

**DETERMINANTS OF AGRICULTURAL PRODUCTIVITY
IN RICE-WHEAT CROP ROTATION AND ITS IMPACT
ON AGRICULTURAL COHESION: LESSONS LEARNED
FROM PAKISTAN**

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Abstract

This research work estimated technical efficiency (TE), allocative efficiency (AE) and economic efficiency (EE) of cereal crops and identified the determinants of technical inefficiency of rice-wheat farming system. Primary data was collected from 120 farmers in Sheikhpura district, Pakistan randomly. For this purpose, a non-parametric Data Envelopment Analysis (DEA) technique was applied. Tobit regression model was estimated to investigate determinants of technical inefficiency of the system. The results revealed that TE, AE, and EE of rice farmers were 0.81, 0.61, and 0.50, respectively. The results revealed that TE, AE, and EE of wheat farmers were 0.87, 0.80, and 0.70, respectively. The investigation shows that if wheat farmers operated at a full efficiency level, they could reduce their input use by 13% and reduce cost by 20% without reduction in output and with existing technology (modified agricultural and information and communication technology).

Key words: technical efficiency, allocative efficiency, economic efficiency, cereal crops, information and communication technology

Introduction. Wheat is the leading food cereal of the country regarding area under cultivation and production followed by rice and maize. It is also consumed as a basic food in different countries including India, Australia, Bangladesh,

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Argentina, Canada, France, etc. It is being grown in different rainfed and irrigated regions of the world. With the continual increase in the population, there is a need to boost up wheat production, so that we can fulfill the food demand. Wheat contributes 13.1% to the value added in agriculture and 2.8% to GDP [1]. Rice is also the main cash crop and holds a specific position in the agro-based economy of the country. Pakistan cultivates enough good quality of the rice to fulfill the demand of both national and international markets [2]. There are two chief rice growing provinces in Pakistan namely Punjab and Sindh [3].

Among food cereals, the share of wheat and rice in agriculture is 12.5% and 4.9%, respectively. On the other hand, wheat and rice contributions are 2.6% and 1.0%, respectively, in GDP [4]. The difference between the potential yield for a specific crop and actual yield of a farmer at a given technology, production environment, quality of inputs and resources is known as yield gap [5]. Furthermore, exploitation of small farmers and improper post-harvest handling of agriculture produce in Pakistan results in quantitative and qualitative losses causing low productivity of major food crops in the country [6, 7].

Various studies on the efficiency of agricultural production, mainly for wheat and rice have highlighted the presence of a yield gap. This gap explains the variation in the productivity on good agricultural best practices and on other agricultural farms working with equivalent resource endowments under the same conditions [8, 9]. Farming community is mainly concerned with the productivity and revenue earned from the farming business that depends on the resource use efficiency directly or indirectly. Little efforts have been made along these lines in the wheat and rice crops of Pakistan [10, 11].

The recent food crisis (wheat and rice) and occasional surpluses and shortages of agricultural commodities underline the need for taking measures by the government to improve the working of agricultural production system [12, 13]. The main thrust is to enhance wheat and rice production, to decrease the imports, and to ensure the food security in order to provide the requirements of the increasing population day by day [14, 15]. In this context, the study in hand is designed to explore the impact of the major determinants affecting low productivity in the study area that will assist policy makers to find useful information for effective policy making.

Materials and methods. The collection of primary data was undertaken in district Sheikhupura from 120 rice and wheat growers (71 small farmers, 32 medium farmers, and 17 large farmers) to find out determinants of technical, allocative and economic efficiency of rice-wheat system in the study area. Sheikhupura was selected as universe of this study. This area is included in the rice-wheat belt of Punjab and all varieties of rice and wheat are grown here. This district is also included in the top ten districts of Pakistan in production of basmati rice.

According to FARRELL [16], efficiency is defined as the actual productivity of a firm relative to its maximal productivity. Maximal productivity (also called

best practice) is defined by the production frontier [16]. The data envelopment analysis (DEA) is a non-parametric technique in research for measuring the relative efficiency of decision-making elements. These elements might be, for instance, farmers, organizations, or departments, which transform various inputs into various outputs.

The basic philosophy behind this technique is to compare elements based on the inputs and outputs, without making explicit assumptions about the production function. In simple words, this method is used to assess the performance of decision-making elements relative to each other, supposing their various inputs and outputs.

Technical efficiency scores can be obtained by running constant returns to scale DEA model [17]. By running constant returns to scale DEA model, the technical efficiency scores of each decision making element shows how close they are to the production frontier or efficiency [18]. High efficiency scores claim better performance whereas the low scores highlight the areas where necessary modifications in the efficiency might be done. These scores give valuable insights for the farming community to delineate and address inefficiencies in agriculture [19]. The allocative efficiency was estimated by dividing economic efficiency by technical efficiency.

Basically the calculations are made with linear programming method. In order to examine the impact of these socioeconomic and farm-specific variables on inefficiency estimates, we use the Tobit regression model. Tobit model employs simultaneously estimation of the coefficients of the regression equation as well as the parameters of the censored observation. The Tobit regression equation is given as:

$$(1) \quad E_i = \beta_0 + \beta_1 \cdot Z1_i + \beta_2 \cdot Z2_i + \beta_3 \cdot Z3_i + \beta_4 \cdot Z4_i + \beta_5 \cdot Z5_i + \beta_6 \cdot Z6_i.$$

where

- i refers to the i -th farm in the sample;
- E_i represents technical inefficiency of the i -th farm;
- $Z1_i$ represents the extension services;
- $Z2_i$ represents the age of the i -th farm's operator in years;
- $Z3_i$ represents the education of the i -th farmer in years of schooling;
- $Z4_i$ represents the number of contacts of the i -th farmer with extension agents;
- $Z5_i$ represents the distance of the i -th farm from main market in kilometers;

- $Z6_i$ is a dummy variable having value equal to 1 if farmer has access to credit or 0 otherwise.

Results and discussion. Total technical scores of rice are presented in Table 1. Results of the study indicate that the mean total technical efficiency of the sample farms is 0.81, with a range of 0.71 and 1.0, respectively.

T a b l e 1
Technical efficiency of rice farmers

Efficiency level	Frequency	Percentage
70–80	62	51.7
81–90	43	35.8
91–100	15	12.5
Total	120	100.0
Overall efficiency		
Mean	0.81	
Maximum	1.00	
Minimum	0.71	

These results imply that if sample farms operated at full efficiency level they could reduce, on an average, their input use by 19% and still produce the same level of output and with the same technology. The mean allocative efficiency of the sample farms is estimated at 0.61, with a low of 0.39 and a high of 1. The mean economic efficiency of the sample farms is 0.50, ranging between 0.30 and 1.0. Results of the study also reveal that if sample farmers of rice operated at full efficiency level, they could reduce their cost of production by 39% and still produce the same level of output and with the existing technology. The maximum efficiency of farmers is 100%, so the farmers falling in this category were operating at efficiency level. The minimum Technical efficiency score is 71%. There are 62 farmers from the total 120 selected farms who have efficiency in the range of 70–80%. So there are 51.7% farmers who have efficiency up to 80%. In efficiency range of 81–90 there are 43 farmers; 35.8% of the farmers were technically efficient up to 90%. A small amount of only 15 farmers lie in efficiency level of 91–100. We can explain this as the 12.5% of farmers are technically efficient up to 100%. It is shown in Table 2 that the allocative efficiency of majority of the sample farms falls within the range of 41 and 80. Out of 120 sample farms, only 2.5% of farms have allocative efficiency greater than 0.80, 12.5% of farms have allocative efficiency between 0.71–0.80, 40% of farms have allocative efficiency between 0.61–0.70, 39.2% of farms have allocative efficiency between 0.51–0.60, 4.2% of farms have allocative efficiency between 0.41–0.50, 1.7% of farms have allocative efficiency between 0.31–0.40.

It is evident from Table 3 that the economic efficiency of majority of the sample farms falls within the range of 0.30 and 0.60. Out of 120 sample farms, only 2.5% of farms have economic efficiency greater than 0.80, 2.5% of farms

T a b l e 2

Allocative efficiency of rice farmers

Efficiency level	Frequency	Percentage
30–40	2	1.7
41–50	5	4.2
51–60	47	39.2
61–70	48	40.0
71–80	15	12.5
81–90	0	0.0
91–100	3	2.5
Total	120	100.0
Overall efficiency		
Mean	0.61	
Maximum	1.00	
Minimum	0.39	

T a b l e 3

Economic efficiency of rice farmers

Efficiency level	Frequency	Percentage
30–40	14	11.7
41–50	45	37.5
51–60	49	40.8
61–70	6	5.0
71–80	3	2.5
81–90	0	0.0
91–100	3	2.5
Total	120	100.0
Overall efficiency		
Mean	0.50	
Maximum	1.00	
Minimum	0.30	

have economic efficiency between 0.71–0.80, 5% of farms have economic efficiency between 0.61–0.70, 40.8% of farms have economic efficiency between 0.51–0.60, 37.5% of farms have economic efficiency between 0.41–0.51, 11.7% of farms have economic efficiency between 0.31–0.40.

The coefficients of explanatory variables in Tobit regression models are of particular interest in terms of understanding the inefficiency differentials among the farmers and for making policy options. A negative sign of a parameter means that the variable reduces inefficiency while positive sign means that the variable increases inefficiency.

Sources of technical inefficiency of rice-wheat system are presented in Table 4. The sources of technical inefficiency indicate that the years of schooling, contact with extension agents, and access to credit variables are negatively related while

T a b l e 4

Sources of technical inefficiencies of rice farmers

Predictor	Coefficient	SE Coefficient	Prob.
Constant	0.26277	0.05056	0.657
Age	0.0007	0.001044	0.030
Education	-0.00317	0.005242	0.064
Extension services	-0.00416	0.01964	0.083
No. of farmer visits to extension agent	-0.00504	0.009906	0.061
Farm to market distance	0.00753	0.003145	0.050
Credit access	-0.03243	0.01591	0.044

age of farm's operator is positively related with the technical inefficiency of farms in rice-wheat system. The parameter for years of schooling variable has a negative sign. This implies that the farmers with more years of schooling are technically less inefficient than the farmers with less/no years of schooling.

More years of schooling create awareness among the farmers and thus educated farmers get better yields. The age of farm's operator variable is positively and significantly related with the technical inefficiency of farmers, which implies that the younger farmers are technically less inefficient than the older ones. The older farmers are less likely to have contact with extension agents and are less willing to adopt new practices and modern inputs. It is safe to conclude that the younger farmers are likely to have some formal education and therefore, might be more successful in gathering information and understanding new practices. The coefficient of contact with extension agents variable is negative and significant which strengthens. This implies that the farmers having more contacts with extension agents are technically less inefficient than their counterparts who have less/no contacts with extension agents.

The number of farmer visits to extension agent has a negative impact on technical inefficiency. This shows that the farmers who have greater number of visits are technically less inefficient than others. The obvious reason for this relationship may be that they apply the advice of extension agent in the field. The access to credit dummy variable is introduced to see the impact of availability of credit on technical inefficiency of farmers. The parameter estimates of access to credit dummy variable carries a negative sign. The farm to market distance variable is positively and significantly associated with the technical inefficiency of farms. The results of the study suggest that the technical inefficiency of sample farms would significantly decrease with the development of road and market infrastructure.

Conclusion. The most obvious inference from the results of the study is that there is a need of sound policies to encourage formal education of rural households as a means of increasing efficiency over a long period of time. This will enable farmers to make better technical decisions and help them in allocating the inputs efficiently and effectively. In the short run, informal extension education

could be effective, especially when targeted at those who have limited formal education. Findings of the study indicate that the farmers having more contacts with extension agents are less inefficient than the farmers having low/no contacts. It is, therefore, recommended that the policy makers should focus on enhancing farmer's access to information via provision of better extension services. Results of the study revealed that farmers having better access to credit are more efficient than those with poor access to credit.

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