Bangladesh J. Agric. Econs XXVIII, 1&2 (2005) 73-83

Research Note

TECHNICAL AND ALLOCATIVE EFFICIENCY OF GROWING WHEAT IN NORTHWEST DISTRICTS OF BANGLADESH

M. Elahi Bakh
M. Serajul Islam

ABSTRACT

The present study was undertaken in the Northwest of Bangladesh to measure the technical and allocative efficiency of wheat production. Primary data from 200 farmers field were collected for this study. Frontier production model was used to estimate the technical efficiency and the marginal condition for profit maximization was used to estimate the allocative efficiency (AE). The mean farm specific technical efficiency of wheat growers were 88 percent and 69 percent at Dinajpur and Rangpur, respectively. The frontier farmers received higher yield by following optimum seeding time, using more urea, TSP, gypsum, manure and applying more frequently irrigation water with modest use of seed rate, and human labour at both the sites. So there is scope to increase the farmers' income and wheat yield by adopting the technologies adopted by the frontier farmers.

I. INTRODUCTION

Efficiency is an important factor of productivity growth as well as stability of production especially in developing agricultural economics. In view of slow growth and increasing instability in production, the wheat economy of Northwest Bangladesh could be benefited to a great deal from efficiency studies. Estimates on the extent of efficiency may help to decide whether to improve efficiency or to develop new technologies to raise wheat productivity in Northwest Bangladesh. A farm is technically inefficient in the sense that if it fails to produce maximum output from a given input bundle; technical inefficiency results in an equiproportionate over or under utilization of all inputs. It may also be allocatively inefficient in the sense that the marginal revenue product of input might not be equal to the marginal cost of that input. Allocative inefficiency results in utilization of inputs in the wrong proportions, at given input prices. The main objective of this study is to estimate the technical and allocative efficiencies as well as input use patterns of the most efficient farmers for wheat production.

Economic, Technical' *and Allocative Efficiency*

Farrel, 1957 disaggregated economic efficiency into price or allocative efficiency and technical efficiency. Allocative efficiency (AE) refers to the marginal conditions for profit maximization. Technical efficiency (TE) is the ability of a firm to produce maximum possible output from a given sets of inputs and given technologies. Thus, it is an indicator of productivity of the firm, so the variation in TE can reflect the productivity differences among

The paper is based on results of the first author's Ph.D. thesis. The first author is a Senior Scientific Officer (Agril. Econnomics), Wheat Research Centre, Dinajpur and the second author is a Professor, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

firms. It helps for determining the potentiality of the existing technologies.The basic model used to measure technical and allocative efficiencies in the case of one variable input and one output is illustrated in figure 1. The curve TPP_m shows the maximum possible total output as the variable input X increases, while the curve TPP_a shows the input response on an 'average' farm. All points lying below TPP_m are technically inefficient because they give less output at given level of input. The profit maximization criterion suggests that a producer will hope to utilize X_1 level of input X (where marginal value product of X is equal to its price, P_x) and will produce the technically and allocatively efficient output, Y_1. A producer who uses the input X at X_2 level and produces Y_3 is technically efficient but allocatively inefficient. On the other hand, if the producer produces Y_2 by using X_2, he is both technically and allocatively inefficient. Technical efficiency is defined as the ratio of a farmer's actual output to the technically maximum possible output at the given level of resources (Y_2/Y_3). Allocative efficiency 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 (Y_3/Y_1); and economic efficiency is simply the product of technical and allocative efficiencies $[(Y_2/Y_3)*(Y_3/Y_1)]=Y_2/Y_1$. Technical, allocative and economic efficiencies are measured as $(1-Y_2/Y_3)$, $(1-Y_3/Y_1)$, and $(1-Y_2/Y_1)$, respectively (Ali et al. 1990).

The paper has been organized in four sections. Methodology is discussed in section II. Technical and allocative efficiency of wheat growing farmers are presented in section III while conclusions are provided in the final section.

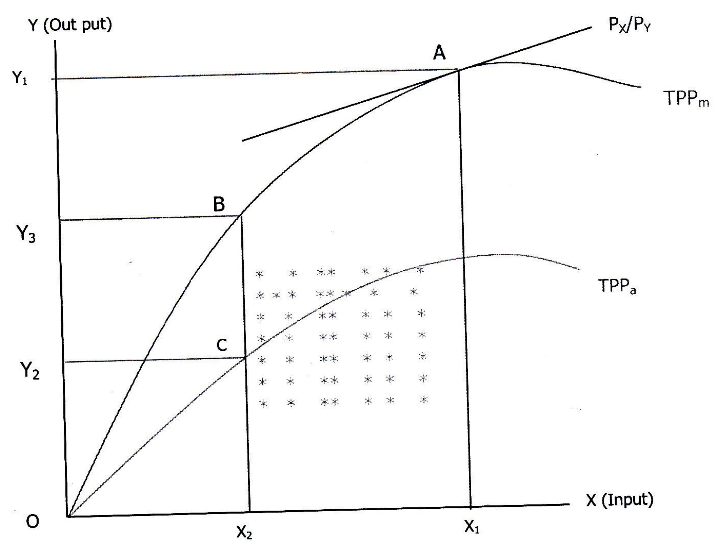

Fig. 1. Technical, Allocative and Economic Efficiency (Source: Farrel, 1957)

II. METHODOLOGY

This study was conducted at Dinajpur and Rangpur districts covering 2 upazilas in each district; Birgonj and Sadar in Dinajpur and Kaunia and Pirgachha in Rangpur district. Two hundred wheat-farming households from eight villages (covering two villages from each upazila) were selected randomly. Data on all inputs used and output were collected from one selected wheat plot of each farmer during wheat season (1999-2000) by three visits. One visit was made just after completion of sowing, second was after completion of all intercultural operations and last one was after harvesting and threshing of wheat. The collected data were computerized, and analyzed through *Microsoft Excel* and *SPSS* programme. The stochastic frontier production function model was used to analyze data and interpretation of the results.

The Stochastic Frontier Production Function Model

The yield potential may be interpolated from yields of research managed plots (e.g. Herdt and Mandac 1981), or the most efficient farmers in a sample (e. g., Kalirajan and Flinn 1983). The latter approach was adopted for this study to find out yield potentials of wheat farmers. The production function maps the maximum possible output that can be produced for a given quantity of a set of inputs (Yotopoulos and Nugent 1976). Most farmers fail to operate on the production surface due to technical inefficiency (Farrel 1957). Following Lingard et al. (1983), the production technology of each farm was characterized by a Cobb- Douglas production function and estimated by using ordinary least squares (OLS) method. Experience has shown that it is desirable to use simple functions involving as few parameters as is practically feasible and perform best, since convergence problems in the estimation process can occur when there are a large number of independent variables in the estimated equation. The Cobb- Douglas functional form is a compromise between a complex production process and a complex estimation technique.

The estimated equation was used to examine Timmer's measure of technical efficiency and Kopp's (1981) measure of allocative efficiency of inputs utilized in wheat. The Timmer's measure of technical efficiency of jth farms is the ratio of actual output to potential output, given the level of input use in jth farms. Thus, it indicates that how much extra output could be obtained if the jth farms are on the frontier.

The specification of the Stochastic Cobb- Douglas production function in general form is:

$$b^{i} e^{uj}$$

This can be written in double log linear form as:

$$\ln Y_j = b_0 + \sum_{i=1}^{n} bi \ln X_{ij} + U_j$$

Where,

$\ln$ = Natural logarithm,

Y_j = Production of jth crop (kg/ha),

X_i = Inputs like labour (man-day/ha), urea (kg/ha), triple super phosphate (kg/ha), murate of potash (kg/ha), manure (t/ha), sowing date of wheat, seed rate (kg/ha)

b_i = Regression coefficient to be estimated,

b_0 = Constant

U = Stochastic error term incorporating the effects of unknown and unexpected variables, and

e = the natural exponent and

i = 1, 2, ...n

The random disturbances (U_j) are assumed to follow a one-sided distribution (e.g., truncated normal, gamma, exponential, etc.) and be independently and identically distributed. In addition, the sets of inputs (Xi) are assumed to be independent of the disturbances. Therefore, the frontier function takes the form:

$$\ln Y_j^* = b_0^* + \sum_{i=1}^{8} bi \ln X_{ij} + U_j$$

Where,

$\ln Y_j^*$ = frontier level of wheat production,

b_0^* = corrected intercept estimate.

$$\text{Technical efficiency (TE)} = \frac{\ln Y_j}{\ln Y_j^*} < 1$$

Where;

$\ln Y_j$ = actual production of wheat, and

$\ln Y_j^*$ = potential production of wheat.

Kopp's measure of allocative efficiency was derived for all resources. A case with reference to frontier level of human labour (X_1), is illustrated below.

Let $R_1 = X_2/X_1$, $R_2 = X_3/X_1$, $R_3 = X_4/X_1$, $R_4 = X_5/X_1$, $R_5 = X_6/X_1$, $R_6 = X_7/X_1$, $R_7 = X_8/X_1$, and X_1^*, X_2^*, X_3^*, X_4^*, X_5^*, X_6^*, X_7^*, and X_8^* denote the frontier use of inputs on jth farm for production of wheat.

Then,

$$\ln X_1^* = \frac{\{\ln Y_j - b_0^* - b_2 \ln (R_1) - b_3 \ln (R_2) - b_4 \ln (R_3) - b_5 \ln (R_4) - b_6 \ln (R_5) - b_7 \ln (R_6) - b_8 \ln (R_7)\}}{\Sigma bi}$$

and $\ln X_2^*$, $\ln X_3^*$, $\ln X_4^*$, $\ln X_5^*$, $\ln X_6^*$, $\ln X_7^*$, and $\ln X_8^*$, were calculated in a similar manner.

Estimation of Allocative Efficiency

Allocative efficiency (AE) refers to the marginal conditions for profit maximization. To attain the goal of profit maximization i.e., for efficient resources allocation, one should use more of the resources as long as the value of the added product is greater than the cost of the added amount of the resources in producing it. The resources are to be considered efficiently used, and profit will be maximum, when the ratio of marginal value product (MVP) to marginal factor cost (MFC) approaches one, or in other words; MVP and MFC for each input are equal. When the marginal physical product (MPP) is measured in monetary terms (MPP x product price), it is called MVP. MFC is the price of one additional unit of input.

The MVP of a particular resource represents the addition to gross returns in value terms caused by an addition of one unit of that resource while other inputs are held constant. The most reliable and perhaps the most useful estimate of MVP is obtained by taking resources (X_i) as well as gross return (Y) and their geometric means. The marginal value products, which were computed by multiplying the production coefficient of given resources with the ratio of geometric mean (GM) of gross return to the geometric mean (GM) of the given resources, i.e,

$$\ln Y = \ln a + bi \ln Xi$$

$$\frac{dY}{dXi} = bi\frac{Y}{Xi}$$

$$\text{therefore, MVP (Xi)} = bi\ \frac{\overline{Y}(GM)}{\overline{X}(GM)}$$

where,

Y = Mean value (GM) of gross return in taka

Xi = Mean value (GM) of the ith variable input in taka

i = 1, 2, 6

GM = Geometric mean

and $\frac{dY}{dXi}$ = Slope of the production function as well as MVP of ith input.

III. TECHNICAL AND ALLOCATIVE EFFICIENCY OF WHEAT GROWING FARMERS

Farm Specific Technical Efficiency

The farm specific technical efficiencies were estimated and the frequency distribution is shown in table 1. It was observed that the farm specific technical efficiency varied among farmer to farmers and ranged from 62% to 96% with a mean of 88% at Dinajpur followed by efficiency range 51% to 96% with mean of 69% at Rangpur. For better presentation of the efficiency result; farms were categorized into 5 different groups with intervals of ten points. It was found that 39 and 9 percent of the total farmers at Dinajpur and Rangpur, respectively belonged to the most efficient category (91 to 100%) and 22% farms at Rangpur were in the least efficient group (51 to 60%). However, majority of the wheat farmers (53%) at Dinajpur belonged higher efficiency (81 to 90%) compared to Rangpur farmers, majority of them belonged to a lower efficiency (61 to 70%)(Table 1).

Table 1. Frequency distribution of technical efficiency.

Efficiency level (percent)	Number of farmers	
	Dinajpur	Rangpur
51 - 60	0	22(22)
61 - 70	3 (3)*	43 (43)
71 - 80	5 (5)	20 (20)
81 - 90	53 (53)	6 (6)
91 - 100	39 (39)	9 (9)
Total farms	100(100)	100(100)

* Figures in the parenthesis indicate percentage of the total.

Efficiency Wise Yields and Resource Use Pattern

Identification of farms, according to variation in farm specific technical efficiency, is an important issue for formulating strategies to increase the productivity. So yield and resource use pattern of different efficient group of farmers were examined and are presented in tables 2 and 3.

Yield level

The higher technically efficient farmers obtained yield of 3338 Kg/ha at Rangpur and 2750 kg/ha at Dinajpur. The lowest yield (1361Kg/ha) was also obtained by the least efficient farmers (22%) at Rangpur. The majority of the farmers at Dinajpur belonged to higher yield groups and majority of the Rangpur farmers belonged to lower yield groups (Tables 2 and 3, Fig. 2).

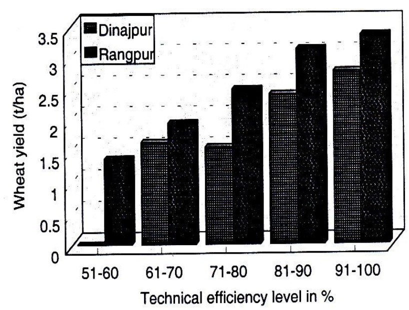

Fig. 2 Technical efficiency wise wheat yield

Table 2. Technical efficiency wise input use pattern of wheat farmers at Dinajpur.

Technical efficiency level (in %)	Character	Yield (Kg/ha)	Sowing time*	Seed rate (Kg/ha)	Human labour (Man-day/ha)	Urea	TSP	MP	Gypsum	Manure	Irrigation number
61-70	Mean	1622	4.00	156	72	194	65	45	00	4430	1.00
	N	3	3	3	3	3	3	3	3	3	3
	Std. Deviation	205	.00	8.62	9.54	38.63	33.04	13.43	00	440	.00
71-80	Mean	1538	3.20	185	71	156.80	50	62	10	5718	1.20
	N	5	5	5	5	5	5	5	5	5	5
	Std. Deviation	549	.84	19.97	21.08	70.27	32.76	14.63	22.09	1022	.83
81-90	Mean	2381	4.06	175	63	200	62	45	13	6536	1.51
	N	53	53	53	53	53	53	53	53	53	53
	Std. Deviation	501	.82	28.01	11.62	57.47	39.24	18.44	25.32	1875	.80
91-100	Mean	2750	3.95	182	66	198	58	43	15	7527	1.77
	N	39	39	39	39	39	39	39	39	39	39
	Std. Deviation	619	.72	25.03	10.25	43.93	46.69	16.82	25.28	2736	.93
All sample	Mean	2460	3.97	177	65	197	60	45	13	6818	1.58
	N	100	100	100	100	100	100	100	100	100	100
	Std. Deviation	627	.78	26.45	11.69	52.85	41.47	17.78	24.67	2289	.85

* For seeding time assuming score number Nov. 16-30 = 5, Dec. 1-7 = 4, Dec. 8-15 and before Nov. 16 = 3, and after Dec.15 = 2.

Table 3. Technical efficiency wise input use pattern of wheat farmers at Rangpur.

Technical efficiency level (in %)	Character	Yield (Kg/ha)	Sowing time*	Seed rate (Kg/ha)	Human labour (Man-day/ha)	Urea	TSP	MP	Gypsum	Manure	Irrigation number
51-60	Mean	1361	2.73	157	97	159	43	48	18	5915	.86
	N	22	22	22	22	22	22	22	22	22	22
	Std. Deviation	402.26	.63	37.27	29.14	81.05	41.49	30.50	37.93	3761	.71
61-70	Mean	1926	3.16	144	106	163	65	45	7	8109	1.35
	N	43	43	43	43	43	43	43	43	43	43
	Std. Deviation	261.32	.65	16.62	39.47	55.25	40.29	23.07	19.24	3605	.61
71-80	Mean	2462	4.25	143	118	168	79	46	9	8320	2.05
	N	20	20	20	20	20	20	20	20	20	20
	Std. Deviation	250.51	.44	26.68	34.74	53.31	44.25	27.93	18.00	3728	.39
81-90	Mean	3112	5.00	134	130	176	123	65	11	13072	2.67
	N	6	6	6	6	6	6	6	6	6	6
	Std. Deviation	151.34	.00	5.16	38.30	48.12	20.30	21.29	28.01	4101	.52
91-100	Mean	3338	5.00	145	145	256	132	51	26	12424	3.00
	N	9	9	9	9	9	9	9	9	9	9
	Std. Deviation	176.66	.00	34.57	45.68	96.47	13.24	35.79	33.25	3516	.00
All sample	Mean	2107	3.56	146	111	173	72	48	11	8355	1.61
	N	100	100	100	100	100	100	100	100	100	100
	Std. Deviation	664.29	.97	26.15	38.78	69.40	46.50	26.88	26.33	4151	.86

* For seeding time assuming score number Nov. 16-30 = 5, Dec. 1-7 = 4, Dec. 8-15 and before Nov. 16 = 3, and after Dec.15 = 2.

Resource use pattern

It was found that the most efficient farms at Dinajpur employed 66 man-days of human labour and used 198 kg urea, 58 kg TSP, 43 kg MP, 15 kg gypsum, 7.5 tones manure and applied 1.8 times irrigation water with 182 kg seed rate per hectare (Table 2, Fig. 2 and 4). But at Rangpur, most efficient farmer applied 3 times irrigation, followed by optimum seeding time (November 16-30) and applied 145 kg seed rate, 256 kg urea, 132 kg TSP, 51 kg MP, 26 kg gypsum and 12.42 tones manure and produced 3334 kg grain per hectare (Table 3, Fig. 3 and 4). However, the most efficient farmers at both the sites obtained higher yield by applying higher quantities of manure, gypsum and more number of irrigation with moderate use of urea, TSP, MP, and human labour compared to low efficient farms. So it was found that even under the existing technologies potentials existed for improving the productivity with proper allocation of the existing resources. Hence proper extension strategies need to be taken to increase the knowledge of the wheat farmers about rational use of inputs.

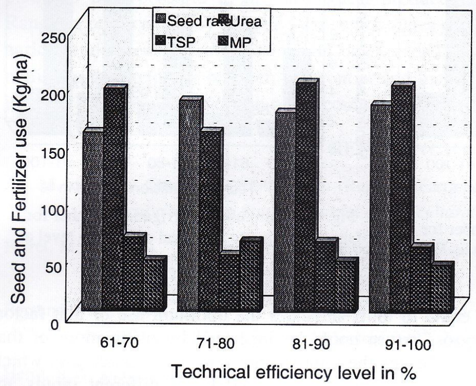

Fig. 3 Technical efficiency wise seed and fertilizer use by the wheat farmers at Dinajpur

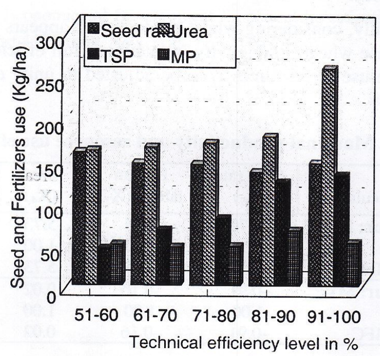

Fig. 4 Technical efficiency wise seed and fertilizer use by the wheat farmers at

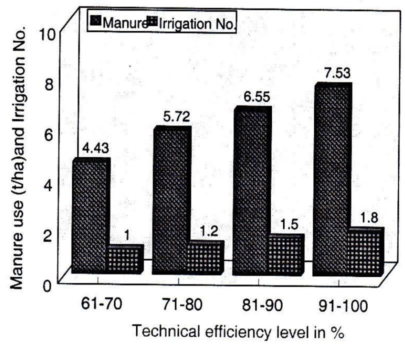

Fig. 5 Manure use and irrigation number for farm according to technical efficiency level at

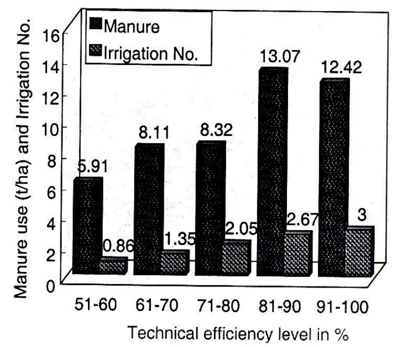

Fig. 6 Manure use and irrigation number for farm according to technical efficiency level at

Allocative Efficiency

If the ratio of MVP and MFC equal to unity indicates the optimum use of that factor, more than unity indicates that the gross return could be increased by using more of that resource and value of less than unity indicates the unprofitable level of resource use, which should be decreased to minimize the loses. The estimated MVPs of different inputs are presented in table 4.

It appears from table 4 that the urea (X_4), irrigation (X_8), TSP (X_5) and manure (X_7) have high productivity. The ratio of MVP and MFC of the variables such as urea (X_4), and irrigation (X_8) were greater than one with positive signs and indicate that more profit can be obtained by increasing the use of these factors at Dinajpur. The ratio of MVPs and MFC of seeds (X_2) was greater than and near to one but negative at Dinajpur and Rangpur, respectively, which indicate the indiscriminate and excessive use of the resource resulting in inefficiency.

Finally, considering wheat production it appears that farmers in the study area had scope to increase wheat productivity by attaining full efficiency through reallocating the resources. Thus the use of resources is to be adjusted to unity depending upon the ratio to achieve full efficiency.

Table 4. Marginal productivity and resource use efficiency of wheat.

Particulars	Seed rate (X_2)	Human labour (X_3)	Urea (X_4)	TSP (X_5)	MP (X_6)	Manure (X_7)	Irrigation (X_8)
Dinajpur: MVP	-3.70	0.35	5.73	0.69	-0.76	0.94	2.35
MFC	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MVP/MFC	-3.70	0.35	5.73	0.69	-0.76	0.94	2.35
Rangpur: MVP	-0.91	-0.16	0.02	0.50	-1.79	0.33	0.72
MFC	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MVP/MFC	-0.91	-0.16	0.02	0.50	-1.79	0.33	0.72

Source: Field survey (1999).

Note: MVP = Marginal value product = MPP x Product price
MFC = Marginal factor cost = Input price

IV. CONCLUSIONS

The farm specific technical efficiency of wheat growers varied from 0.62 to 0.96 with a mean of *0.88* at Dinajpur followed by Rangpur farmers having mean 0.69 ranging 0.51 to 0.96. So it is possible to increase wheat production by 12% and *31%* at Dinajpur and Rangpur, respectively by adopting the technologies used by the frontier farmers. The strategic agricultural extension activities should be extended to wheat crop enterprise basis. This will minimize the yield gap between the frontier and inefficient farmers and at the same time will increase total wheat production of the country.

REFERENCES

Ali, M. and M.A. Chawdhry (1990). "Inter- Regional Farm Efficiency in Pakistan's Punjab: A Frontier Production Function Study". *Journal of Agricultural Economics, 41 (1),* 62-74, January.

Farrel, M. J. (1957). "The Measurement of Productive Efficiency". *Journal of Royal Statistical Society.* A120:253-290.

Forsund, F.R., C.A.K. Lovell and P. Schmidt (1980). "A Survey of Frontier Production Functions and their Relationship to Efficiency Measurement". *Journal of Econometrics.* 13: 5-25.

Herdt, R.W. and Mandac, A.M. (1981). "Modern Technology and Economic Efficiency of Philippine Rice Farmers", Economic Development and Cultural Change, 29 (2), 375-98.

Kalirajan, K.P. and Flinn, J.C. (1983). "The Measurement of Farm Specific Technical Efficiency", *Pakistan Journal of Applied Economics, 2(2),* 167-80.

Lingard, J., Castillo, L. and Jayasuria, S.K. (1983). "Comparative Efficiency of Rice Farmers". Central Luzun, the Philippine, Journal *of Agricultural Economics, 34(2),* 163-73.

Kopp, R.J. (1981). "The Measurement of Productivity Efficiency: A Reconsideration". *Quarterly. Journal of Economics, Vol.* 97, pp. 477-503.

Yotopoulas, P.A. and J.B. Nugent (1976): Economics of Development Emperical Investigations. Haper and Row Publications Inc., 10 East 53`d Street, New York, N.K. 10082: pp7.