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COMPARATIVE STUDY OF TRADITIONAL vs. SCIENTIFIC SHRIMP FARMING IN WEST BENGAL: A TECHNICAL EFFICIENCY ANALYSIS

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COMPARATIVE STUDY OF TRADITIONAL vs. SCIENTIFIC SHRIMP FARMING IN WEST BENGAL: A TECHNICAL EFFICIENCY ANALYSIS

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Abstract

Applying a Stochastic Production Frontier to farm-level data from shrimp farmers in West Bengal, India, this paper examines technical efficiency and its determinants in both scientific and traditional shrimp farming systems. The empirical results suggest high degrees of technical inefficiency among the shrimp farmers at household level. The scientific shrimp farmers have a higher technical efficiency than their traditional counterparts. This necessitates government policy initiatives and extension programmes which will help the shrimp farmers especially the traditional ones of the state to utilize the best of their resources and enhance their production substantially. The government should also give adequate attention to small shrimp producers by providing them credit and other extension facilities.

Introduction

Shrimp has become an important item in the world's seafood production since it forms 20% of the world seafood production and 30% of the world seafood trade. Asian countries like Taiwan, Indonesia, Thailand and India have emerged as global leaders in shrimp production from the past two decades. India, the fifth largest shrimp producing country in the world has achieved considerable progress in shrimp production. Shrimp accounts for 58% of the total value of marine product exports from India. Taking note of the potential of brackish water aquaculture in general and shrimp culture in particular, government has taken many initiatives to promote this sector. The commercial shrimp culture received special attention when it was declared as the "Sunrise Industry" in the eighth five year plan. Nevertheless, the country lags behind in terms of productivity of shrimp compared to other shrimp producing countries in

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Asia.[1] In order to improve the productivity of shrimp in India various steps have been taken which includes up-gradation of technology. In India, semi-intensive scientific shrimp farming technology was introduced in order to enhance the productivity of shrimp farming. But traditional (improved) and extensive shrimp farming continues to dominate in the country and occupies more than 70% of the area under shrimp farming. The productivity of shrimp farming in India can be enhanced either by adopting advanced scientific techniques or by increasing production efficiency. However, improvement in efficiency is more cost-effective than introduction of new technologies if the producers are not efficient (Belbase and Grabowski, 1985; Dey et al., 2000). Thus, improving the efficiency of the shrimp farmers, assumes great importance. This necessitates studies on technical efficiency of shrimp farming across alternative shrimp farming systems and states. A study on technical efficiency of two different shrimp farming systems would help to identify whether the shrimp farmers adopting the advanced scientific shrimp farming system are using the technology in an efficient manner as compared to the traditional[2] shrimp farmers. Such studies would be useful for the policymakers to identify the scope for improving shrimp production using the existing technology.

The technical efficiency of shrimp farming in India has been studied only by few authors like Gunaratne and Leung (1996), Kumar et al (2004), Uma Devi and Prasad (2004) etc. Both the studies by Gunaratne and Leung (1996) and Uma Devi and Prasad (2004) revealed little difference between the technical efficiencies of the alternative shrimp farming systems extensive, and semi-intensive (these systems are similar in nature to the traditional and scientific shrimp farming system as mentioned in the study). But these studies focused on shrimp farms with average farm size of more than 2 hectares. In India more than 80% of the shrimp farmers belong to the category with farm sizes less than 2 hectares. So, a study on shrimp farmers culturing shrimp at household level and at smaller shrimp farms assumes importance.

In this respect the present study attempts to estimate the technical efficiency of alternative shrimp farming systems operated by household level small holders in West Bengal. West Bengal ranks second in terms of area under shrimp culture and third in terms of shrimp production among the Indian maritime states. Thus, the state provides suitable scope for studying the efficiency of alternative shrimp culture systems. The present paper also attempts to identify the factors influencing technical efficiency in shrimp production under two alternative shrimp farming systems.

The paper is organized as follows. The next section outlines the stochastic frontier production function methodology employed to measure the technical efficiency. The third section discusses the specification of the model for empirical estimates. The fourth section describes the data source used. The fifth section presents the results obtained and the final section summarizes the main findings and suggests policy implications.

Methodology

The concept of technical efficiency was first introduced by Farell (1957). Later Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) propounded stochastic frontier model with composite error term in order to estimate technical efficiency. The use of Stochastic Frontier Production Function to measure the technical efficiency of Indian agriculture is quite wide. But the use of Stochastic Frontier Production Function in aquaculture is comparatively recent. In the context of Asian aquaculture, studies by Sharma (1999), Sharma and Leung (1998), Gunaratne and Leung(1996), Dey *et al.*(2000) have used Stochastic Frontier Production Function to measure technical efficiencies of different aquaculture products like Carps, *Telapia* and Shrimp .

In the present study the Stochastic Frontier Production Approach is used to estimate the technical efficiency of traditional and scientific shrimp farming in West Bengal. The Stochastic Frontier Production Function with a composite error term is more appropriate for measuring efficiency in the context of developing country agriculture where the probability of the data being influenced by errors of measurement and the effects of weather conditions, disease etc, is high (Coelli *et al,* 1998; Dey et al., 2000). Hence, in order to examine the efficiency of shrimp farming we have adopted the Stochastic Frontier Production Function approach. A review of technical efficiency analysis in shrimp culture by Sharma and Leung (2003) provides some useful insights towards the use of appropriate methodologies for efficiency analysis in aquaculture. It has been argued that in the case of multi-output aquaculture system Data Envelopment Analysis (DEA) is more appropriate, but in the case of aquaculture products like shrimp, which are highly susceptible to disease outbreak, Stochastic Frontier Production Function is a more appropriate approach. Following this line we have used Stochastic Frontier Production function to measure the efficiency of traditional and scientific shrimp farming at the household level.

The stochastic frontier is defined as the maximum output attainable from a given set of measured inputs and technology. In Stochastic Frontier Production Approach error term is decomposed into two components. The symmetric component captures random variation in output due to the factors that are not under the farmers' control. This term accounts for measurement errors and other random factors such as effects of weather, disease outbreak, luck etc. The other component is a one-sided error accounting for production loss due to unit-specific technical inefficiency. The model can be introduced in a production function specified as:

$$\ln Y_i = X_i \mathrm{b} + v_i - u_i \text{ , i = 1, 2,............N} \qquad \text{........} \qquad (1)$$

Where, Y_i is output of the i th farm. Xi is a (k+1) row vector, whose first element is 1 and remaining elements are logarithms of the quantities of inputs used by i^{th} farm and β is a (k+1) column vector of unknown parameters to be estimated associated with the X_i. The estimated values of β indicate relative importance of each input in production. The term v_i is the symmetric component which captures random variation in output due to factors which are not under the farmers' control. v_i is assumed to be identically and independently distributed N (0, σ_v^2). The one-sided component u_i is assumed to have a non-negative (half-normal) distribution with mean 0 and variance σ_u^2. u_i is always greater than or equal to zero and assumed to be independent of the random error, v_i .A higher value of u_i indicates higher technical inefficiency. If u_i is zero then the farmer is perfectly technically efficient.

Under the above mentioned assumptions Aigner, Lovell and Schmidt (1977) derived the log likelihood function in terms of two variance parameters. $\sigma^2=\sigma_v^2+\sigma_u^2$ and $\lambda=\sigma_u/\sigma_v$. Another alternative parameterization of the model is provided by Battese and Corra (1977). The parameter is $\gamma=\sigma_u^2/\sigma^2$, which has a value between 0 and 1. γ is defined as the total variation of output from the frontier which can be attributed to technical inefficiency (Battese and Corra,1977). A zero value of γ indicates that deviation from frontier is entirely due to noise while a value of one would indicate that the deviations are entirely due to technical inefficiency (Coelli et al, 1998).

The log-likelihood function can be specified as

$$\ln(L) = -\frac{N}{2}\ln(\Pi/2) - \frac{N}{2}\log(\sigma^2) + \sum_{i=1}^{N}\ln[1-\Phi(z_i)] - \frac{1}{2\sigma^2}\sum_{i=1}^{N}(\ln Y_i - X_i\beta)^2 \quad \text{.......(2)}$$

Where $z_i = \frac{(\ln Y_i - X_i\beta)}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}}$ and Φ (·) is the distribution function of standard normal random variable.

The technical efficiency of the i^{th} farm can be defined as:

$$TE_i = \frac{Y_i}{\exp(X_i\beta)} = \exp(-u_i) \quad \text{..............................(3)}$$

From equation (3) it can be seen that farm specific technical efficiency measures are defined as $TE_i=\exp(-u_i)$. This includes unobservable u_i s. The best predictor of ui is the conditional expectation of ui given v_i-u_i. Battese and Coelli (1988) pointed out that the best predictor of exp (-ui) is,

$$E\left[\exp(-u_i)/e_i\right] = \frac{1-\Phi(\sigma_A + \gamma e_i/\sigma_A)}{1-\Phi(\gamma e_i/\sigma_A)}\exp(\gamma e_i + \sigma_A^2/2) \quad \text{..............................(4)}$$

$$\sigma_A = \sqrt{\gamma(1-\gamma)\sigma^2} \text{ and } e_i = \ln(Y_i) - Xi\beta$$

The technical efficiency can be obtained by replacing the unknown parameters by the maximum likelihood estimates of the parameters.

For the frontier model (specified as equation 1) the null hypothesis that there are no technical inefficiency effects in the model can be checked by considering $H_0:\sigma^2_u = 0$, as against $H_1: \sigma^2_u > 0$. This hypothesis can be alternatively tested as $H_0: \gamma = 0$, as against $H_1: \gamma$ 0 using one-sided generalized likelihood ratio test.[3]

After obtaining the technical efficiency scores, in the second stage, the technical efficiency scores are regressed across different farm specific variables in order to identify the factors influencing technical efficiency in shrimp culture.

Model Specification

In order to measure farm level technical efficiency scores we have specified Stochastic Production Frontier with Cobb-Douglas functional form propounded by Aigner et al. (1977) and Meeusen and Van den Broeck (1977). Other more flexible functional forms could have been chosen. Since Cobb-Douglas functional from is widely used in studies estimating technical efficiency of agricultural production (Battese, 1992), in the present study, this function form is chosen. The Stochastic Frontier Production Function with Cobb- Douglas functional form for *scientific* shrimp farming system is specified as:

$$\ln Y = \alpha + \beta_1 \ln Stock + \beta_2 \ln LAB + \beta_3 \ln Feed + \beta_4 \ln PUMPHR + \beta_5 \ln FERT + \beta_6 \ln CAP + \beta_7 D_1 + \beta_8 D_2 + v_i - u_i \quad (3)$$

Where, Y is the output (gross return of the ith shrimp farmer in Rs./acre) , Stock is the number of shrimp seed stocked per acre, LAB is the hired and family labour used in production (man days/acre), Feed is amount of shrimp feed used (Kg./acre), PUMPHR is the machine power used in production measured in terms of total pump hour used in production (hour/acre), FERT is expenditure on fertilizers and other medicines (Rs./acre), CAP is the capital cost incurred in the production which includes depreciation and interest on farm building and construction, farm machineries and other farm equipment (Rs./acre). D1: Dummy variable; = 1, if the shrimp farm(s) is situated at a distance of 100 meters to 500 meters from the creek; =0 otherwise. D2: Dummy variable; =1, if the shrimp farm(s) is situated at a distance of more than 500 meters from the creek; =0 otherwise.

Given the different nature of production in traditional shrimp farming we have specified the Stochastic Frontier Production Function for traditional farmers as follows:

$$\ln Y = \alpha + \beta_1 \ln Stock + \beta_2 \ln LAB + \beta_3 \ln FERT + \beta_4 \ln CAP + \beta_5 D_1 + \beta_6 D_2 + v_i - u_i \quad (4)$$

The technical efficiencies under the above mentioned assumptions for scientific and traditional shrimp farming are estimated using Maximum Likelihood Method with the help of Frontier 4.1 software, which also considers γ parameterization of the frontier model for estimation.

The Schumpeterian theory of development emphasizes that efficiency of a farmer depends on the technological know-how and on the socio-economic conditions under which they work (Kalirajan and Shand, 1994). Accordingly we have included the variables representing the socio-economic characteristics of the shrimp farmers as factors determining their technical efficiency. For example, EDU is a continuous variable representing the number of years of education of the shrimp farmers. EXP is another continuous variable reflecting the number of years of experience that shrimp farmers possess in shrimp farming. Shrimp farmers exposure to information is represented by the variable TR which is defined as the number of training programmes or meeting related to aquaculture attended by the shrimp farmers. ASSET is a continuous variable for the value of non-farm asset of the shrimp farmers[4]. Farmers association with the other fisheries related activities is captured by dummy variable OFISH which assumes value 1 if the shrimp farmer is associated with fisheries related activities and 0 otherwise. We have included dummy variables for the size groups of shrimp farmers. The variable FMAR is a dummy variable which takes value 1 if the shrimp farmer is a marginal farmer and 0 otherwise; FSMALL is a dummy variable which takes value 1 if the shrimp farmer is small farmer and 0 otherwise; FMED is a dummy variable which takes value 1 if the shrimp farmer is a medium farmer and 0 otherwise. Since there are no shrimp farmers culturing shrimp in more than five acres of land in the case of scientific shrimp farming, the category of shrimp farmer has been represented by only two dummy variables, FMAR and FSMALL considering medium shrimp farmers as the base category. The tenure status of the shrimp farms is represented by the continuous variable LEASEPR, the proportion of leased area to total operational area under shrimp culture. GP is a dummy variable representing the gram panchayat to which the shrimp farmer belongs. In the case of traditional shrimp farming, GP=1, if the shrimp farmer belongs to Bermajur-I gram panchayat and 0 otherwise. In the case of scientific shrimp farming, GP=1, if the shrimp farmer belongs to Heria gram panchayat and 0 otherwise.

The important reasons for including these variables and their expected signs are as follows:

The variables EDU and EXP are expected to have a positive impact on the technical efficiency. Education and experience of the farmers capture the role of human capital in improving efficiency. The education and experience of the shrimp farmers are expected to help shrimp farmers to adopt better farm management practices. As evident from the literature, tenure status can affect efficiency in two ways. Theoretical arguments on the effect of tenure status on efficiency follow two streams. The Marshallian argument considers the tenants under sharecropping contracts as inefficient relative to owner operators, in the absence of supervision.

The other streams of literature consider tenancy as a second best solution. It is also argued in the literature that the efficiency of the tenants who pay fixed rentals for leased-in land is almost same the as that of the owner operated farms(Mookherjee, 2001). In the present case shrimp farmers who cultured shrimp solely on leased-in land were limited in number. The shrimp farms were often a mixture of own land and leased-in land. Thus in this case instead of considering the tenure status of the shrimp farms we have considered the continuous variable LEASEPR as one of the explanatory variables of technical efficiency. If the supervisory factors and higher application of family labour in the owner operated shrimp farms work, the owner operated shrimp farms can be considered to be more efficient than the shrimp farms based largely on leased land. The insecurity of land rights can also work as an impediment to shrimp farmers for investing in long term land improvement measures which might lead to inefficient use of the resources. Thus, following this line we assume that LEASEPR will have a negative coefficient. The shrimp farmers' association with the fisheries related activities is supposed to expose them to higher information and other facilities. Thus the association of the shrimp farmers with fisheries related activities is expected to have higher technical efficiency than those who are related to non-fisheries activities as their supporting occupation. The non-farm asset of the shrimp farmers is included as an indication of economic the condition of the shrimp farmers. It is expected that the shrimp farmers who are having more non-farm asset would be able to invest more in the shrimp farms and hence would be able to achieve better technical efficiency. But it should be mentioned in this case that comparatively rich shrimp farmers generally engage themselves into various other businesses and depend mainly on hired labour for the supervision of their farms. The lack of personal supervision may act as a hindrance in attaining the maximum possible output with given input levels and technology. Different categories of shrimp farmers have been included in order to find out how far the technical efficiencies of smaller categories of shrimp farmers differ from the highest size group in the cases of traditional and scientific shrimp farming.

The regression equation for factors influencing technical efficiency of shrimp farming is specified as :

$$TE_i = \alpha + \beta_1 FMAR + \beta_2 FSMALL + \beta_3 FMED + \beta_4 EDU + \beta_5 EXP + \beta_6 LEASEPR + \beta_7 TR + \beta_8 OFISH + \beta_9 ASSET + \beta_{10} GP + e_i \qquad (5)$$

Where e_i is the error term.

Data

The technical efficiency of traditional and scientific shrimp farming in West Bengal was estimated using farm level cross section data for the year 2004-2005. The sample shrimp farmers were selected by multistage stratified random sampling. In West Bengal brackish water, shrimp farming exists in three coastal districts- North 24 Parganas, South 24 Parganas and East Midnapur. Traditional shrimp farming is prevalent in the North 24 Parganas and South 24 Parganas district. The semi-intensive scientific farming is practiced in East Midnapur district. As the North 24 Parganas district covers higher area under shrimp culture than South 24 Parganas and the percentage of utilization of the potential area in this district is also higher, we chose North 24 Parganas district for studying traditional shrimp farming[5]. Since, the present study looks into the economics of small-scale household-level shrimp culture, first we identified the blocks where household level small-scale shrimp culture existed in the selected districts. In North 24 Parganas district, small-scale shrimp culture is a predominant practice in the Sandeshkhali region. From North 24 Parganas district, Sandeshkhali-II block was purposively selected where small-scale shrimp culture following traditional farming system is a prominent practice among the village households. Sandeshkhali-II block is located in the lower part of Sandeshkhali, where the salinity level of river water ranges from 10-20 ppt[6]. The household level small-scale shrimp culture started in the area during the mid 1990s mostly by conversion of agricultural land to shrimp ponds.

While selecting the block for studying household level small scale scientific shrimp culture from the East Midnapur District, our choice fell on Khejuri-I block which is also situated in a medium saline brackish water zone (salinity level 10-20 ppt). The household level shrimp culture started in the same period as in the selected block for studying traditional shrimp farming. From each block, two Gram Panchayats and from each Gram Panchayat two villages were selected randomly. The shrimp farmers in the selected villages were identified and grouped into four categories according to their operating area under shrimp farming, i.e., marginal - less than 1 acre operational holding under shrimp farming, small -greater than or equal to 1 acre but less than 2.5 acres operational holding under shrimp farming, medium -greater than or equal to 2.5 acres but less than 5 acres operational holding under shrimp farming and large- greater than or equal to 5 acres operation holding for shrimp farming[7]. At the next stage proportionate random sampling (30% from each category in the case of traditional shrimp farmers and 50% from each category of scientific shrimp farmers) was followed in order to select the shrimp farmers. Finally, a total sample of 108 traditional and 100 scientific shrimp farmers was selected for the study.

Before getting into the analysis it is important to have a brief idea about the history of shrimp culture in the study areas. In Sandeshkhali-II block there was no brackish water shrimp culture before 1975,as tank fisheries were existing in this area. Local people used to lead a life of immense hardship depending on cultivation of paddy and out-migrating as casual labourers for their livelihood. Before 1990s Bermajur-I Gram Panchayat was fully dominated by agriculture with one-crop paddy cultivation as the major means of land use in this area. In 1992-93 *boro* paddy cultivation started with the help of additional irrigation facilities. But in early 1997 because of low water levels, irrigation became a major problem for the paddy cultivators and they reported low returns. The farmers faced a grave situation and as an alternative shrimp culture in own lands started sprouting. However, farmers who had leased out their land to big fisheries started facing problems in respect of repayment of the lease money or in some cases profit share. The landholders who could not use their land in other ways, decided to culture shrimp on their own so that in years of good production, good returns would be ensured. In the same way in Sandeshkhali Gram Panchayat large shrimp farms started coming up in 1985 and many small farmers started leasing-out their river side lands to big fisheries. Gradually, after 1996 farmers started culturing shrimp in their own land.

Scientific farming was first initiated in Digha and Contai region of East Midnapur district in West Bengal. Big corporate houses like Jains, Hindustan Liver etc. ventured into this business in 1990-91. But during 1994-95 due to massive disease outbreaks these companies started incurring huge losses. Seed prices were also hiked during this time and coupled with these problems, pollution control regulations imposed by Aquaculture Authority of India in 1996 compelled large corporate bodies to leave the business. Small household level shrimp farms using scientific techniques started to operate in this area in 1996-97. The World Bank project also facilitated the development of small scale shrimp culture by either converting agricultural land or existing ponds. Given this backdrop the technical efficiency estimations of the present paper will shed some light on the performance of the shrimp farmers who had taken up the risky shrimp farming giving up agricultural production.

Results and Discussion

A summary of values of the key variables used in the estimation of stochastic frontier production function and the farm specific factors determining technical efficiency are presented in Table A2 and A3 respectively in Appendix 1. It can be observed from the tables that the traditional shrimp farmers on the average use 153 man-days of labour, per acre, whereas scientific shrimp farming requires a higher labour input amounting to 439 per acre. As demands of the corresponding technologies vary, more intensive scientific shrimp framing has a higher use of capital, labour as well as fertilizers in shrimp production.

The socio-economic characteristics of the shrimp farmers used as determinants of technical efficiency are presented in Table A3 of Appendix 1. It can be observed that the level of experience of the sample traditional shrimp farmers is higher than that of the scientific shrimp farmers. The sample scientific shrimp farmers are having higher level of education. In the case of sample traditional shrimp farmers the proportion of leased land in shrimp farms is more.

The results of the estimation of the Stochastic Frontier Production Function for traditional and scientific shrimp farming are presented in Table 1. In case of traditional shrimp farming, coefficients of all the inputs are significant and have the expected positive sign except fertilizer (FERT). The results show that the per acre output in traditional shrimp farms is positively related to labour, stocking of shrimp seeds and the capital cost incurred in production. The slope coefficient of capital has the highest elasticity followed by that for stocking of shrimp seeds. Only coefficient of fertilizer has negative effect on output in the case of traditional shrimp farming, although it is not statistically significant. Further, the estimation results signify that location of the shrimp farms also has a significant impact on shrimp output. The coefficient of dummy variable D_2 is negative and statistically significant. This implies that traditional shrimp farms which are located at a distance more than 500 meters from the creek yield less output.

Table 1: Maximum Likelihood Estimates of the Stochastic Production Frontier for Scientific and Traditional Shrimp Farmers

Variables	Scientific shrimp farmers Coefficient	Traditional shrimp farmers Coefficient
Constant	7.84* (3.89)	7.6* (5.9)
Stock	-0.03 (0.21)	0.22** (2.03)
LAB	-0.06 (1.17)	0.12*** (1.80)
Feed	0.35* (4.16)	-
PUMPHR	0.11* (2.91)	-
FERT	-0.002 (-0.017)	-0.08 (-0.61)
CAP	0.18*** (1.89)	0.26** (1.99)
D1	-0.19 (-1.04)	-0.11 (-0.4)
D2	-0.27** (-2.4)	-0.73* (-2.66)
γ	0.79* (8.41)	0.71* (7.47)
σ^2	0.66* (4.6)	2.18* (5.07)
Log-likelihood	-83.71	-160.29
Mean TE	0.61	0.49

Source: Primary Survey, Note: (1) Numbers in parentheses are the t-statistics; (2) The number of observations is 100 for scientific and 108 for traditional shrimp farming, (4)*, **and*** denote that the coefficients are significant at 1%, 5% and 10% respectively.

The significant value of γ indicates that the difference between observed output and actual output is not only due to factors that are beyond the farmer's control, but also due to some technical inefficiency. The value of γ (0.71) signifies that 71% of the difference in observed and the frontier output is primarily due to factors, which are under the control of the farmers. The mean technical efficiency of the traditional shrimp farmers is estimated as 49%. This implies, using the existing inputs in an efficient manner, the traditional farmers can increase the output by 51%.

In the case of scientific shrimp farming, the slope coefficients of the inputs, feed, pumphours and capital are statistically significant and have positive influence on output. Feed has the highest elasticity of output followed by capital and pump hours in the case of scientific shrimp farming. As for the case of traditional shrimp farming, for scientific shrimp farmers also we find that location of shrimp farms has significant influence on output. It can be observed from Table 1 that scientific shrimp farms which are located at a distance above 500 meters from the creek yield lesser output. The significant value of γ implies that the difference between observed output and actual output is not only due to the statistical variability alone, but also due to the technical inefficiency.

The value of γ (0.79) signifies that 79% of the difference in observed and the frontier output is primarily due to factors, which are under the control of the farmers. The mean technical efficiency of the scientific farmers is estimated as 61%. This implies that scientific shrimp farmers realize only 61% of the potential output, which they can produce, with the existing levels of inputs. So, without increasing the use of inputs, just by following the best possible management practices the scientific shrimp farmers can enhance their output by 39%.

The frequency distribution of the technical efficiency of the traditional and scientific shrimp farmers is depicted in Fig 1. It can be observed from the figure that more than 40% of the traditional shrimp farmers operate within the range 0.40 - 0.50 of technical efficiency. Twenty percent of the traditional shrimp farmers also operate within the range

0.50-0.60. This implies that most of the traditional shrimp farmers can enhance their input by 50 % if they follow the best practice. The figure also depicts that most of the scientific shrimp farmers operate within the technical efficiency ranges 0.6- 0.7 and 0.7-0.8, which is higher than that of the traditional shrimp farmers.

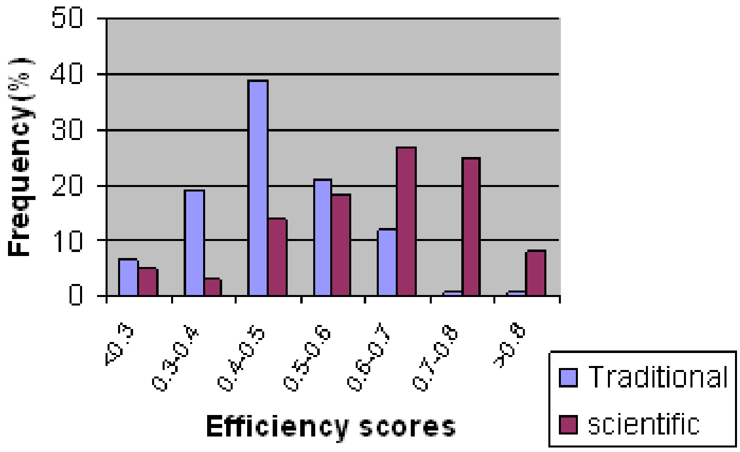

Fig.1: - Frequency Distribution of Efficiency Scores of Traditional and Scientific Shrimp Farmers

The above estimation of the technical efficiency of traditional and scientific shrimp farmers reveals that there is high level of inefficiency in household level small-scale shrimp farming in West Bengal. The inefficiency is significantly high in traditional shrimp farming. The estimates from the present study for scientific shrimp farming are almost similar to the all India estimate of technical efficiency by Shang *et al.* (1996), which amounts to 0.64 for semi-intensive shrimp farming. But efficiency estimate of extensive shrimp farming by Shang et al. (1996) was 0.61, which is much higher than that of traditional (which by nature is similar to extensive shrimp farming) shrimp farming in the present study. Efficiency estimates of extensive and semi-intensive shrimp farms in Nellore district of Andhra Pradesh by Uma Devi and Prasad (2004), who gave values of 0.81 and 0.83, respectively, were substantially higher than those of the present study. This Signifies that despite being the second largest state in terms of area under shrimp culture and third among the states in terms of production, shrimp farmers in West Bengal were quite incompetent in terms of efficiency. This suggests that given proper extension facility and government patronage, the shrimp farmers can substantially improve their production and contribute to the export earnings of the state.

Profile of Traditional and Scientific Shrimp Farmers by Technical Efficiency Rankings

After obtaining the farmer specific technical efficiencies as described in the previous section, now let us observe the profile of the traditional and scientific shrimp farmers across the technical efficiency rankings. For this purpose we have divided the technical efficiency scores for both traditional and scientific shrimp farmers into four categories-low(0 to 0.30), medium (0.31 to 0.50), moderately high(0.51 to 0.70) and high (above 0.70). The profile of the categories of farmers belonging to different technical efficiency groups has been analyzed in terms of the level of output, ownership of license for shrimp farming, the farmer's association with the village level committees and organizations and the disease-management practices followed by the shrimp farmers. Table 2 and Table 3 furnish the profile of the shrimp farmers across various categories of technical efficiency for traditional and scientific shrimp farming, respectively. Instead of taking the absolute level of output (in terms of gross return from the shrimp farm per acre), we have classified the output into four categories- Low, Medium, Moderately high and High.

It can be observed from Table 2 that in the case of traditional shrimp farming, the farmers having low technical efficiency belong to only low and medium level of output. Most of the traditional shrimp farmers who belonged to the medium technical efficiency group also produced medium level of output per acre. Among the traditional shrimp farmers belonging to high level of technical efficiency none were in low and medium output category and 50% of them obtained high output. This implies that in the case of traditional shrimp farming, the higher the level of output/acre, the greater was the ability of the shrimp farmers to reach the frontier . The table also reveals that the traditional shrimp farmers belonging to low efficiency rank had highest percentage of farmers attached to the village level farmers' association. This suggests that, by just being a member of the local /village association a shrimp farmer does not achieve higher efficiency in traditional shrimp farming. Table 2 also shows that the higher the level of efficiency, the greater was the percentage of shrimp farmers having license for undertaking shrimp farming. This observation suggests that the possession of a license is likely to have a favourable influence on technical efficiency. We have also analyzed the disease management practices adopted by the traditional shrimp farmers across the efficiency groups. The disposal of the diseased shrimp is an important aspect of shrimp farm management. In the case of traditional shrimp farming the diseased shrimps were generally treated in three ways: Disposing the diseased shrimps in the pond water itself for natural dissolution, dumping diseased shrimps beside the shrimp pond and either burying the diseased shrimps in the soil or dumping them in some water source away from the shrimp ponds. The first two are not prescribed options, as such disposals would contaminate the pond water and may lead to further disease outbreaks. The prescribed practice for disposing the affected shrimp is burying the diseased shrimps in the soil or disposing them away from the pond. It can be observed from the table that the percentage of shrimp farmers who followed the prescribed practice of disease management was higher for the higher technical efficiency groups. The shrimp farmers with lower technical efficiency mostly followed the first two practices which are not the prescribed ones. This indicates that the traditional shrimp farmers who attained higher level of technical efficiency mostly followed the prescribed disease management practices.

Table 2: Profile of Traditional Shrimp Farmers across Technical Efficiency Groups

		Groups according to Technical Efficiency			
		Low	Medium	Moderately high	High
Categories based on level of output (Rs./acre)	Low	66.7	33.3	-	-
	Medium	31.7	41.3	27.0	
	Moderately high	6.1	18.2	66.7	9.1
	High	16.7	-	33.3	50.0
Percentage of shrimp farmers associated with village level committees		86.1	73.0	81.8	63.7
Percentage of shrimp farmers owning license		16.7	36.5	36.4	66.7
Type of Disease management practice	Natural disposal of diseased shrimp	66.7	20.6	15.2	16.7
	Dump dead shrimps beside the pond	16.7	14.3	15.2	
	Disposal by burying the diseased shrimp /throwing diseased shrimps away from the pond	16.7	44.4	48.5	66.7

Source: Primary Survey. Note: The figures in the table represent the percentage of shrimp farmers processing a particular characteristic under each efficiency group.

In the case of scientific shrimp farmers also we find that the higher the per acre output of the shrimp farmers, the higher was the technical efficiency level obtained by them. Table 3 shows that more than 85% of the shrimp farmers, who belonged to low technical efficiency level also had low level of output per acre. The percentage of shrimp farmers associated with the village level associations was highest (62.9) for the high technical efficiency groups, but even the shrimp farmers belonging to the low technical efficiency group also had considerable association (60%) with the village level committees. Thus the farmers' membership in the village committees does not necessarily lead to higher technical efficiency. Table 3 also reveals that though the percentage of shrimp farmers owning licence for shrimp farming was quite less for the lower technical efficiency group, the other three technical efficiency groups contained almost similar percentages of licensed shrimp farmers. In the case of scientific shrimp farming an important step to manage shrimp diseases is the testing of water quality regularly and taking the advise of trained technicians. It can be seen from the table that percentage of shrimp farmers who went for regular checking of water quality by trained technicians was higher in the higher groups of technical efficiency than in the lower groups. This suggests that the shrimp farmers who attained higher level of technical efficiency were more conscious about the quality of water and went for regular water checking.

Table 3: Profile of Scientific Shrimp Farmers across Technical Efficiency Groups

		Groups according to Technical Efficiency			
		Low	Medium	Moderate high	High
Categories based on level of output (Rs./acre)	Low	85.5	23.8	2.5	-
	Medium-	42.9	28.2	3.1	
	Moderate high	-	28.6	60.0	40.3
	High	15.5	4.8	15.0	56.3
Percentage of shrimp farmers associated with village level committees		60.0	49.9	35.7	62.9
Percentage of shrimp farmers owning license		28.6	42.9	42.5	43.8
Type of water management practice	Regular water quality hecking with the help of trained technicians	42.9	42.9	57.5	53.1

Source: Primary Survey. Note: the figures in the table represent the percentage of shrimp farmers processing a particular characteristic under each efficiency groups.

Factors Influencing Technical Efficiency

The results of the present study reveal that there is significant inefficiency in shrimp farming by the sample shrimp farmers. According to Kalirajan and Shand (1994) the technical efficiency is influenced by the technical knowledge and understanding as well as by socio-economic environment under which the farmers make decisions. In order to examine the factors determining technical efficiencies of traditional and scientific shrimp farming we have estimated equation (5) by Ordinary Least Squares (OLS). But since the dependent variable in the regression lies between zero and one, a limited dependent variable estimation technique like Tobit model is often advocated in the literature. The underlying assumption of the Tobit model is that the dependent variable is censored and there is some underlying latent variables which is not observed. In the present situation all the values of TE_i is observed and there are no latent values. Moreover, in the present situation, none of the technical efficiency scores takes the value zero. If there is no observation with $TE_i=0$, the Tobit approach is equivalent to the OLS approach (Green,2000). Thus in the present paper we have gone for an OLS estimation of the technical efficiency scores on the variables mentioned in equation (5).[8]

The results of the estimation are presented in Table 4. The results suggest that in the case of traditional shrimp farming, all the dummy variables for shrimp farmer categories had a significant influence on the technical efficiency. The negative sign of the coefficients of the dummy variables FMAR, FSMALL and FMED indicates that the marginal, small and medium traditional shrimp farmers had lesser technical efficiency than the large shrimp farmers, i.e, the large farmers had higher efficiency than all the other categories of traditional shrimp farmers. In many studies pertaining to Indian agriculture (Bagi, 1981; Sekar *et al*, 1991) it has been found that the small farmers will try to operate at higher efficiency level than large farmers using their own resources. In the case of Bangladesh a study by Thomas et al (2001) also reveals that small shrimp farmers are more efficient. In the present case higher efficiency of smaller shrimp farmers does not hold good. Better access to credit, more experience and better access to marketing facilities might have contributed to the higher efficiency of large shrimp farmers.

Table 4 also reveals that the coefficients of the variables LEASEPR and OFISH are statistically significant. The positive sign of the variable LEASEPR suggests that leasing has a positive impact on the technical efficiency in the case of traditional shrimp farming implying thereby that the more the proportion of leased-in land, the higher the technical efficiencies. This contradicts the findings of the study by Kumar *et al.* (2004), which reveals that leased shrimp farms were less efficient than the owner operated ones. One of the reasons for the positive association between lease proportions in the total operational area under shrimp culture in the present study could be the long term lease contracts in the study area ranging from four to ten years. These long term contracts do not prevent the farmers from undertaking long term pond improvement activities and there is high chance of lease renewal if the production is satisfactory. Surprisingly, the coefficient of the variable OFISH is negative which signifies that farmers who are associated with only fisheries related activities have lesser technical efficiency in shrimp farming. Even though the shrimp farmers who are associated with fisheries related activities (like working in fish market, own retail fish selling outlet etc.) had better access to information, lesser time spent on their own shrimp farms might have led to a lesser efficiency for them.

Table 4: Factors Determining Technical Efficiency of Traditional and Scientific Shrimp Farmers

	Traditional Shrimp farming	Scientific Shrimp farming
Variable	Coefficient	Coefficient
Constant	0.46* (6.54)	0.64* (5.76)
FMAR	-0.07** (-1.76)	-0.08 (-1.14)
FSMALL	-0.06* (-2.51)	-0.11** (-1.97)
FMED	-0.07* (-2.50)	-
EXP	-0.005 (-1.04)	0.01 (0.80)
EDU	0.002 (.87)	0.006 (1.80)***
TR	0.01 (1.32)	0.005 (0.83)
LEASEPR	0.06** (2.02)	-0.04 (-1.00)
OFISH	-0.04** (-1.99)	0.04 (0.95)
ASSET ('000Rs.)	.007 (1.32)	-0.006* (-3.30)
GP	0.003(0.33)	0.08** (2.24)
R^2	0.31	0.38
F-statistic	3.46	3.53
Prob(F-statistic)	0.000	0.000
Durbin-Watson stat	1.75	1.86

Source: Primary Survey; Note: (1) Numbers in parentheses are the t-statistics; (2) Total number of observations are 100 and 108 in the case of scientific and traditional shrimp farming systems respectively, (3)*, **and*** denote that the coefficients are significant at 1%, 5% and 10% respectively.

Estimation results for scientific shrimp farmers reveal that variables FSMALL, GP, EDU and ASSET are statistically significant. The negative coefficient of variable FSMALL signifies that the small scientific shrimp farmers have lesser efficiency than the medium scientific farmers, which is the base category. The positive coefficient of the variable GP indicates that the gram panchayat in which the shrimp farm is located has significant influence on the technical efficiency of scientific shrimp farmers. The results indicate that, shrimp farmers of the gram panchayat (coded as 1) who had better access to marketing and other facilities because of its proximity to the city gained higher technical efficiency. Shrimp farmers with higher level of education had higher technical efficiency than those with lesser education in the case of scientific shrimp farming. The educated shrimp farmers are expected to follow the shrimp farm management practices properly which might have led to higher efficiency for them. In the case of scientific shrimp farming it was found that the farmers with higher asset lagged behind in terms of technical efficiency. This implies that farmers who own more non-farm asset are not able to utilize the resources properly. This could be due to the fact that the wealthy farmers engage themselves in other business activities and therefore cannot provide more time to their individual farm activities and rely more on the hired supervisory labour. The lack of personal supervision of these shrimp farmers might have led to their lower levels of efficiency.

Conclusion and Policy Implications

The study has assessed the technical efficiency of traditional and scientific shrimp farming in West Bengal. The average technical efficiency of traditional shrimp farming is estimated as 0.49 as against 0.61 for scientific shrimp farming. The estimates suggest that there are high degrees of technical inefficiency among the shrimp farmers culturing shrimp at household levels. Thus traditional and scientific shrimp farmers have substantial scope to improve their production with the existing levels of input use and technology. The largest shrimp farmers in both traditional and scientific shrimp farming tend to have higher technical efficiency. In the case of traditional shrimp farming, the shrimp farmers' association with fisheries related activities does not help them to reach higher technical efficiency. The traditional shrimp farmers with higher proportion of leased-in land to their total operational area under shrimp farming have demonstrated higher technical efficiency than shrimp farms with lesser proportion of leased-in land. The higher level of education would help the scientific shrimp farmers to operate at higher levels of technical efficiency. An analysis of the farmers' profile across different levels of technical efficiency reveals that in the case of traditional shrimp farming, majority of the shrimp farmers who belong to the high and moderately high levels of technical efficiency followed the prescribed practice of disease management by burying diseased shrimps or dumping them away from the pond. In the case of scientific shrimp farming also it was found that majority of the shrimp farmers who attained higher levels of technical efficiencies had carried out regular water checking with the help of trained technicians which is essential for proper shrimp disease management. Some important implications of the study are as follows. Firstly, the higher degree of technical inefficiency indicates scope for improving the production of traditional and scientific shrimp farmers with the existing level of inputs and technology. This calls for government policy initiatives and extension programmes which will help the shrimp farmers especially the traditional shrimp farmers of the state to utilize the best of their resources and enhance their production to a considerable extent. Moreover, in case of traditional and scientific shrimp farming, the largest size groups of shrimp farmers had higher technical efficiency than the other categories. This calls for more attention towards the smaller shrimp producers on the part of the fisheries department, by providing them appropriate credit and other extension facilities, so that they can also attain a higher technical efficiency as the larger shrimp farmers. The government fishery departments can help the smaller shrimp farmers to enlarge their shrimp farm size by direct redistribution of brackish water lands to the shrimp farming households who cannot afford to lease land through a private lease-market. Utilisation of the prescribed disease management practices predominantly by the shrimp farmers belonging to the higher technical efficiency groups indicate that creating more awareness about the prescribed disease management practices amongst the shrimp farmers is quite important to improve the level of technical efficiency in shrimp farming.

[1] The productivity of shrimp in India is about 635 kg/ha, as against 3116 kg/ha in Thailand, 1500 kg/ha in Malaysia , 800 Kg./ha in China and 770 kg/ha in Philippines(Kumar et al.,2004)

[2] The terms *traditional and scientific shrimp farming* used in the present study have the features as described in Table A1 of Appendix 1.

[3] For details see Coelli, Rao and Battese (1998).

[4] The non-farm assets are valued at 2004-2005 prices and the value of assets does not include depreciation.

[5] Percentage utilization of the potential area available in North 24 Parganas District is 30% as against 17.14% in south 24 Parganas district.

[6] ppt is a measure of salinity, which implies particles per thousand.

[7] In general the classification of shrimp farm size in India is less than two hectares, two to five hectares and larger than five hectares. In the study area we have considered, barring a few, most of the shrimp farms were of size less than 2.5 hectares . Thus, we have followed local conventions in classifying the size holdings in shrimp farming.

[8] However, in order to confirm the similarity of the OLS estimations with the Tobit regression model, we had also regressed technical efficiency scores on the farm specific variables using a two limit Tobit model (upper limit one and lower limit zero) with LIMDEP 7.0 software. But the same set of variables which was found to be statistically significant in OLS estimation, was statistically significant in the case of Tobit model also. Thus, in the present paper we have presented and interpreted only the results of the OLS estimations.

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Appendix 1

Table A1: Characteristics of Traditional and Scientific Shrimp Farming

Traditional shrimp farming	Scientific shrimp farming
▪ Fully tide fed ▪ salinity varies according to monsoon regime ▪ seed of mixed species from the adjoining creeks and canals by auto stocking ▪ Additional stocking of natural seeds ▪ Dependence on natural food ▪ Water intake and drainage managed through sluice gates, depending on the tidal effects ▪ Periodic harvesting during full and new moon periods, collection at sluice gates by traps and bag nets.	▪ Ponds are manured and fertilized, water filling and exchange are done by pumping ▪ Selective stocking with hatchery seeds @6 – 25 PL/m^2 .use of high nutritive feeds ▪ Usage of aerators ▪ Harvesting at the end of one crop season, normally 120 days.

Table A2: Mean of Key Variables Used in the Estimation of Stochastic Frontier Production Function:

Variables	Traditional shrimp farmers	Scientific shrimp farmers
Stocking (Number of shrimp seed stocked per acre)	4333(1335)	4940(1053)
Feed (kg/acre)	-	2278(1538)
Labour (Mandays/acre)	153(149)	439(272)
Fertilizer (Rs./acre)	402(349)	15898(12758)
Pump hour (Hr./acre)	-	1971(1408)
Capital cost (Rs./acre)	3030(5155)	12785(15624)

Source: Primary survey, Note: Figures in the parentheses indicate standard deviations

Table A3: Descriptive Statistics of the Key Variables Used As Determinants of Technical Efficiency

Variable	M ean/Percentage	Traditional shrimp farmers	Scientific shrimp farmers
EXP	Mean	4.86(5.38)	2.98(1.74)
EDU	Mean	8.38(2.63)	11.25(4.55)
TR	Mean	0.69(0.92)	1.45(1.39)
LEASEPR	Mean	0.44(0.42)	0.26(0.40)
ASSET	Mean	93176 (117426)	103108.6(56083)
OFISH	percentage of OFISH=1	23%	24%

Source: Primary survey, Note: Figures in the parentheses indicate standard deviations