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Technical Efficiency of Wheat Farmers in Mixed Farming System of the Punjab, Pakistan

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ABSTRACT

In this study, the technical efficiency of the wheat farmers in the mixed farming system of the Punjab was estimated by using stochastic frontier production function, incorporating technical inefficiency effect model. The Cobb Douglas production function was found to be an adequate representation of the data, given the specification of the corresponding translog frontier model. The technical inefficiency effects were found present. The technical inefficiency effects were found to be a linear function of different firm specific factors. The mean predicted technical efficiency of wheat farmers was 0.936 ranging between 0.58 and 0.985. The results of frontier model indicated that wheat production could be increased by increasing wheat area, weedicides, cultivations and fertilizer use. The results of the inefficiency effect model indicated that the technical inefficiency could be reduced by sowing the crop in time, increasing education of the farmers, by providing credit to the farmers and sowing the crop by drill method. The shortage of the canal water on the other hand increased the inefficiency of the wheat farmers in the mixed farming system of the Punjab. The individual impacts of some of the variables in the inefficiency effect model were non-significant, but the combined influence of all the ten variables was significant in reducing the inefficiency of the wheat farmers in the mixed farming system of the Punjab, Pakistan.

Key Words: Technical; Farmers; Wheat; Punjab

INTRODUCTION

Development of food and agriculture ranks highest in the global economic order. Future must focus on it to avert catastrophy which looms on the world community. Hunger must be avoided at all costs because it has killed more people than all the wars put together. Out of the 121 countries growing wheat, Pakistan at present ranks 8th in terms of wheat area as well as production, but 29th in terms of yield per unit area (FAO, 2000). The World Food Council has found out that the rate of food consumption is faster then that of its production that is why availability of food on per capita basis has been declining each year that goes by (Amjad, 2001). Over greater period of Pakistan's existence, wheat has been imported to meet the minimum food need of the country. Food deficits at times averaged 10-15 % of the wheat requirement. Wheat imports in some years went over 2 million tons. In the current year, wheat deficit has further widened. For the year 2022, wheat production has been projected at 23.71 million tons and wheat requirement at 28.92 million tons, showing a deficit of 5.2 millions tons (Hammad, 1998). This, amongst others, is due to the faster growth rate of human population which is squeezing land and water availability on per capita basis. Other disquieting factors in food sufficiency are rapidly deteriorating state of ground water and land quality. The fact is that due to significant constraints, future expansion of both land and water resources are rather impossible (Khan & Zaidi, 2001). Ahmad (2001) showed negative trend in efficiency in the main cropping zones of cotton, mixed cropping zone and rice zone (which constitute about 70% of the crop wealth of Pakistan), due to land degradation caused by the existing nutrient exhaustive cropping patterns, increasing incidence of waterlogging and salinity, the use of brackish underground water and insects and diseases.

Low yields in Pakistan are mainly due to physiological, agronomic, socio-economic, political factors and poor resource management. Poor management is more conspicuous of all factors, particularly in terms of input use. That is why irrigated wheat per hectare varies from 0.5 tons to 5.5 tons (Hussain *et al*., 2000). Close look at the production technologies of the progressive farmers and those of the research stations shows that the wheat yield can be more than doubled (NCA 1988). Studies (Nadeem 1989; Javed, 1991; Mustafa, 1991) showed that the yield of wheat, sugarcane and berseem can be increased by 2 to 4 times by proper management of soil resources.

The above discussion brings out that source of additional wheat production is by way of improvement in wheat productivity. The present study was oriented towards the goal of achieving higher productivity by improving technical efficiency of wheat farmers. The main objectives were as follows:

OBJECTIVES

1. To measure technical efficiency in wheat production in the district of Toba Tek Singh (Mixed Farming System).
2. To locate reasons underlying inefficiency, if any.
3. To suggest policy measures to enhance efficiency in wheat production

Model and variables. The study used the primary data which were collected from 112 wheat farmers located on the head, middle and tale of the lined/unlined water courses in the mixed farming system. The Cobb-Douglas (CD) production function was found to be an adequate representation of the data, given the specifications of the corresponding translog frontier model. The stochastic frontier model is defined by[1]:

Where ln represents the natural logarithm (base, e); the subscript, i denotes the i-th farmer in the sample, i=1,2,……..112;

Wheat production, (Y_i) represents the total wheat production (in maunds i.e. 40 kg) for the farmer; Wheat area (X_{1i}) represents the total area of wheat (in acres); Irrigation (X_{2i}) represents the quantity of irrigation water applied to wheat crop, which is defined as the number of irrigations times the area of wheat grown; Weedicide (X_{3i}) represents the total cost of weedicide applied to the wheat crop, which is defined as cost of weedicide per acre times area of wheat grown; Cultivation (X_{4i}) represents the total number of cultivations given to the wheat crop, which is defined as number of cultivation per acre times area of wheat grown; Fertilizer (X_{5i}) represents the total nutrient kg of fertilizer applied to the wheat crop, which is defined as nutrient kgs of fertilizer per acre times area of wheat grown; Farm Yard Manure (X_{6i}) represents the total number of trollies applied to the wheat crop, which is defined as the number of trollies applied per acre times area of wheat grown; Family Labour (X_{7i}) represents the total number of adult male equivalents available on the farm and Seed (X_{8i}) represents the total quantity of seed kgs used for the wheat crop, which is defined as the quantity of seed used per acre times area of wheat grown.

The β_ks, k = 0, 1, 2, 3, 4, 5, 6, 7, 8, are unknown parameters for the production function; the V_is are random errors associated with measurement errors in the production of wheat reported, or the combined effects of input variables not included in the production function, where the V_is are assumed to be independent and identically distributed N(0, σ^2_V)-random variables; the U_is are non-negative random variables, associated with technical inefficiency of production of the farmers, assumed to be independently distributed, such that the technical inefficiency effect for the i-th farmer, U_i, is obtained by truncation (at zero) of the normal distribution with mean U_i, and variance, σ^2, such that[2]

Where

Z_{1i} represents the operational farm area in acres; Z_{2i} is a dummy variable for sowing time (if the wheat crop is sown in time, then it has a value of one, otherwise zero); Z_{3i} represents the age of farmer in years; Z_{4i} represents the education of farmer in years of schooling; Z_{5i} is a dummy variable indicating the location of farm on the watercourse (if the farm is located at the head of the watercourse, then it has a value of one, otherwise zero); Z_{6i} is a dummy variable indicating the watercourse (if the watercourse is lined, then it has a value of one, otherwise zero); Z_{7i} represents the canal water shortage measured as the %age of total water used supplied by the tubewell; Z_{8i} is a dummy variable for credit (if the farmer acquired credit, then it has a value of one, otherwise zero); Z_{9i} is a dummy variable for sowing method (if the farmer had sown his crop with drill, then it has a value of one, otherwise zero); Z_{10i} is a dummy variable for tubewell (if the farmer had its own tubewell, then it has a value of one, otherwise zero) and the δ_{ks} are unknown parameters to be estimated and k = 0, 1, 2, …..10.

This stochastic frontier model is estimated using the computer program, FRONTIER 4.1, written by Coelli (1996). The parameters of the frontier model are estimated, such that the variance parameters are:

$$\sigma^2_S = \sigma^2_V + \sigma^2 \quad \text{and} \quad \gamma = \sigma^2 / \sigma^2_S$$

where the γ parameter has a value between zero and one.

A basic summary of the values of the key variables, which are defined in the econometric model in the previous section, is given in Table I. The values are on per farm basis.

RESULTS

The maximum likelihood estimates of the parameters of the stochastic frontier production function defined by equation 1 and 2 are presented in Table II along with their standard errors and t-values.

The Cobb Douglas production function was found to be an adequate representation of the data, given the specification of the corresponding Translog Frontier Model, so these β-estimates are the average elasticities of production. The value of coefficient for wheat area (acres) is 0.783. This indicates that one percent increase in wheat area increase the wheat production by 0.783%. The calculated t-value is 4.28, which indicates that this coefficient is statistically significant at less than one percent level of significance. This finding is in line with those of Hussain (1999), Bettese and Hassan (1999), Bettese and Broca (1997), Coelli and Bettese (1996), Parikh *et al.* (1995), Bettese *et al.* (1993), and Ali and Chaudhry (1990).

[1] $\ln(Y_i) = \beta_0 + \beta_1 \ln(X_{1i}) + \beta_2 \ln(X_{2i}) + \beta_3 \ln(X_{3i}) + \beta_4 \ln(X_{4i}) + \beta_5 \ln(X_{5i}) + \beta_6 \ln(X_{6i}) + \beta_7 \ln(X_{7i}) + \beta_8 \ln(X_{8i}) + V_i + U_i$

[2] $U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \delta_9 Z_{9i} + \delta_{10} Z_{10i}$

Table I. Basic Statistics on Farm Basis

	Efficiency Level			
	Mean Value	**Standard error**	**Minimum Value**	**Maximum Value**
Efficiency (%)	93.6	0.007	58.20	98.8
Production (Munds)	558.74	60.93	37.50	4500.0
Yield (Munds)	40.35	0.81	25.0	65.0
Cultivation (No)	85.18	7.42	4.42	450.0
Irrigation (No)	68.92	7.46	4.0	600.0
Fertilizer (Nutrient Kg.)	1248.52	146.6	48.0	11000.0
FYM (Trollies)	12.19	0.89	0.0	51.0
Weedicides (Rs.)	4902.87	557.94	0.0	45000.0
Family Labour	3.41	0.20	1.0	13.0
Seed Quantity (Kg.)	707.63	72.24	49.90	5500.0
Sowing Time (Dummy)	74.04	0.04	0.0	1.0
Age (Years)	46.16	1.2	22.0	80.0
Education (Years)	7.68	0.43	0.0	16.0
W.C. Position (Dummy)	33.92	0.04	0.0	1.0
Farm Area (Acres)	19.55	1.59	1.25	112.0
Water Course (Dummy)	46.42	0.05	0.0	1.0
Water Shortage (%)	59.22	1.12	30.0	90.0
Loan (Dummy)	66.96	0.04	0.0	1.0
Drill (Dummy)	54.46	0.05	0.0	1.0
Tubewell (Dummy)	41.07	0.05	0.0	1.0

Table II. Maximum likelihood Estimates for Parameters of Stochastic Frontier Production Function and Inefficiency Model for Wheat Farmers in the mixed farming system of Punjab, Pakistan

Variable	Parameter	Standard error	T-Value
β_0	3.558	0.596	5.97
Ln of Wheat area (acres)	0.783	0.183	4.28
Ln Irrigation (No.)	0.046	0.005	0.86
Ln Weedicide cost (Rs.)	0.029	0.012	2.51
Ln Cultivation (No.)	0.323	0.052	6.18
Ln Fertilizer (N.kg)	0.201	0.474	4.24
Ln FYM (Trollies)	0.007	0.008	0.89
Ln Family labour	0.041	0.033	1.24
Ln Seed (Kg.)	-0.395	0.162	-2.45
Inefficiency Model			
δ_0	-0.135	0.715	-0.19
Farm area (acres)	-0.001	0.008	-0.14
Sowing time (dummy)	-0.088	0.081	-1.09
Age (years)	-0.003	0.005	-0.67
Education (years)	-0.031	0.015	-2.03
Location of farm (dummy)	-0.0009	0.097	-0.009
Water course (dummy)	-0.097	0.163	0.59
Water shortage (%age)	0.010	0.006	1.61
Credit (dummy)	-0.311	0.214	-1.45
Drill	-0.389	0.003	-1.29
Owned Tubewell (dummy)	-0.070	0.100	-0.69
Variance Parameters			
σ_s^2	0.039	0.007	5.18
γ	0.594	0.136	4.36
Log-likelihood Function	63.44		

The coefficient for the weedicide cost variable is 0.03. This indicates that one percent increase in the weedicide cost will increase the wheat production by 0.03%. The calculated t-value for this coefficient is 2.51, this indicates that the coefficient is statistically significant at less than five % level of significance. The value of the coefficient for the cultivation (No.) variable is 0.32. This shows that a 1% increase in the cultivation (No.) increases the wheat production by 0.32%. This coefficient is significant even at less than one percent level of significance. This result is in line with that of Bettese *et al.* (1993). The coefficient for the fertilizer (nutrient kg.) variable is 0.020. This indicates that a one percent increase in fertilizer use will increase the wheat production by 0.20%. This coefficient is statistically significant at less than one percent level of significant. This result is in line with those of Hussain (1999) and Bettese *et al.* (1993). The coefficient for the family labour (adults male workers) is 0.04. This indicates that a one percent increase in the variable will increase the wheat production by 0.04%. The calculated t-value for this coefficient is greater than one. This result is in line with those of Hussain (1999) and Bettese *et al.* (1993). The coefficient for the irrigation (No.) is positive but non-significant. This coefficient is non-significant due to the use of tubewell water, which is of poor quality. This result is in line with that of Hussain (1999) and Ahmad (2001). The coefficient for the Farm Yard Manure (Trollies No.) variable is positive but non-significant.

The coefficient for the seed (Kg.) variable is 0.39 with negative sign. This indicates that one percent increase in seed usage will reduce the wheat yield by 0.39%. This coefficient is statistically significant at less than five percent level of significance. The primary reason for this negative sign is that farmers use much higher seed rate than the recommended one (45 kg.). This result is in line with that of Bettese and Hassan (1999).

The coefficients of the explanatory variable in the model for the technical inefficiency effects, defined by equation 2, are of particular interest to this study. The coefficient for the sowing time variable is negative, with a t-value greater than one. This indicates that the farmers, who sow their crops timely, are technically more efficient. This result is in line with that of Hussain (1999).

The coefficient for the age variable is negative too, but it is non-significant so we can not say that older the farmers are technically less inefficient than the younger farmers. This result is in line with those of Hussain (1999) and Coelli (1996). The coefficient for the education variable is negative. This implies that wheat farmer with greater year of schooling tends to be less technically inefficient. This coefficient is statistically significant at less than five percent level of significance. This result is in line with those of Hussain (1999), Ahmad (2001), Coelli (1996), Bettese *et al.* (1993, 1996), Rauf (1991), and Ali and Flinn (1989). The coefficient for the location variable is also negative but is non-significance. This does not imply that the wheat farmers located at the head of the water course are technically less inefficient, because of the larger availability of good quality irrigation water. The coefficient of the farm area variable is negative, but it is non-significant. Thus we can not say that large farmers are technically less inefficient than the small farmers. This result is in line with those of Khan and Makki (1979) and Coelli (1996). The coefficient for the water course (lined/unlined) is also negative, it is also non-significant. The coefficient for the water shortage variable is positive with calculated t-value greater then one, this indicates that as water shortage increases the technical inefficiency of the farmer also increases. This result is in line with that of Ali and Flinn (1989). The coefficient for the loan variable is also negative with calculated t-value greater then one, this indicates that farmers who get loan are technically less inefficient as compared to the farmers who do not get loan. This result is in line with those of Hussain (1999), Ali and Flinn (1989) and Parikh *et al.* (1995). The coefficient for the sowing method (drill or not) is also negative with a t-value greater than one. This indicates that the farmers who have sown their crop by drill are technically less inefficient than the other farmers who did not used it. The coefficient for the tubewell variable is also negative, but this coefficient is statistically non-significant. So we cannot say that the farmers having their own tubewells are technically less inefficient than those who do not have the tubewells. But the joint effect of these explanatory variables on the levels of technical inefficiencies is significant, although, the individual effects of some of these variables are not statistically significant.

The estimate for the variance parameter, σ^2/σ^2s, indicates that the variance, σ^2, associated with the inefficacy effect is about 60% of the two variances.

Given the specification of the Cobb Douglas frontier production function for the wheat farmers in the mixed farming system of the Punjab, the technical inefficiencies of production are found to be significant. The predicted technical efficiencies of the individual sample wheat farmers are presented in Table III, together with the mean technical efficiency. The numbers of observations are 112. The highest level of technical efficiency is 0.985, while the lowest level is 0.58. The mean predicted technical efficiency of the wheat farmer is 0.936. The frequencies of occurrence of technical efficiencies of farmers in different ranges are presented in Fig. 1. The average loss in production due to technical inefficiency is 6.4%, but this loss varies from 1.15 to 42% among the sample farmers.

CONCLUSIONS AND SUGGESTIONS

The results of the study indicated that technical inefficiency is present in wheat farming. This inefficiency is a linear function of the firm specific factors.

As a result, the study in hand concludes and suggests the following policy recommendations for the wheat growers in the mixed farming system of the Punjab, Pakistan

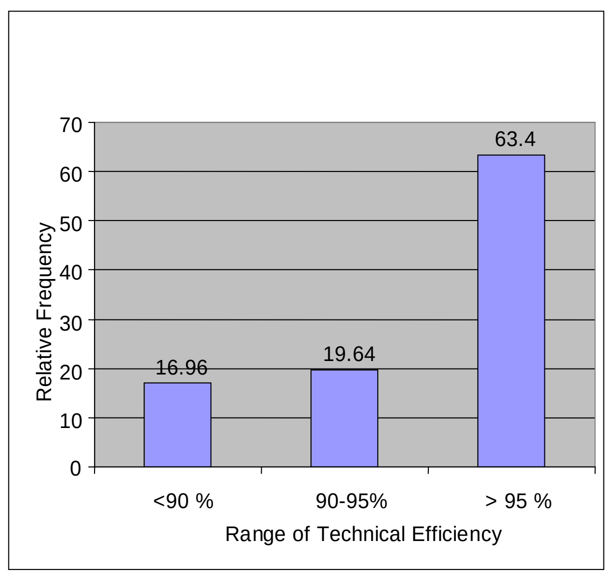
1. Since size of farm and wheat acreage had positively enhanced wheat production and efficiency, increase in size of farm must deserve top priority. Squeezing farm land area as a result of increasing population pressure has been consistently drifting the country away from this desired goal. Cooperative or corporate farming could be the feasible way out. The government should give top priority to these developments. Consolidation of holdings should equally deserve top attention of the policy makers. If efforts are pursued vigorously in these directions, the existing subsistent agriculture may blossom in the country side. These developments would improve flow of capital to

Table III. Technical Efficiencies of Sample Wheat Farmers obtained using the Cobb-Douglas Stochastic Frontier Production Function Model

Farmers Number	Technical Efficiency	Farmers Number	Technical Efficiency	Farmers Number	Technical Efficiency
1	0.97567	39	0.96847	77	0.91722
2	0.94231	40	0.96897	78	0.94322
3	0.97277	41	0.97821	79	0.88015
4	0.95773	42	0.97389	80	0.77215
5	0.96764	43	0.97808	81	0.86940
6	0.79722	44	0.97914	82	0.94557
7	0.93610	45	0.98205	83	0.94095
8	0.97888	46	0.97638	84	0.86457
9	0.97696	47	0.97179	85	0.96663
10	0.96362	48	0.98109	86	0.96354
11	0.94662	49	0.97239	87	0.94965
12	0.80248	50	0.97596	88	0.95567
13	0.98073	51	0.97778	89	0.95559
14	0.97734	52	0.97825	90	0.98097
15	0.98292	53	0.58091	91	0.84045
16	0.98215	54	0.93697	92	0.95551
17	0.97477	55	0.73704	93	0.61234
18	0.98363	56	0.94697	94	0.92616
19	0.98417	57	0.83764	95	0.96849
20	0.97160	58	0.88292	96	0.91655
21	0.80661	59	0.97302	97	0.90862
22	0.98080	60	0.96740	98	0.85306
23	0.97239	61	0.92591	99	0.95657
24	0.97758	62	0.94725	100	0.96412
25	0.96491	63	0.97785	101	0.83602
26	0.98101	64	0.97564	102	0.95578
27	0.98526	65	0.97230	103	0.94374
28	0.94116	66	0.97865	104	0.96940
29	0.93189	67	0.96755	105	0.74678
30	0.97262	68	0.96951	106	0.96127
31	0.96534	69	0.96413	107	0.87278
32	0.97534	70	0.95355	108	0.97632
33	0.97590	71	0.97626	109	0.91523
34	0.97242	72	0.94897	110	0.96919
35	0.94128	73	0.96946	111	0.98049
36	0.77278	74	0.95784	112	0.97159
37	0.97153	75	0.95062		
38	0.88127	76	0.94510		

Mean Technical Efficiency = 0.93604

Fig. 1. Relative Frequency Distribution of Technical Efficiencies of Wheat Farmers



agriculture and pave way for the use of modern production technology on a massive scale. Failing this, farm size and wheat acreage would get smaller and smaller with the passage of time.

2. Canal water deficiency increased the inefficiency of the farmers. These deficiencies were met from the poor quality tubewell water, as natural precipitation is of minor significance in the mixed farming zone of system of Punjab. Surface irrigation is, however, mixed blessing because it is usually associated with the twine problems of water logging and salinity. For improvement in this system, following suggestions deserve attention of the policy makers.

a. Surplus rainy water be taped with the help of additional water storage capacity.

b. Drainage be improved.

c. Check transit water losses in the canal and water channels as well at the farmer's field. Lining of canals, water channels and field leveling are steps in the right direction. For this purpose the On-Farm Management and command water management projects be implemented throughout the farming areas.

3. At the individual farm level, the variables which reduced inefficiency included drill and timely sowing of wheat, lining of water channels and education of the farmers. These non-priced variables can be adopted without any involvement of subsidy. For drilling, requisite machinery should be popularized. In the mixed farming zone most of the wheat comes after cotton, sugarcane or rice crop. As far as timely sowing of wheat is concerned, short duration, early maturing cotton and rice varieties need to be evolved. Early harvesting of sugarcane is also step in the right direction. For this purpose early start of sugarcane crushing is a must, sugar mills be asked to commission their mills early in October each year, so that ratoon sugarcane could vacate area for sowing of wheat.

Education of the farmers also reduces the production inefficiency, but farmers cannot be educated in a short period of time. Here extension service, as a substitute for education has a positive role to play. The Government should strengthen its extension service both qualitatively and quantitatively. Adequate funds be provided enabling the extension workers to lay out model farms and demonstration plots.

4. Last but not the least; credit availability can remove most of constraints in the way of higher efficiency. Provision of easy, quick, timely and adequate credit must deserve top attention of the policy makers. At present agriculture is starved of capital. This deficiency be corrected at the earliest convenience.

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