AN ECONOMIC ANALYSIS OF TECHNICAL EFFICIENCY OF RICE FARMERS AT DELTA REGION IN MYANMAR

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1. INTRODUCTION

Rice is the most important crop, grown on 5.83 million hectares or about 46.3% of the country's total cultivated area in 1996-97. The suitable area for rice in Myanmar is estimated to be around 6 million hectares (IRRI Rice Almanac, 1993-94). Consumption of rice is increasing at a rapid rate both in the urban and rural areas alike. The growth of production to cope with the growing demand is constrained by limited access to irrigation. Rice is a water intensive crop and under the limited availability of irrigation potential an extension of the rice area is not feasible. The increase in production would have to come from a breakthrough in productivity and increased efficiency in production.

A major issue, agricultural economists, policy makers and planners in the country are facing today, is to find out whether the agricultural production under present technology could be increased without the use of high capital investment such as irrigation. The level of production efficiency is strongly affected by the management ability of individual farmer and also by the use of chemical input. In a country, like Myanmar, where the capital stock is small, this situation provides an opportunity for relatively inexpensive gains in production. If the farmers are operating efficiently, output from the existing inputs and technology are maximized and resource allocation are optimal then farm output can be increased only by introducing improved methods of production. The question raised is to identify whether the farmers are technically efficient in their resource utilization.

As pioneer work of Kendall (1939) and others showed, there is considerable variation in agricultural productivity because crop productivity is the function of various factors including the physical, socio-economic, technical ones and infrastructure. All these factors are by nature, highly variable and dynamic (Subbaiah and Ahmad, 1980). Social factors such as size of holding, population density, tenancy system and labour (nature, availability and quality) have a direct and indirect effect on agricultural production. Some of them are dynamic, while others are static. Economic and technological factors, which are very dynamic, emerge in the form of mechanisation of farming. Several studies have proved that these factors affect agricultural productivity to a large extent, both directly and indirectly.

As such, agricultural productivity can be defined as a measure of efficiency with which an agricultural production system employs land, labour, capital and other resources. Among these land is the primary and the most important one. Due to the rapid increase in population pressure in recent decades special attention has been focused on land productivity. It is mainly by increasing yield per unit area that the growing need for food can be met. Productivity may be raised also by replacing the pattern of production by more intensive systems of cultivation or by cultivating higher value crops. Shafi (1984) stated that in developing countries, where land is relatively scarce and labour abundant, yield per unit area is more important, while in countries where land is abundant and labour is scarce, yield per man may constitute a more suitable measure for the determination of agricultural productivity.

Two types of production efficiency were defined by Farrell (1957): technical efficiency and allocative efficiency. Technical efficiency evaluates the ability to obtain a higher level of output from a given set of inputs, while allocative efficiency measures the extent to which farmers make efficient decisions by using inputs up to the level at which marginal contribution to production value is equal to the factor cost.

The objective of this paper is to derive a statistical measure of economic performance of rice farmers in the Delta region of Myanmar using stochastic frontier production function based on farm level survey data and then to examine the technical efficiency level of different farm size groups in the rice production.

2. RICE PRODUCTION TREND IN MYANMAR

In the course of the last two decades, area planted, production, yield and consumption of rice crop have changed considerably. Table 1 shows the index value of area sown, production, yield and consumption and has exhibited a distinct pattern of change in production over the 16 years. Within these period the average growth rate of area under rice has increased by 1.02% but only 0.8% increase in yield was observed. This increase in area and yield kept in production increase to 1.7% while in this period consumption has increased by 0.97% (calculated from the index value).

Increases in total output are maily due to land area expansion, with yield gains playing a minor role. Area expansion took place mainly in the delta region, lower part of Myanmar, although irrigation projects are developing in the dry zone area of upper Myanmar. The growth in area under rice can be attributed principally to the rapid growth in demand during the 16 years. Swe and Wah (1996) highlighted that to supply the growing population of the country there is a need for further continued effort for the promotion of higher paddy production. Summer paddy cultivation was initiated in 1992-93. Because of this, rice sown area has increased by 5.95% in 1992-93 compared to previous year (Figure 1).

The improved varieties that are presently cultivated in Myanmar have virtually the same yield potential as the traditional varieties. The potential productivity of high yielding variety (HYV) seed at the present technology level was attained in the range of 75 to 100 basket per acre (3.8 to 5.1 ton/ha). However, the HYV grown by the sample farmers gave the yield level from 45.81 to 58.69 basket per acre (2.4 to 3.0 ton/ha), whereas the corresponding local variety gave its customary yield level of 39.79 to 49.87 basket per acre (2.1 to 2.5 ton/ha). Such a narrow yield gap could not lead to appreciable increase in agricultural productivity regardless of increase in per cent area under HYV. It indicated that there may be scope for further improvement even in high yielding variety to productivity (own unpublished Ph.D dissertation).

3. SAMPLE DATA AND EMPIRICAL SPECIFICATION

Phyapone, one of delta rice bowl regions in Myanmar, was selected for this study. This region has an average rainfall of 2396 mm and average minimum and maximum temperatures of about 16 and 37 degree Celsius respectively. The data used in this study are based on a set of the primary data collected from randomly selected farm households by administering structured questionnaires in 1997. A total of 182 farmers from 12 villages were randomly selected in the Delta region. By using two stage stratified sampling the population was stratified into more or less homogenous strata before sampling was done. For each village 15 households were selected at random. Detailed information partaining to inputs such as fertilizer, seed, labour, irrigation etc. and yield of rice crop cultivated during the study period 1996-97 and other environmental data such as socio-economic and education characteristics of the household members were also collected. A basic summary of the values of the key variables, which are defined in the econometric model in the next section, is given in Table 2. Thus average yield of rice per acre basis in the survey is 55.64 to 56.68 basket per acre. The average area on which rice was grown in the sample farms varied from the range of 3.47 to 17.09 acre. The application of urea fertilizer varied between 46.06 to 57.2 Kg per acre. The seed rate used by sample farmers was found to be at a rate of 82.62 to 88.56 Kg per acre. The number of irrigations varied between about 4 to 5 times. Human labour in the rice production is measured in mandays which is computed as in following ways.

Mandays used = (1/8)(LABR)(WKHR)(WD)

Where LABR = Number of labourers, including hired and own labour

WKHR = Number of working hours per day

WD = Number of working days for rice production

The mandays used for a farmer based on acre basis were within the average range of 5 to 16 days.

4. ANALYTICAL MEASUREMENT IN TECHNICAL EFFICIENCY

The techanical efficiencies of individual observations were estimated by the parametric approach using a stochastic frontier production function, proposed by Battese and Coelli (1995). Since Farrell (1957), a great deal of effort has been directed towards the estimation of frontier models of a production technology and obtaining production efficiency measures. The types of models used included nonparametric deterministric models, deterministic full frontier models, stochastic full frontier models, and stochastic frontier models. The basic concept of a stochastic frontier production function was first proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977a) and various others. The same concept was applied in this study. In this function the disturbance component of these frontiers is composed of a systematic random variable which captures the effects of weather, luck and other factors outside the control of the economic agent and a one-sided disturbance which measures technical efficiency. The mean of the one-sided distribution provides a measure of the average technical efficiency for firms in the sample. The stochastic frontier model for farmers in three different farm size groups namely small, medium and large is explained by

$$LnY_i = \alpha + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 X_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + V_i - U_i \quad \text{eq (1)}$$

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 \quad \text{eq (2)}$$

Where the subscript i indicates the i[th] farmers in the sample

Ln represents the natural logarithm

Y represents the average yield of rice based on two season (bskt/ac)

V_is are assumed to be independent and idententically distributed random errors, having N (0,σ^2) distribution, independent of the U_i

U_is are technical inefficiency effects, which are assumed to be non-negative random variables which are assumed to be independently distributed and such that U_i is defined by the truncation (at zero) of the N (0,σ^2) distribution and

βs are unknown parameters to be estimated

μ_is are technical inefficiency effect predicted by the model itself

X_1	Urea fertilizer per acre
X_2	Seed rate per acre
X_3	Manure use as dummy
X_4	Labour employed
X_5	Number of irrigation
X_6	Cropping intensity
Z_1	Level of education as dummy
Z_2	Extension contact as dummy

The production function defined by equation (1) has as explanatory variables: use of urea fertilizer, seed rate used by farmers, manure application as dummy, labour (both family and hired labour) involved in farming, number of irrigation, and level of cropping intensity. These variables are assumed to explain the output of rice at delta region in Myanmar. It is further hypothesized that the output might also be influenced in its level by the existence or not of education and extension contact offered by the government institution.

The technical inefficiency effects outlined by equation (2) indicate that these effects in a stochastic frontier (1) are expressed in terms of various explanatory variables which include the education of the farmers described by dummy and extension contact as dummy. It is expected that a high level of education is affecting technical efficiency more while contact with extension agent has less technical inefficiency effects. Battese and Coelli (1995) state that the technical efficiency of production of the i^{th} farmer is estimated as

$$TE_i = \exp(-U_i)$$

The technical efficiency of a farmer is between zero and one and is inversely related to the level of the technical inefficiency.

5. About the concept figure of production frontier with technical efficiency

Farrel’s concept of the production frontier is depicted in Figure 3. The horizontal axis represents the inputs (vector) of X, associated with producing Y. Since farm do not attain the maximum output possible for the inputs involved with the technology available, the observed input-output values are below the production frontier. A measure of the technical efficiency which produces output Y with inputs X denoted by point „A„ is given by Y/Y*, where Y* is the frontier output associated with the level of inputs X (see point B). This is an input-specific measure of technical efficiency. The existence of technical inefficiency of enterprises angaged in production has been a subject of considerable debate in economics. It has been argued that little is known about the role of non-physical inputs, especially information or knowledge which influence the farm’s ability to use its available technology set fully. If the concept of maximization is accepted, the econometric modelling of frontier production functions is considered to provide useful insights into best practice technology and measures by which the productive efficiency of different firms may be compared (cited by Battese, 1991).

6. Empirical result and discussion

The maximum-likelihood estimates (Greene, 1980) of the parameters of the stochastic frontier model are presented in Table 3 using the program, FRONTIER 4.1 (Coelli, 1994), which can predict the variance parameter in terms of σ_s^2 and γ. The estimates for the γ-parameter among different farm size groups are quite high showing the value of 0.99, 0.83 and 0.99. It can be interpreted that the inefficiency effects are highly significant in the analysis of the output in physical term for the rice farmers.

The determinants of output included in the frontier model are urea chemical fertilizer per unit land area, seed rate used by farmers, manure use, labour employed, number of irrigation and cropping intensity while those for technical inefficiencies effect are level of education and extension contact measured as dummy.

The function was estimated separately for different farm size groups in the study period. Results of the run show that among explanatory variables tested the use of urea fertilizer at different farm sizes was found to significantly affect the output of rice at 1% level for small and medium group and 5% level for large farm size group. This result means that an increase in the use of chemical fertilizer by 10% will lead to increase in yield of rice production by 2 to 4%.

For the small farm size group, the coefficients of seed rate used by the farmers, labour use and number of irrigation are negatively related to yield of rice though not significant. The similar trend was followed in large farm group except in labour which had the positive relationship. In case of medium farmers the coefficients of seed rate and labour showed the expected positive trend, however, only 10% significant in seed rate. The variable „number of irrigation„ indicates a highly significant and negative relationship to yield for the medium farmers. The reason could be that the number of water application in rice is beyond the optimum level.The coefficients of cropping intensity for all farmers were found to be negative. In case of manure use, only the small farm group showed a positive effect while inefficient application was observed in medium and large groups.

The reason for negative trend in use of seed in small and large farm sizes can be explained by the fact that the average were noted to be 85.7223.61 and 82.6221.01 kg per acre respectively. Such a wide variation in seed rates used by farmers indicates that very different technologies are being used (Table 2).

For technical inefficiencies effects, the variable of education showed positive relation with predicted inefficiency in small and medium group though only 10% significant in medium group. The negative relation, which indicates that the farmers with higher level of education seem to be more technically efficient, was observed for the large farm size group, but it was not significant. The positive coefficient of education for small and medium groups revealed that high level of education does not result in increases in technical efficiency of rice farming.

According to R.A.Azhar (1991) it was expressed that education affects productivity in two distinct way (1) via a choice of better inputs and outputs (allocative efficiency effect) (2) through a better utilization of existing inputs (technical efficiency aspect). Where as the allocative effect is inherently predicated on disequlibrium, there is some evidence to suggest that even the technical effort of education is more likely to arise during disequilibrium caused by technical change. In agriculture this may be because technical change renders the existing cultural practices obsolete or inadequate and calls for an adjustment. A more educated farmer is supposed to make the required adjustment more quickly. The adoption of new crop variety may require not only an allocative response such as the use of modern input (i.e., pesticide and insecticide, chemical fertilizer etc.) but also different cultural practices.

There was a negative relation between the extension contact variable and inefficiency effect across all different groups of farm size. This implies that extension contact tends to reduce the technical inefficiency of rice farmers at Delta area.

Birkhaeuser, Evensen and Feder (1991) explained that an effective agricultural extension can bridge the gap between the discoveries from the experiment station and changes in the individual farmer's field. In addition to information about cropping techniques, optimal input use, high yielding varieties, and prices, extension agents can inform farmers about improved record keeping and aid in the development of their managerial skills, thus facilitating a shift to more efficient methods of production. By accelerating the diffusion process of improved technology, extension can bring about a faster growth of yiels and rural incomes than would occur in the absence of extension.

The level of technical efficiencies of individual rice farmers were also estimated although these values could not be presented in a table because of the large number of values involved. The estimation of technical efficiencies of Cobb-Douglas production frontier model shows that these value are less than one for the differnt farm size groups. Small farm size group has technical efficiencies ranging from 0.44 to 0.99 with the mean value of 0.81 whereas for medium group this value falls between 0.33 and 0.98 with a mean of 0.73. For the large farmers, the technical efficiencies ranged from 0.48 to 0.99, with a mean of 0.80. According to the predicetd mean values of technical efficiencies, small and large farmers have higher efficiencies than farmers with medium farm size, relative to their respective frontiers associated with different level of technologies.

The percentage of sampled rice farmers with estimated technical efficiencies in the range of 0.3 to 1.0 are graphed in Figure 2 for different farm size groups. As shown in Figure 2, the frequencies of occurrence of the predicted technical efficiencies in different interval indicated that the highest number of sampled farmers for small farm size group have technical efficiencies between 0.8 and 0.9 whereas that for medium group as well as that for large farm group have 0.9 - 1.0 and 0.8 - 0.9 respectively. Although it can be seen in the figure that high percentage of medium group farmers is closely clustered near 1.0 as compared to small and large farmers group, the frequency distribution revealed that there is a considerable wide distribution of technical efficiencies even among the rice farmers observed. These calls for the consideration of effecting improvement in the technical efficiencies of the farmers within the farm size group in this delta area.

7. SUMMARY AND CONCLUSION

A Cobb-Douglas stochastic frontier production function is applied in the analysis of farm-level data of rice farmers in Myanmar. The empirical result shows that out of the explanatory variables identified, urea fertilizer application is the most important explanatory variable in the frontier estimate. The elasticities of urea fertilizer application are calling for a higher intensity of fertilizer level in the production of rice. Since the production system is dominated by an intensive cropping system, intensive fertilizer use in rice production might have an important role in increasing total output. Therefore, efficiency of the farms may be associated with high level of fertilizer intensity in rice production.

8. ACKNOWLEDGEMENT

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Table 1. Index of sown area, production, yield and consumption of rice, 1981-82 to 1996-97 (1981-82=100)

Year	Rice			
	Area	Production	Yield	Consumption
1981-82	100.00	100.00	100.00	100.00
1982-83	95.77	101.92	108.00	101.73
1983-84	94.77	101.32	108.00	98.23
1984-85	81.37	101.08	108.00	101.10
1985-86	96.17	101.52	108.00	102.06
1986-87	95.01	100.17	108.00	101.61
1987-88	91.54	96.69	108.00	101.23
1988-89	93.73	93.35	104.00	99.52
1989-90	95.71	97.88	104.00	102.75
1990-91	97.01	99.05	104.00	103.43
1991-92	94.74	93.61	104.00	95.64
1992-93	100.69	105.21	104.00	107.71
1993-94	111.22	118.84	108.00	121.87
1994-95	116.09	128.76	112.00	122.35
1995-96	120.39	127.30	108.00	123.26
1996-97	115.26	125.53	112.00	114.53

Source: Calculated on the basis of the data provided by settlement and land record department and FAOSTAT

Table 2. Summary statistics for variables of average rice farmer in Delta area in Myanmar

Variables	**unit**	**Mean**			**Minimum**			**Maximum**		
		1	2	3	1	2	3	1	2	3
Yield	(bskt /acre)	56.68 (15.89)	56.91 (17.2)	55.64 (12.77)	25.0	23.5	28.3	88.8	87.8	78.8
Urea fertilizer	(kg/ac)	47.41 (26.0)	46.06 (27.91)	57.20 (23.11)	12.5	8.3	16.3	100.0	100.0	125.0
Seed rate	(kg/ac)	85.71 (23.61)	88.57 (23.97)	82.62 (21.01)	36.5	53.7	48.9	128.8	151.2	134.1
Manure use	dummy[1]	0.31 (0.47)	0.37 (0.49)	0.62 (0.49)	0.0	0.0	0.0	1.0	1.0	1.0
Labour	Man day	16.22 (9.58)	10.27 (4.99)	5.33 (1.54)	6.1	2.6	2.7	39.9	20.9	9.3
Number of irrigation	No	4.38 (4.38)	4.59 (2.34)	4.92 (2.11)	1.0	0.0	1.0	10.0	9.0	13.0
Cropping intensity	%	189.50 (17.45)	184.22 (25.91)	176.05 (25.91)	140.8	117.1	110.0	200.0	217.6	200.0
Level of education	dummy[2]	0.14 (0.35)	0.37 (0.49)	0.24 (0.43)	0.0	0.0	0.0	1.0	1.0	1.0
Extension contact	dummy[3]	0.86 (0.35)	0.96 (0.19)	0.84 (0.37)	0.0	0.0	0.0	1.0	1.0	1.0
Farm size	acre	3.47 (1.32)	7.29 (1.41)	17.09 (5.96)	1.0	5.2	11.0	5.0	10.0	35.0

Figure in parentheses indicate the standard deviation of the corresponding value

Note: The column indicated by (1) represents small farm size, whereas those by (2) and (3) represent medium

[1] Manure use measured as dummy takes the value of one if farmer applied cowdung to increase the soil fertility and zero otherwise

[2] Level of education measured as dummy takes the value of one if the household head finished secondary education and higher, otherwise zero

[3] Extension contact measured as dummy takes the value of one if the household head contacted the extension agents and zero otherwise

farm size and (3) large farm size respectively; Source: based on survey data

Table 3. Maximum-likelihood estimates for parameters of the Cobb-Douglas stochastic frontier production functions for rice farmers at different farm size in Delta region

Variables	Parameter	Farm size					
		Small		Medium		Large	
Stochastic frontier							
Constant	β_0	6.51	(6.6)	5.57	(3.98)	4.99	(2.20)
Ln (Urea fertilizer)	β_1	0.41***	(11.7)	0.31***	(6.76)	0.19**	(1.76)
Ln (Seed rate)	β_2	-0.097	(-1.1)	0.25*	(1.47)	-0.33	(-1.18)
Manure use	β_3	0.05***	(2.7)	-0.058	(-0.90)	-0.15	(-1.15)
Ln (Labour)	β_4	-0.034	(-0.7)	0.012	(0.21)	0.094	(0.89)
Ln (Irrigation)	β_5	-0.032	(-0.7)	-0.04***	(-4.29)	-0.018	(-0.09)
Ln (Cropping intensity)	β_6	-0.63***	(-3.5)	-0.55**	(-1.86)	-0.025	(-0.15)
Inefficiency model							
Constant	δ_0	0.17	(1.1)	-1.69	(-1.03)	0.34	(1.06)
Level of education	δ_1	0.053	(0.9)	2.26*	(1.35)	-0.41	(-1.15)
Extension contact	δ_2	-0.18	(-0.9)	-1.71***	(-5.07)	-0.17	(-0.99)
Variance parameters							
$\sigma_s^2 = \sigma^2 + \sigma_v^2$	σ_s^2	0.064	(1.27)	0.051	(1.96)	0.045	(1.29)
$\gamma = \sigma^2 / (\sigma^2 + \sigma_v^2)$	γ	0.99	(29.82)	0.83	(7.94)	0.99	(17.25)
Loglikelihood function		16.22		11.16		22.18	

- Figure in parentheses are the t statistics of model estimate
- *,**,*** indicate significance at 10%, 5% and 1% level and ns indicates not significance, respectively

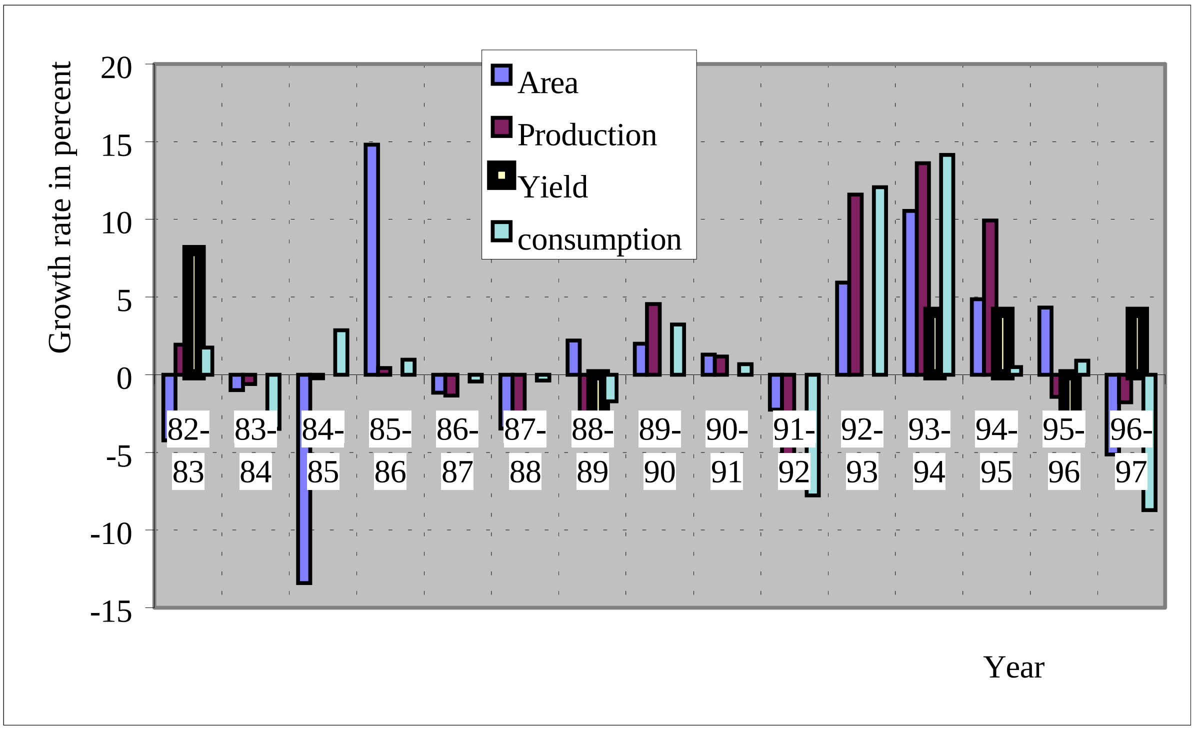


Figure 1. Growth pattern of area grown, production, yield and consumption of rice for various years in Myanmar

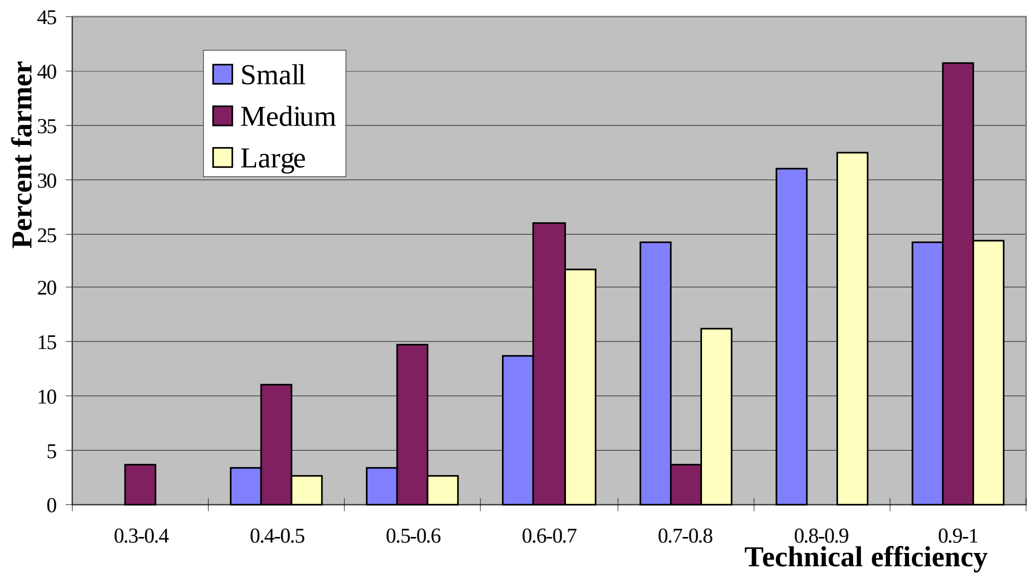
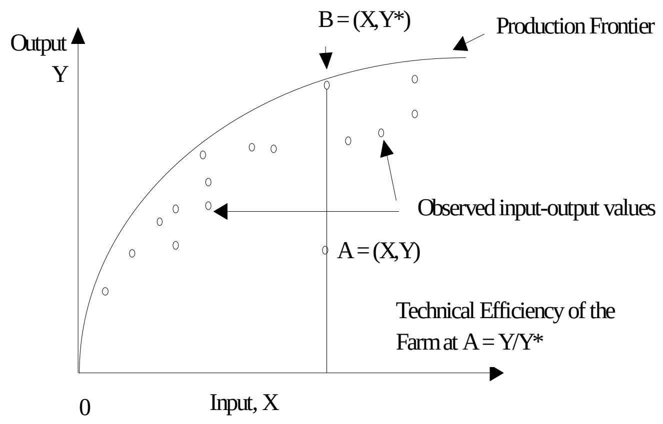


Figure 2. Distributions of technical efficiencies of rice farmers at different farm size in delta region



Farrell, 1957
Figure 3. Technical efficiency of farms in the input-output relationship

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