Research Article

Technical Efficiency Analysis of Rice Production in Pakistan under Dry and Puddle Conditions: A Case Study of Selected Districts of Punjab province, Pakistan

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Abstract | In Pakistan, two methods mainly using for the transplanting of rice paddle (Conventional method) and Direct seeded method (Dry method) in rice growing areas of Punjab. In last some years, the direct seeded rice system is introduced in some of the rice cropping districts of Pakistan. The current research estimate the technical efficiency of conventional and dry rice farmers and also determine the factors which significantly contribute to increase the rice output. Moreover, this study estimated the sources of inefficiency. Data collected from 300 sample rice farmers into the Kharif cycle (2013-14) at five main rice growing districts of Punjab namely: Hafizabad, Sheikhupura, Jhang, Vehari, and Gujranwala. Stochastic frontier analysis (SFA) was applied to find the results of a study. Study results reveal that direct seeding method is more profitable for dry rice farmers in terms of yield and also increases the efficiency of farmers. Area under rice crop, NPK ratio, Seed, number of irrigation hour, weedicides, insecticides and pesticide variable would significantly contributes to improve the rice production. On average technical efficiency of sample rice farmers is 86 percent, which indicates that rice farmers in selected areas can increase the production of rice 14 percent only by managing efficiency level, without increasing input quantities. Hence, it is possible for rice farmers to increase rice output without increasing the level of inputs by using efficient management practices.

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Keywords | Technical efficiency, Stochastic frontier analysis, Technical inefficiency index, Ordinary least squares, Maximum likelihood estimates, Log likelihood ratio, Farm yard manure.

Introduction

Rice crop is the major staple crop of Pakistan, which is the second major source of foreign exchange earnings after Cotton. According to Economic Survey of Pakistan (2013-14), rice share in GDP 0.7 percent and 3.1 percent in farming. In addition, rice production has increased 6,798 thousand tons in 2013-14 as compared to 5536 thousand tons in 201-13 reflecting, an increase of 22.8 percent.

Punjab and Sindh are the leading rice growing provinces out of which about 92 percent of the total area under rice. The main rice tract lies in the Punjab province covering more than one million hectares annually. Punjab province, soil condition suitable for rice thus, received hundred percent of Basmati rice production in the country. In Punjab,the main rice producing districts of rice are: Gujranwala, Sialkot, Okara, Hafizabad, Sheikhupura, Mandibahuddin and Jhang. These areas contribute more than 70 percent of Basmati rice yield in the county. In Punjab, total rice cropping areas are 1.76 million hectares which have a big share (68%) on the total rice area of Pakistan.

There are two most important methods to use for transplanting of rice like direct seeding system and wet seeding system. Wet seeding system (Puddled condition) is basically a conventional technique for sowing rice and most of the farmers use conventional techniques for sowing rice. Direct seeded method is a Dry method for sowing rice. It is a latest technique for sowing rice. Direct seeding method comprises of seeding dry seeds on to dry loam whereas, conventional method, wet seeding comprises of sowing pre-germinated seeds on to puddle loam. Ali et al. (2013) said that per acre puddle production in Pakistan too much less than the key rice producing countries of the world because of many yield-limiting factors like weed infestation, improper combination of fertilizers, smaller plant population per acre, shortage of labor are the major constraints for the transplanting and harvesting of rice crop. Pandey and Velasco (2002) said that in reaction to increasing labor costs, viable demand for water and the demand to increase crop yield, several Asian farmers have moved from the conventional method of rice to direct seeding of rice.

Unfortunately, in Pakistan, at present, no proper and economically viable cropping system in practice to make the best usage of rice land for determining productivity. Usually, farmers used the conventional method for transplanting of rice. Conventional method required a lot of water for the transplanting of rice and this technique farmers face higher labor cost. On the contrary, recently dry rice method is introduced in the rice growing areas. It is the modern cost saving technique that not only save water, but also gives the farmers higher yield as well as it increases the efficiency of farmers.

Objectives

- To measure the relative technical efficiency analysis of conventional rice and direct seeded rice sowing systems.
- To evaluate the technical inefficiency in conventional and direct seeded rice system.

Literature review

Measurement of farm efficiency for both in developed and developing agricultural countries are very important. Farrell (1957) was the first one who introduce the idea of efficiency analysis at the farm level. Farrell's (1957) determine the article that led to the development of several methods to estimate the efficiency of production. After that, the significance of increasing efficiency in agriculture production have been examined by the researchers both in Pakistan and all over the world such as., Abedullah et al., (2010); Abid et al. (2011); Krasachat (2003), Linh and Thiruchlvarn (2004); Brazdik (2006), Abedullah et al. (2007), Akmal and Saleem (2008), Narala and Zala, (2010), Gomez and Neyra (2010), Javed et al. (2010) and Abu (2011) estimated efficiencies in farming sector by applying Stochastic Frontier analysis (SFA) and Data Envelopment Analysis (DEA) which commence the results that variety of natural resources influences on technical efficiency of rice farmers like seeds, labor hour, ploughing hour, irrigation hour, fertilizers nutrients, and mechanical power. Moreover, concluded that technical inefficiency is very much influenced by primary education and regional factors.

Ahmad et al. (1999) assessed the technical efficiency of Pakistani rice farmers concluded that agriculture credit and extension offices perform the main role for increasing the technical efficiency of farmers. Educated and experienced framers also obtain higher productive efficiency as a result achieved higher output.

Erhabor and Ahmadu (2012) determine the socio-economic factors that affect the technical inefficiency of rice farmers in Taraba state Nigeria. The results states that farmers inefficiency increases with increase in age and inefficiency of a farmers decreases as increases the number of male farmers, household size, education level and farmers experience in farming sector.

Abedullah et al. (2007), Javed et al. (2008), Narala and Zala (2010), Bjorndal and Adhikari (2012), identified some factors., age, education, experience, access to credit, tenure status, utilization of extension service, involvement in off farm work, farm size, number of male in the farmers household and soil fertility were the major factors which significantly contribute to reduce farmer's technical inefficiency.

Research Methodology

Data collection procedure

The cross-sectional data were used in this study. Study was undertaken by collecting primary data of input and output quantities from 300 respondents belongs to five main rice growing districts of Punjab namely: Sheikhupura, Hafizabad, Gujranwala, Jhang and Vehari. From each district total four villages were chosen by applying purposive random sampling technique. Two types of farmers (conventional and direct seeded) were chosen in the selected areas. Total 15 famers selected randomly from each village for interview purpose. Data was collected for the rice crop during Kharif season in year 2013- 2014. A well designed and comprehensive questionnaire was used to collect the data from the particular respondents.

Efficiency measurement methodology

Concept of efficiency: Farrell (1957) develop the idea of efficiency. He describes there are three types of efficiency. i) Technical efficiency. ii) Price or Allocative efficiency. iii) Economic efficiency.

The neoclassical production theory explains the production function which is constructed on the idea of efficiency that gives high yield for a given set of inputs.

Theoretical framework of stochastic frontier approach: According to Kumbhakar and Lovell (2000) and Cabrera et al. (2010) stochastic frontier model is the most suitable approach, especially in the rural sector because of its ability to deal with stochastic noise like unsystematic variables: weather, Luck, and other incidence which cannot control the firm). It is capable for hypothesis testing, and allows for single step estimation of the ineffectiveness effects. This research is an agriculture based research. Hence, the present study used the Stochastic Frontier Approach (SFA) for empirical analysis.

Stochastic production frontier model was instantaneously introduced by Aigner and Chu (1968), Seitz (1971), Timmer (1971), Richmond (1974), Aigner et al. (1977) and Meeusen and Van den Broeck (1977). The main feature of SFA is that the error term, which had two instruments, one describes the accidental effects and another explain the technical inefficiency. The term "V_i" captures the random/accidental effects that occur due to the measurement error, statistical noise and other non-fair influences which are beyond the control of farmers and the term "U_i" captures the technical inefficiency that can control the farmers.

The model functional form can be written as:

$$Y_i = X_i\beta + (V_i - U_i) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

i: 1,2,----------N; Y_i: Output of the i[th] farm; X: Inputs used by the producer of firm; β: Vector of unknown estimated parameters; V_i: Random variable supposed to be identically independent distribution (iid) N (0, δ^2v); U_i: Non- negative random variable supposed to accumulate for technical inefficiency in output function and supposed to be iid N (0, δ^2u).

$$E = V_i - U_i \ldots\ldots\ldots (2)$$

E: Error that shows the difference of technical inefficiency and random error term; V_i: Symmetrical random variables that carry the random effects which are outside of farmers control like Climate, Disaster, and Luck etc; U_i: It is a one sided ($U_i \geq 0$) efficiency factor and non-negative which measures the technical inefficiency of the rice growers. Both U_i and V_i are independent of each other's.

$$\delta^2 = \delta^2_U + \delta^2_V \ldots\ldots\ldots\ldots (3)$$

$$\Upsilon = \delta^2_U / \delta^2_U + \delta^2_V \ldots\ldots\ldots (4)$$

Battese and Corra (1977) extended the model and change the δ^2v and δ^2u with the term δ^2 explains that total deviation in regressed variables is referred to technical inefficiency and accidental shocks collectively and γ shows that the systematic influence that are not explained the production function.

It can be calculated by the Maximum likelihood (MLE) estimates. The γ value must be lies between zero and one.

According to Aigner et al. (1977) the technical efficiency of the farmers can be expressed as:

$$TE_i = Y_i / Y^* = exp\,(-U_i) \ldots\ldots\ldots\ldots (5)$$

or

$$TE_i = exp\,(X_i\beta + V_i - U_i) / exp\,(X_i\beta + V_i) = exp(-U_i)$$

TE: Technical efficiency of the ith farmer; Y_i: i[th] farmer estimated output (kg); Y_i^*: Frontier output (kg).

To estimate the efficiency analysis of the rice crop, some authors recommended a two-step method, in which the first step comprises of the technical efficiency estimate using an SFA approach, and second step involve the condition of a OLS(ordinary least square) model that estimate technical efficiency with some independent variables (Pitt and Lee, 1981).

Technical inefficiency can be estimated by subtracting one from technical efficiency.

$$U_i = 1 - TE \quad 0 \leq TE \leq 1 \ldots\ldots\ldots\ldots(6)$$

Empirical Model

Translog stochastic production frontier approach: The translog production function is a well-designed flexible function which comprises of both linear and quadratic terms. Translog stochastic production frontier functional form can be calculated by second order Taylor series (Christensen et al., 1975)". The following advantages of translog stochastic production frontier approach are defined by Coelli (1998) and Coelli et al. (2005). It provides the opportunity to describe the data in a more flexible way. The translog functional form imposes no limitations on returns of scale. The translog stochastic frontier production function logarithmic functional form for a single output were used in the model by Madau (2011), Strauss (1986) and Al-Hassan (2012).

This study translog production function approach were used which can be defined as:

$$LnY_i = \beta_o + \beta_1 lnx_1 + \beta_2 lnx_2 + \beta_3 lnx_3 + \beta_4 lnx_4 + \beta_5 lnx_5 + \beta_6 lnx_6 + \beta_7 lnx_7 + \beta_8 lnx_8 + \beta_9 lnx_9 + \beta_{10} lnx_{10} + \beta_{11} lnx_{11} + \tfrac{1}{2} [\beta_{11} (lnx_1)^2 + \beta_{22} (lnx_2)^2 + \beta_{33} (lnx_3)^2 + \beta_{44} (lnx_4)^2 + \beta_{55} (lnx_5)^2 + \beta_{66} (lnx_6)^2 + \beta_{77} (lnx_7)^2 + \beta_{88} (lnx_8)^2 + \beta_{99} (lnx_9)^2 + \beta_{10} (lnx_{10})^2 + \beta_{11} (lnx_{11})^2] + \beta_{12} (lnx_1 * lnx_2) + \beta_{13} (lnx_1 * lnx_3) + \beta_{14} (lnx_1 * lnx_4) + \beta_{15} (lnx_1 * lnx_5) + \beta_{16} (lnx_1 * lnx_6) + \beta_{17} (lnx_1 * lnx_7) + \beta_{18} (lnx_1 * lnx_8) + \beta_{19} (lnx_1 * lnx_9) + \beta_{110} (lnx_1 * lnx_{10}) + \beta_{111} (lnx_1 * lnx_{11}) + \beta_{23} (lnx_2 * lnx_3) + \beta_{24} (lnx_2 * lnx_4) + \beta_{25} (lnx_2 * lnx_5) + \beta_{26} (lnx_2 * lnx_6) + \beta_{27} (lnx_2 * lnx_7) + \beta_{28} (lnx_2 * lnx_8) + \beta_{29} (lnx_2 * lnx_9) + \beta_{210} (lnx_2 * lnx_{10}) + \beta_{211} (lnx_2 * lnx_{11}) + \beta_{34} (lnx_3 * lnx_4) + \beta_{35} (lnx_3 * lnx_5) + \beta_{36} (lnx_3 * lnx_6) + \beta_{37} (lnx_3 * lnx_7) + \beta_{38} (lnx_3 * lnx_8) + \beta_{39} (lnx_3 * lnx_9) + \beta_{310} (lnx_3 * lnx_{10}) + \beta_{311} (lnx_3 * lnx_{11}) + \beta_{45} (lnx_4 * lnx_5) + \beta_{46} (lnx_4 * lnx_6) + \beta_{47} (lnx_4 * lnx_7) + \beta_{48} (lnx_4 * lnx_8) + \beta_{49} (lnx_5 * lnx_9) + \beta_{410} (lnx_5 * lnx_{10}) + \beta_{411} (lnx_5 * lnx_{11}) + \beta_{56} (lnx_5 * lnx_6) + \beta_{57} (lnx_5 * lnx_7) + \beta_{58} (lnx_5 * lnx_8) + \beta_{59} (lnx_5 * lnx_9) + \beta_{510} (lnx_5 * lnx_{10}) + \beta_{511} (lnx_5 * lnx_{11}) + \beta_{67} (lnx_6 * lnx_7) + \beta_{68} (lnx_6 * lnx_8) + \beta_{69} (lnx_6 * lnx_9) + \beta_{610} (lnx_6 * lnx_{10}) + \beta_{611} (lnx_6 * lnx_{11}) + \beta_{76} (lnx_7 * lnx_6) + \beta_{77} (lnx_7 * lnx_7) + \beta_{78} (lnx_7 * lnx_8) + \beta_{79} (lnx_7 * lnx_9) + \beta_{710} (lnx_7 * lnx_{10}) + \beta_{711} (lnx_7 * lnx_{11}) + \beta_{89} (lnx_8 * lnx_9) + \beta_{810} (lnx_8 * lnx_{10}) + \beta_{811} (lnx_8 * lnx_{11}) + \beta_{910} (lnx_9 * lnx_{10}) + \beta_{911} (lnx_9 * lnx_{11}) + \beta_{1011} (lnx_{10} * lnx_{11}) \text{-------}(7)$$

Where;

$(V_i - U_i)$: Composed error term; $Ln(Y_i)$: Dependent variable natural log of rice output and $ln(X_i)$: Natural log of independent variables; i: Represents the i^{th} farm; Y_i: Rice Output/ acre of the i^{th} farm; X_1: Dummy variable 0 for conventional puddling and 1 for Dry rice; X_2: Area under Rice crops; X_3: NPK Nutrients/ acre (N=Nitrogen, P= Potash= Phosphorus it is the fertilizer that used the farmers for sowing rice); X_4: Seed per acre/ (kg) (seed bags use the farmers per acre); X_5: Irrigation hours / acre; X_6: Weedicide (liters) / acre; X_7: Labor hour/ acre (Labor hours for weeding, fertilization, and Spraying Pesticide); X_8: Total tractor hour for land preparation (Ploughing, Planking, Hewing, Spraying and land leveling); X_9: Farm Yard Manure (Kg)/Acre; X_{10}: Insecticide (Liters)/Acre; X_{11}: Pesticide (Liters) /Acre.

Functional Form of Technical Inefficiency: Coelli and Battese (1996) developed the concept of inefficiency model which can be defined as:

$$U_i = \delta_o + \delta_1 Education + \delta_2 Experience + \delta_3 Owner + \delta_4 Tenant + \delta_5 Market\ Distance + \delta_6 Selling\ Agency + \delta_7 Credit\ Access + \delta_8 Tractor + \delta_9 tube\ well + \delta_{10} Extension\ Service + \delta_{11} Family\ Size + V_i \text{-------}(8)$$

Where;

U_i: Represents the technical inefficiency; Z_i: Represent the socio economic and farm management factors; δo, δ_i (i=1,2,--------11): Parameter to be estimated; V_i: Unobserved random variables which are identically independently distributed.

Explanatory variables of this model are: farmers education, experience, Owner status (used as a Dummy Variables if farmer is an owner = 1, Zero),Tenant (Dummy Variable if farmer is a tenant=1, Zero), owner-cum-tenant (Dummy variable if farmers is owner-cum-tenant ,0), Distance from main market (Km), Selling Agency (Dummy variable 0 if the crop sale in a village and 1 if the crop Sale in a market. Credit availability (Farmers borrow money from bank or own cash or borrow to relatives), Tractor (Dummy variable equal=1, if farmer is a tractor owner, other case zero), tubewell (Dummy variable =1 if farmer tubewell owner other case zero), Extension Service (Dummy Variable=1, If farmers have a facility of extension service in a village other case zero). Family

Size (Number of family members).

Model Specification Test: The hypotheses have been tested with respect to model specification. These tests are executed by using generalized LR ratio statistics, (LR). The maximum-likelihood (MLE) technique is suitable for parameters estimation and for forecasting the firms' technical efficiencies over time. The general form of likelihood ratio was used to test the null hypothesis where inefficiency effects are not uncertain. (Battese and Collie 1992; 1995).
Which are defines as:

$$LR = -2ln [L (H_o) – L (H_1)]$$

L (H_0) and L (H_1) are the log likelihood values under the condition of the null and alternative hypothesis, respectively.

$$H_0 = \delta = \delta o = \delta 1 \text{ -------------------- } \delta 11 = 0$$
$$H_0 = \delta o = \delta 1 \text{ ---------------------- } \delta 11 = 1$$
$$H_0 = \Sigma \beta ij = 1$$

I[st] null hypothesis states that the farm level technical inefficiency not exist in the production frontier model. The second null hypothesis which states that farm level technical inefficiency is not affected the independent variable which are included in the production frontier model.

The third null hypothesis states that Cobb-Douglas Production function is subject to constant return to scale. After testing hypothesis, we were decided to use translog stochastic frontier model in the study. Details are mentioned in section 4.

Results and Discussion

Hypothesis testing

For the selection of production function which is well suited for our data set we had tested the hypothesis. The null Hypothesis $H_0 = \Sigma\beta_{ij} = 1$ the cobb-Douglas production function is subject to constant return to scale. Hence, for selection of well suited function estimated both cobb-Douglas and translog production functions. Cobb Douglas and translog production functions likelihood values are 16.47 and 51.33. Through estimating the likelihood ratio test calculated the χ^2 value [χ^2 = -2*(16.47-51.33)] = 69.72. This χ^2calculated value is compared with the tabulated value $\chi^2_{(22, 0.05) = 33.924.}$ The null hypothesis is rejected as the calculated value is greater than tabulated value. Therefore, the test results show that in present model there is no constant return to scale. So, the flexible functional form based on translog were used in the present study.

The null Hypothesis $H_0 = \delta = \delta o = \delta 1$ -------------------- $\delta 11 = 0$ stated that technical inefficiency effects are not exist in the production frontier model. It should be renowned that ordinary least square fit and log likelihood function for the full SFA model values to be 37.65 and 51.33 respectively. This suggests that ($\chi^{2)}$ testing for the lack of technical inefficiency effect from the frontier values to be χ^2 = 27.36. The values are calculated by using the Frontier 4.1. Degree of freedom is equal to the number of restrictions in null hypothesis. The value of "χ^2" test is significant because its value is greater than the tabulated value (χ^2 (0.05) = 21.02). Hence, the test results show that inefficiency exists in the data set. So, the null hypothesis of technical inefficiency effects doesn't exist in the production frontier model is rejected. It means that technical inefficiency effect exists in the data set.

$H_0 = \delta o = \delta 1$ ---------------------- $\delta 11 = 1$ states that the farm level technical inefficiencies have no impact on explanatory variables which is involved in the production model. The results provide a likelihood ratio test statistic of 64.72, which is greater than the critical value (χ^2 (0.05) =19.68) Hence, this hypothesis is also rejected.

Production frontier and technical efficiency estimates

The Ordinary Least Square (OLS) and Maximum Likelihood Estimates (MLE) of the translog stochastic production frontier are presented in Table 1. To observe the effects of sowing methods on rice productivity, either rice is planted under conventional method or direct seeded method. The dummy variable was used in the model, shows the value 1, if farmer using direct seeded technique for rice sowing and 0 value indicates that farmers of the study area adopted the conventional technique for rice sowing. The estimated parameter of rice under direct seeded method is significant at the 1 percent level and carry positive sign. This result reveal that rice production per acre increases significantly when rice is planted through direct seeded method. Area under rice crop is another important factor of rice production. The estimated parameter of area under rice is also positive and statistically significant at 1 percent level indicates that area under rice crop have a positive contribution

Table 1: *OLS and Maximum Likelihood Estimation (MLE) of the translog stochastic production frontier.*

		OLS		Frontier Function	
Variables	Parameter	Coefficient	t-ratio	Coefficient	t-ratio
Stochastic Production Frontier					
Constant	β_0	77.61***	31.04	48.31***	5.77
Ln(Conventional Rice/Direct seeded Rice)	β_1	21.49***	15.68	24.13***	27.20
Ln(Area under rice crop)	β2	24.73***	18.64	43.22***	5.07
Ln(NPK Ratio per Acre)	β3	-12.67***	-10.74	-13.71***	-14.87
Ln(Seed use per acre/kg)	β4	22.33***	10.13	21.54***	25.65
Ln(Irrigation hour per acre)	β5	84.26***	5.34	31.82***	24.21
Ln (Weedicide liters per acre)	β6	21.58***	3.29	15.64***	15.04
Ln(Labor hour per acre)	β7	31.03***	10.51	98.31***	10.71
Ln(Total tractor hour for land preparation)	β8	-10.07***	-3.60	-10.94*	-1.85
Ln (Farm Yard Manure)	β9	-28.48***	-15.96	-11.21***	-10.41
Ln(Insecticide)	β10	12.79***	13.51	10.36***	21.20
Ln(Pesticide)	β11	-78.85***	-17.25	-69.83***	-8.60
0.5*ln(Area under rice crop)^2	β13	14.01***	5.40	23.67***	3.23
0.5*ln(NPK Ratio)^2	β14	-29.96*	-1.84	-24.59**	-2.11
0.5*ln(Seed)^2	β15	45.97***	23.53	30.97***	6.71
0.5*ln(Irrigation)^2	β16	16.21***	25.27	23.88***	14.03
0.5*ln(weedicide)^2	β17	30.66*	1.91	11.90***	7.37
0.5*ln(Labor hour)^2	β18	13.96**	2.08	19.11***	9.16
0.5*ln(Tractor Hour for land preparation)^2	β19	-10.60***	-3.41	-10.65***	-10.44
0.5*ln(Farm Yard Manure)^2	β20	-95.13***	-7.27	-39.46***	-5.10
0.5*ln(Insecticide)^2	β21	-49.10***	-10.98	-15.23***	-13.96
0.5*ln(Pesticide)^2	β22	-16.56***	-8.50	-16.57***	-11.26
Ln(Area under rice crop*NPK Ratio)	β23	24.04***	10.12	37.20***	23.21
Ln(Area under rice crop*seed)	β24	61.07***	7.23	84.06***	12.63
Ln(Area under rice crop*Irrigation)	β25	20.01***	16.94	18.41***	18.69
Ln(Area under rice crop*weedicide)	β26	52.76***	8.14	41.63***	-11.03
Ln(Area under rice crop*Labor hour)	β27	78.34**	2.12	38.88***	-27.46
Ln(Area under rice crop*tractor hour)	β28	24.58***	4.91	38.05***	-19.23
Ln(Area under rice crop*FYM)	β29	46.43***	5.43	30.00***	13.24
Ln(Area under rice crop*insecticide)	β30	-14.80***	-2.68	-15.79***	-17.04
Ln(Area under rice crop*Pesticide)	β31	77.78***	8.19	10.36***	11.54
Ln(NPK Ratio*Seed)	β32	17.05**	2.10	13.87***	10.43
Ln(NPK Ratio*Irrigation hour)	β33	26.50***	5.45	35.76***	5.90
Ln(NPK Ratio*Weedicide)	β34	58.24***	8.19	16.01***	15.93
Ln(NPK Ratio*Labor hour)	β35	17.05***	3.17	29.14***	19.43
Ln(NPK Ratio*Tractor hour)	β36	64.16***	10.12	94.44***	21.82
Ln(NPK Ratio*FYM)	β37	24.97***	5.66	45.93***	12.88
Ln(NPK Ratio*Insecticide)	β38	-97.14***	-0.77	-10.43***	-20.76
Ln(NPK Ratio*Pesticide)	β39	14.20***	9.11	28.04***	26.00
Ln(Seed*Irrigation Hour)	β40	17.37***	6.04	68.61***	24.30
Ln(Seed*Weedicide)	β41	82.79***	4.16	51.65***	8.21
Ln(Seed*Labor Hour)	β42	36.21***	3.57	20.33***	10.53
Ln(Seed*Tractor Hour)	β43	34.91***	10.67	22.38***	9.37
Ln(Seed*FYM)	β44	28.16***	3.90	56.53***	13.41

Ln(Seed*Insecticide)	β45	-25.45***	-11.46	-32.01***	-18.45
Ln(Seed*Pesticide)	β46	71.68***	8.76	45.49***	8.86
Ln(Irrigation hour*Weedicide)	β47	19.95***	13.02	62.35***	2.60
Ln(Irrigation*Labor Hour)	β48	22.63***	9.66	27.29***	13.78
Ln(Irrigation*Total Tractor Hour)	β49	19.86***	26.61	47.80***	10.57
Ln(Irrigation*FYM)	β50	10.62***	18.51	11.65***	9.17
Ln(Irrigation*insecticide)	β51	-29.26***	-12.74	-13.39***	-2.60
Ln(Irrigation*Pesticide)	β52	55.71***	16.98	53.40***	1.96
Ln (weedicide*Labor Hour)	β53	16.65***	2.02	58.06***	35.60
Ln(Weedicide*Tractor Hour)	β54	14.17***	11.37	55.39***	6.64
Ln(Weedicide*FYM)	β55	77.73***	19.02	17.83***	6.79
Ln(Weedicide*Insecticide)	β56	11.88***	6.59	83.16***	7.24
Ln(Weedicide*Pesticide)	β57	61.68***	46.60	29.01**	2.15
Ln(Labor Hour*tractor hour)	β58	14.80***	4.60	19.95***	11.03
Ln(Labor Hour*FYM)	β59	18.98***	19.52	47.07***	10.16
Ln(Labor hour*Insecticide)	β60	13.10***	34.20	31.34***	11.51
Ln(Labor hour*Pesticide)	β61	17.93***	7.34	23.26***	12.02
Ln(Tractor hour*FYM)	β62	17.69***	3.10	43.28***	13.87
Ln(Tractor Hour*Insecticide)	β63	19.34***	13.90	12.20***	12.21
Ln(Tractor hour*Pesticide)	β64	47.67***	15.70	47.73***	20.23
Ln(FYM*Insecticide)	β65	15.83***	2.51	15.41***	26.56
Ln(FYM*Pesticide)	β66	89.70***	17.01	50.51***	13.37
Ln(Insecticide*Pesticide)	β67	10.66***	2.58	14.04***	8.96
Variance Parameters					
Sigma Square	δ^2			24.15***	29.63
Gamma	γ			91.09***	25.06
Log Likelihood Function		37.65		51.33	

Note: ***: *1% significance;* ****: *5% significance;* ***: *10% significance*

in improving the rice yield. Same results are acquired by (Abedullah and Mushtaq, 2010), (Nimoh et al., 2012), (Bakash et al., 2007) along with Pakistani rice and wheat farmers and Sri Lanka tea small holders respectively.

The coefficient of NPK ratio is negative and significant at the 1% level demonstrating that farmers use inappropriate amount of NPK nutrients. On the other hand, the total quantity of fertilizer (NPK) was being used by the farmers is less than the recommended level. Abedullah et al. (2007) found a negative relationship between fertilizer use and rice output.

Seed variable coefficient carry positive sign and significant at 1 percent level. It demonstrates that there is a positive impact of seed appreciation on rice output. The similar results are acquired by (Islam et al., 2005; Erhabor and Ahmadu, 2012; Idiong, 2007; Myint and Kyi, 2005).

The coefficient of irrigation variable carry positive sin and significant at the 1 percent level. This result depicts that the productivity of rice might be raised by enhancing the accessibility of irrigation water in the study area. It is consistent with other studies (Ali and Flinn, 1989; Castillo et al., 1983) which demonstrate that rice is a water demanding crop and required higher quantity of water than other crops. The estimated variable usage of weedicide carry positive sign and significant at the 1 percent level. This implies that, as farmer use more weedicide spray it would lead to increase rice yield. These results are according to our expectation because growth of weeds tends to reduce rice yield. So, farmers of study area very much conscious about weeds effects on rice production. The result is in line with (Bakash et al., (2007); Hassan, (2005); Abedullah et al., (2010); Chaudhary et al., (2002). The estimated parameter of labor hour is positive and significant at the 1 percent level. This implies that an increase in labor hour would lead to rise rice output. Although, the results is inconsistent to the common phenomenon of the presence of labor surplus in agriculture sector of Pakistan. The similar results are find by Erhabor and Ahmadu, 2012; Abedullah et al. (2007); Sowunmi and Akintola, (2009) and De Silva and Philips (2007). The coefficient of tractor hours for land preparation is significant at 10 percent level and carry negative sign. It shows that there is a negative contribution of excessive tractor hour on rice yield. Abedullah et al. (2010) also found an inverse relationship between tractor hour and rice output in the study area.

The estimated parameter of FYM is significant at 1 percent level and carry negative sign. However, it shows adverse impact on productivity. FYM is the traditional fertilizer and mostly used by Punjab farmers in the fields because it is convenient and available in the markets at cheaper price. Though, the result indicates that additional usage of FYM has an adverse effect on rice yield. The same results found by Akond and Dutta (2013) and Myint and Kyi (2005). The coefficient of pesticide usage carry negative sign and significant at 1 percent level in this study. This result indicate that excessive use of pesticide will lead to reduce rice output. The reason is that heavy pest infestation making the spray unproductive. It is consistent with other studies Nimoh et al. (2012). The estimated parameter of insecticide variable carry positively sign and significant at 1 percent level in the study area. This variable has a major contribution in increasing rice output. The result is in line with Hidayah and Susanto (2013) and Rahman et al. (2012).

Some of the square terms in the translog production model are statistically significant. The square terms of NPK ratio, tractor hour and pesticide, FYM are statistically significant and maintaining a negative sign both at initial and later stages. It means that as continue to increase these variables lead to decreases rice output both at initial and later stages. The same statement is given by Naqvi and Ishfaq (2013), Mooma and Adkins (2000).

On the other hand, the area under rice crop, seeds, weedicides, irrigation hour and labor hour are significant and maintaining a positive sign in both stages. It means that as continue to increase these variables would lead to increase rice output both at initial and later stages. On the other hand, the estimated coefficient insecticide has positive sign at the initial stage, while on the second stage insecticide variable is statistically significant with a negative sign. It means that an increase in usage of insecticide lead to increase rice output at initial stage, but at later stage rice output decreases as continue to increases in insecticides spray. The same results are acquired by Abedullah et al. (2010).

The two interaction terms for the trans log production frontier model are statistically significant with some cross terms coefficient having positive signs and some having negative signs. The negative value of cross terms indicates a substitute relationship between two inputs. Further, the positive terms reveal that a complementary relationship occurs between two inputs. (Abedullah et al., 2010; Naqvi and Ishfaq, 2013; Mooma and Adkins, 2000).

Table 2: *Technical inefficiency model.*

Technical Inefficiency			
Variables	**parameters**	**Coefficient**	**t-ratio**
Constant	δ_0	-30.09***	-10.90
Education	δ_1	-16.70***	-10.64
Experience	δ_2	-12.90***	-5.44
Owner	δ_3	-59.19***	-17.64
Tenant	δ_4	-24.02***	-17.52
Market Distance	δ_5	26.99***	20.32
Selling agency	δ_6	-67.65***	-22.77
Credit Access	δ_7	-42.19***	-13.21
Tractor	δ_8	-12.73***	-6.39
Tube well	δ_9	-19.46*	-1.86
Extension services	δ_{10}	-62.35**	-2.23
Family size	δ_{11}	63.77***	8.37

Note: *:** *1% significance;* ****:** *5% significance;* ***:** *10% significance.*

Inefficiency model

Inefficiency model results are given in Table 2. Technical inefficiency model results demonstrate that the parameter of farmer education carry negative sign and significant at 1 percent level. This result is according to our expectations, implies that with increasing years of schooling leads to rice farmers more technically efficient. Hence, the results demonstrate that high farmers' education is an attractive tool for enhancing agriculture production. The same results find that Abedullah (2010), Hassan (2005), Ahmad et al. (2002); Coelli (1996), Coelli and Battese (1996), Ali and Flinn (1989), Bakash (2007).

The coefficient of farmer's experience carry negative sign and significant at 1 percent. The result implies that years of experience have an adverse impact on farmers' inefficiency, as years of experience increases the farm efficiency increases. The same result is in line with Bakash et al. (2007), Backman et al. (2012), Erhabor and Ahmadu, 2012 and Idoing (2007).

The estimated parameter of farm owner taken as a dummy variable. The coefficient of the farm owner variable carry negative sign and significant at the 1 percent level, reveal that farm efficiency would significantly increases as if the farmer is a farm owner.

The dummy variable of tenant carry negative sign and significant at 1 percent level shows that tenurial management is one of the important factor and playing a significant role in determining the farm level efficiencies. According to Ahmad et al. (2002) the tenants, mostly hold small area under cultivation and are generally under the economic burden paying the rent of land, facing high variable cost and also have a burden to save something for their family subsistence. Hence, all these factors make the tenant responsible to fight more to achieve a higher level of output.

The estimated parameter of market distance carry positive sign and significant at 1 percent level. The result indicates that farm to market distance variable have a positive association with inefficiency. As the distance from farm to market increases farmer inefficiency also increases. The same result is in line with Joseph and Julius (2012) and Ahmad et al. (2002). The coefficient of selling agency carry negative sign and significant at the 1 percent level, reveal that those farmers sell rice yield in the market can get a higher profit as compared to those farmers who sell rice yield in the village. The reason behind that if farmers sell the rice crop in market farmers may be able to get the right prices of rice output as compared to sell rice output in the village Chaudhary et al. (1998).

The estimated parameter of credit access carry negative sign and significant at 1 percent level. The results imply that the easing of financial constraint increases farming efficiency. According to Ahmad et al. (2002) the reason for adverse relationship between credit access and inefficiency is that the accessibility and usage of purchasing inputs mostly rely on the high amount of working capital.

The coefficient of tractor and tubewell ownership is negative and significant at the 1 percent level, reveal that those farmers having their own tractor and tube well are technically more efficient than those farmers who don't have their own tractor and tube well. The reason for this relationship is due to the fact that farmers who have their tractor and tube well were able to deliver timely supply of water and prepare land at the right time during the cropping cycle. The same results acquired by Abedullah (2007).

The extension agent coefficient is negative and statistically significant at the 5 percent level. The results reveal that the coefficient of extension visits is negatively associated with inefficiency. According to Backman et al. (2011) extension services guide the farmers to attain well farm management methods and more effective uses of scarce resources. The estimated

Table 3: *Frequency distribution of technical efficiency of rice farmers.*

Over all			Conventional farmers			Direct seeded rice farmers		
Efficiency level	F	%	Efficiency level	F	%	Efficiency level	F	%
<0.20	0	0	<0.20	0	0	<0.20	0	0
0.21-0.30	0	0	0.21-0.30	0	0	0.21-0.30	0	0
0.31-0.40	2	1	0.31-0.40	2	1	0.31-0.40	0	0
0.41-0.50	1	1	0.41-0.50	1	0	0.41-0.50	0	0
0.51-0.60	5	2	0.51-0.60	3	2	0.51-0.60	2	1
0.61-0.70	16	5	0.61-0.70	13	9	0.61-0.70	3	2
0.71-0.80	21	7	0.71-0.80	10	7	0.71-0.80	11	7
0.81-0.90	154	51	0.81-0.90	72	48	0.81-0.90	82	55
>0.90	101	33	>0.90	49	33	>0.90	52	35
Total	300	100	Total	150	100	Total	150	100
Mean	0.86		0.85			0.87		

parameter of family size is positive and significant at 1 percent level. The results reveal that household size is positively associated with inefficiency. The same results reveal by Khan et al. (2012).

Technical efficiency analysis

The frequency distribution of estimated technical efficiency for rice farmers provided in Table 3. The estimated technical efficiency of rice farmers ranges from 0.34 to 0.97 shows that there is a great potential exist for rice farmers to increase per acre rice yield. The results demonstrate that mean technical efficiency turned out to be 86% at the aggregate level and the average technical efficiency of conventional farmer is 85 percent and 87% of direct seeded farmers. This indicates that direct seeded rice farmers are technically more efficient as compared to conventional farmers. Overall, the results reveal that around 14% of technical inefficiency exist in the production of rice farms in selected areas. On the other hand, technical efficiency model results reveal that overall technical inefficiency turned to be 14% at the aggregate level, 15% in conventional rice farms and 13% in directs seeded rice farms.

Conclusion and Policy Implication

Overall, this study result indicates that the direct seeded rice technique is more profitable for farmers in terms of rice yield. Dry Rice farmers are technically more efficient as compare to conventional rice farmers. By adopting direct seeded technique dry rice farmers may be able to get a higher economic return. The research suggests that agriculture department and research institutes should design training programs to aware farmers about latest technology related to rice sowing and give knowledge to farmers about benefits of latest technology direct seeding method for sowing rice and its uses.

Authors Contribution

Sania Shaheen conceived the idea of the study, collected data, reviewed literature and did result and discussion. The estimation, drafting the manuscript and interpretation of the results had been carried out by the joint effort of Sania Shaheen and Hina Fatima. Dr. Azeem Khan provided the technical back supporting and suggestions.

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