
Urea	215	137
TSP	314	172
Lime	169	136
Manure (kg)		
a) Cowdung	2359	2939
b) Compost :	8812	5958
Water hyacinth	5897	3532
Cowdung	2775	2346
Urea	70	40
Lime	70	40

Estimates of Average and Frontier Production Functions

The average and frontier production function analyses are presented in Table 2. In case of credit farmers, the elasticity of fish production with respect to labour is 0.3998. It indicates that a hundred percent increase in labour increases the total fish output by 39.9 percent. The elasticity of fish production with respect to feed is 0.084, implying that a hundred percent increase in feed use increases the total fish output by 8.4 percent. The elasticity of fish output with respect to fertilizer is 0.105, indicating that a hundred percent increase in fertilizer increases total fish output by 10.5 percent. The elasticity of fish output with respect to manure is 0.03, indicating that hundred percent increase of manure use increases fish output by 3 percent. The elasticity of fish output with respect to fingerlings is 0.024, indicating that a hundred percent increase of fingerlings use increases fish output by 2.4 percent. Returns to scale in variable inputs estimated through the sum of elasticities is 0.62, which implies that decreasing return to scale prevail in varibable input uses.

Table 2. Estimates of average and deterministic frontier production function

Parameters	Credit Farmer		Contact Farmer	
	Average Function	Frontier function	Average function	Frontier function
Constant	5.4322	5.5737	5.0764	5.2214
Labour	0.3998* (0.1257)	0.3998* (0.1257)	0.4218* (0.1463)	0.4218* (0.1463)
Feed	0.0841 (0.0664)	0.0841 (0.0664)	0.0377 (0.0638)	0.0377 (0.0638)
Fertilizer	0.1054** (0.0573)	0.1054** (0.0573)	0.0115 (0.0074)	0.0115 (0.0074)
Manure	0.0303 (0.0293)	0.0303 (0.0293)	0.0066 (0.0413)	0.0066 (0.4113)
Fingerlings	0.0245 (0.0633)	0.0245 (0.0633)	0.1817* (0.0596)	0.1817* (0.0596)

* Significant at 1% level.
** Significant at 5% level
Figures in the parentheses are standard errors.
Source : Field survey, 1995.

On the other hand, in case of contact farmers, the elasticity of fish output with respect to labour is 0.421, indicating that a hundred percent increase of labour increases fish output by 42.1 percent. The elasticity of fish output with respect to feed is 0.037, indicating that a hundred percent increase of feed increases fish output by 3.7 percent. The elasticity of fish output with respect to fertilizer is 0.011, which indicates that a hundred percent increase of fertilizer use increases fish output by 1.1 percent. The elasticity of fish output with respect to manure is very insignificant (0.006). The elasticity of fish output with respect to fingerlings is 0.181, indicating that a hundred percent increase of fingerlings use increases fish output by 18.1 percent. Returns to scale in variable inputs estimated through the sum of elasticities is 0.62, which implies that decreasing return to scale prevail in variable input uses.

Technical, Allocative and Economic Efficiency of the Pond Fish Farmers

The results of the technical, allocative and economic efficiencies are presented in Table 3. The average technical efficiency of the credit farmers and the contact famers are 0.9880 and 0.9874 respectively, which indicates that credit and contact farmers are only 1.20 and 1.26 percent technically inefficient. This means that there exists only 1.20 and 1.26 percent potential for increasing credit and contact farmer's income respectively at the existing level of their resources. But the results of the "t" test confirmed that the technical efficiency co-efficients of credit and contact farmers were not significantly different from 1. The calculated values of "t" for credit and contact farmers with 29 d. f. were 9.81 and 9.32 respectively, but at the 1% level of significance the tabulated value of "t" with same d. f. was 2.46. Hence, the null hypothesis was rejected indicating that credit and contact farmers were technically efficient. In judging the mean difference of technical efficiency between credit and contact farmers the result of the "t" test confirmed that there was no singnificant difference in technical efficiency between credit and contact farmers.

Table 3. Technical, allocative and economic efficiency of pond fish farmers

Type of efficiency	Credit farmer		Contact farmer	
	Average efficiency level	Standard deviation	Average efficiency level	Standard deviation
Technical	0.9880	0.0067	0.9874	0.0074
Allocative :				
Overall	0.9702	0.0061	0.9648	0.0069
Input specific :				
Labour	0.9531	0.0107	0.9386	0.0130
Feed	0.9414	0.0338	1.0414	0.0465
Fertilizer	0.8633	0.0327	0.9592	0.3826
Manure	0.9849	0.0697	1.2198	0.0855
Fingerlings	1.1455	0.0322	0.9076	0.0271
Economic	0.9586	0.0090	0.9526	0.0100

Source : Field Survey, 1995.

Overall allocative efficiency of the credit farmers and the contact farmers are 0.9702 and 0.9648 respectively which means that there is a probability to increase farmer's gross revenues by increasing resources properly. But the results of the "t" test indicate that both credit and contact farmers were allocatively efficient. In case of allocative efficiency the calculated values of "t" for credit and contact farmers with 29 d. f. were 25.63 and 27.94 respectively while at 1% level of significance the tabulated value of "t" with same d. f. was 2.46. The calculated values were much higher than tabulted value. So, the hypothesis was rejected indicating that credit and contact farmers were allocatively efficient. Justifying the mean difference of overall allocative efficiency between credit and contact farmers, the results of "t" test showed that there was a significant difference in the overall allocative efficiency between the two types of farmers.

The individual allocative efficiency of labour, feed, fertilizer, manure and fingerlings for credit farmers are 0.9531, 0.9414, 0.8633, 0.9849 and 1.1455 respectively. In case of labour, feed and fertilizer the credit farmers are allocatively inefficient at 5 percent, 6 percent, and 14 percent respectively which means that there is a potential to increase the credit farmer's gross revenues by increasing labour, feed and fertilizer. In case of manure, the credit farmers are 0.9849 percent efficient which is close to unity indicating that the credit farmers are almost efficient in use of manure. The allocative efficiency of fingerlings of credit farmers is greater than one which indicates that the credit farmers stocked more fingerlings, as a result, credit farmers are allocatively inefficient in fingerlings stocking. So, the credit farmers should decrease fingerlings stocking to increase their gross income. The individual allocative efficiency of labour, feed, fertilizer, manure and fingerlings for contact farmers are 0.9386, 1.0414, 0.9592, 1.2198 and 0.9076 respectively. In case of labour, fertilizer and fingerlings the contact farmers are allocatively inefficient at 6 percent, 4 percent and 9 percent respectively, which means that there is a potential to increase contact farmer's gross revenues by increasing labour, fertilizer and fingerlings. The allocative efficiency of feed and manure of contact farmers are greater than one which indicates that contact farmers use more feed and manure, as a result, contact farmers are allocatively incfficient in use of feed and manure. So, the contact farmers should decrease feed and manure use to increase their gross income.

The economic efficiency of the credit and the contact farmers are 0.9586 and 0.9526 respectively, which means that there exists a potential for increasing the gross revenues of credit farmers by 4 percent and contact farmers by 5 percent to use the available resources properly. To determine whether economic efficiency coefficients of credit and contact farmers are significantly diffeerent from one, "t" test was also done. The calculated values of "t" with 29 d. f. for credit and contact farmers were 25.06 and 25.96 respectively. But the tabulated value of "t" at 1 percent level of significance with same d. f. was 2.46. Since the calculated values were much higher than the tabulated value, the set hypothesis was rejected. This implies that credit and contact farmers were economically efficient. To judge the mean difference of economic efficiency between credit and contact farmers, the calculated "t" value with 58 d. f. was found 2.42. But the tabulated value of "t" at 1 percent level of significance with same d. f. was 2.39. As calculated value was higher than the tabulated value, the null hypothesis was rejected indicating that there was a significant difference in economic efficiency between the two groups of farmers.

IV. CONCLUDING REMARKS

Pond fish production can be increased either by increasing the size of pond or improving the production technology in existing ponds. Considerling the scarcity of land in this country, fish production should be increased through intensification, rather than increasing farm size or constructing new ponds. The Mymenshing Aquaculture Extension Project has developed a model field extension programme which is effective in spreading semi-intensive fish culture to farmers. The study revealed that pond fish production in the study area was mainly based on stocking of fingerlings, application of manure, fertilizer, supply of supplementary feed and human labour for different phases of operations and pond management. The study found that pond fish farming is a highly profitable business. Credit farmers are more profit earner between the two types of farmers. The study reveals that the production of pond fish are positively related with the variable inputs such as labour, feed, fertilizer, manure and fingerlings. The present study found that pond fish farmers were technically, allocatively and economically efficient which support Schultz's (1964) 'poor-but efficient' hypothesis of traditional agriculture.

V. LIMITATION OF THE STUDY

Present study did not analyze factors affecting efficiency or inefficiency of the fish farmers. There is further research scope on this issue. The results of this study could not be generalized for the pond fish farmers of Bangladesh as a whole. Further research could be conducted on this topic covering all Bangladesh.

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