

Research Article



Profit Efficiency among Transplanting and Direct Seeded Rice Producers (Case Study of Certain Rice Growing Areas of Province Punjab, Pakistan)

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Abstract | Profit efficiency of transplanted rice production (TRP) and direct seeded rice system (DRS) is gaining greater attention in Pakistan. Profit efficiencies of TRP and DRS are estimated with data from farmers belonging to various districts of Punjab. Gujranwala, Hafizabad, Sheikhupura, Jhang and Sialkot are the major rice producing areas of Punjab. The primary data is collected from the above mentioned areas through random sampling. Stochastic Frontier Analysis (SFA) serves as a tool of obtaining reliable estimations of profit efficiency of rice production. Findings from SFA reveal profit efficiency of rice farmers for TRP to be 57% and 83% for DRS farmers. The results further Bring to light the loss of 43% profit of TRP and 17% profit loss of DRS due to unsuitable combinations of inputs. Direct seeded rice farmers displayed more efficiency compared to the transplanted rice farmers. However, for DRS and TRP farmers' opportunities still exist to maximize profit through adopting improved farming practices and production techniques. Moreover, the results also demonstrated that farmer's education, age, farming experience, extension service facility and land tenancy considerably effects profit efficiency of rice producers. Therefore, the efficiency of rice farmers can be improved through increase in the number of educated people in farming system, and the enrichment of extension services in the rural areas.

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Introduction

Rice is considered to be an Asian crop because the production and consumption of rice is as large as 90%, approximately. Rice has the status of staple food for about half of the population of the world and three fourth of the people in developing regions. Rice is the second most important food crop in Pakistan, preceded by wheat. Pakistan ranks as the 11th rice producing country in the world and 5th

largest exporter worldwide. There is value addition by rice crop, accounting to 3.2% in agricultural sector and a small contribution of 0.7% in GDP of Pakistan. In July-March 2014-15, rice crop was sown on an area of 2,891 thousand hectares, presenting growth of 3.6% compared to the year 2013-14, while rice production in 2014-15 was around 7005 thousand tonnes, revealing growth of 3% as compared to the year 2013-14 that accounted for earning of US\$ 1.53 billion foreign exchange from rice exports.

Around the globe, two rice sowing methods are primarily used: I) Direct Seeding Rice Method (DRS). II) Conventional or Transplanting Rice Method (TRP). In DRS sowing procedure, seeds are directly sown in the farmland, whereas in case of TRP method, seeds are first sown in the nursery and later on rice plants are planted in the land (Akhgari and Kaviani, 2011). According to Pandey and Velasco (2005) the DRS method was introduced in developing countries in 1950s. Currently, in developed and developing parts of the world such as America, Italy, France, Western Europe, Russia, Japan, Korea, India, Phillipian and in some parts of Iran, rice farming is practiced through the DRS method (Akhgari, 2004). On the other hand, in Pakistan conventional TRP method is swiftly substituting the direct seeded broadcasting method. Shortages of mandatory labor, water scarcity and higher cost borne by the farmers are the shortcomings associated with TRP method (Pandey et al., 2002; Tuong et al., 2005; Nguyen and Ferrero, 2006).

In Pakistan, most of the rice growing farmers cultivate rice through the conventional TRP method. This method not only needs lot of water rather also requires number of skilled labor, along with high time consumption and is also an expensive method for raising nursery, uprooting and transplantation. The existence of these limitations results in low rice yield and productivity (Younas et al., 2015). Currently rice growers have shifted from traditional method to DRS including areas like Sheikhpura, Gujranwala, Hafizabad, Jhang, Sailkot, Gujrat, and Faisalabad (Murugaboopathi et al., 1991). After comparison of both the methods, DRS turned out to be less expensive than the TRP method (Awan et al., 2007).

Objectives of this study include an estimate and compare profitability of DRS and TRP users in 2014-15 during Kharif season, in the selected districts of Punjab to examine the sources of inefficiency affecting the profit margins of rice farmers under DRS and TRP methods.

Objectives of the study

- To carry out gross margin analysis of DRS and TRP farmers.
- To compare the profit efficiency among DRS and TRP farmers.
- To estimate the sources of profit inefficiency.

Literature review

Previous pool of studies has estimated profit efficiency of rice crop in various geographical regions. Major findings of some of the studies are highlighted in this section. Abdulai and Huffman (1998) estimated the profit inefficiency in Northern Ghana by using farm level survey data. The results of the study concluded that educational level, access to credit and specialization in rice farming practices have a positive influence in enhancing the productive efficiency of rice farmers. Rahman (2003) estimated the profit inefficiency among Bangladeshi rice farmers in both Aman and Aus/Boro seasons by using Stochastic Frontier Analysis (SFA). The results revealed that on an average, profit efficiency was 64%, indicating 36% of farmers incurring loss due to the technical and allocative inefficiency in modern rice production system. The profit inefficiency was greatly influenced by Infrastructure, extension services, tenancy status and share of non-agriculture income.

Rahman et al. (2015) estimated the profitability and efficiency of rice producing methods in coastal areas of Bangladesh. The results support the fact that average level of technical efficiency was 87% however, average output can be raised by 12.50% with the given set of technology and inputs. The study concluded that farmers' age, education and farm related trainings have a positive contribution towards cumulative profit efficiency of farmers. Younas et al. (2015) measured the economic evaluation of direct seeded and conventional rice by selecting some important districts of Punjab. The results established that compared to paddy yield farmers, the Direct seeded farmers get higher profit in the selected study areas. Hence, DRS is a favorable technology if farmers overcome weed problems by using chemical control procedures.

Research methodology

Sampling procedure of TRP and DRS systems: The study was developed on primary data sources consisting of cross sections collected from 300 randomly selected farmers in five selected rice growing districts of Punjab. Structured questionnaire served as a tool for collecting data from farmers following the interview method. From each district 4 villages were selected using purposive random sampling technique to find out both the types of farmers, i.e., Transplanting (TRP) and direct seeded (DRS) rice farmers in the selected areas. TRP and DRS farmers were randomly selected to a total of 15 famers from each village.

Materials and Methods

Farrell (1957) did the pioneer work on the concept of efficiency and produced the frame work for the development of production frontier. Production inefficiency was estimated by using technical and allocative efficiency recently combined into one measure (Ali and Flinn, 1989; Wang et al., 1996). Technical efficiency analysis is the most renowned approach for efficiency measurement, computed with the help of production frontier function (Battese and Coelli, 1995). Ali and Flinn (1989) argue about the inappropriate production frontier approach for technical efficiency analysis in the presence of price dissimilarity due to various factor endowments, faced by farmers. As an alternative of analyzing the production and cost frontier separately, a profit frontier function is generally used for the analysis of farm efficiency (Kumbhakar and Bhattacharya, 1992; Ali et al., 1994; Wang et al., 1996).

Profit efficiency is defined as capacity to achieve highest profit level at given prices and input units. Contrary to this is the profit inefficiency which is the position of the farm loss because of not operating on frontier (Ali and Flinn, 1989). Technical and allocative efficiencies are used together in profit function however, any limitations on production side can decrease producer's profit (Ali et al., 1994). Numerous studies have used efficiency measurement as a tool to calculate level of efficiency. The estimated efficiency indices were regressed on a number of socio-economic factors in order to describe the observed difference in farm level efficiency by using a two-step process (Sharif and Dar, 1996). Whereas, Battese and Coelli (1995) integrated the SFA model with an inefficiency model that is based on the linear function of independent variables (farm-specific factors). This model comes with the benefit of calculating the farm specific efficiency and to estimate the factors that describe farmer's efficiency difference by using a single estimation process. In the present research, the model of Battese and Coelli (1995) was used to estimate the profit function by using stochastic frontier approach.

The basic functional form of stochastic profit function is as:

$$\pi_i = f(P_{ij} Z_{ik}). \exp(\varepsilon_i) \dots (1)$$

π_i = It shows the normalized profit which is calculated as total revenue-total cost divided by the rice output prices; P_{ij} = Price of jth input variable of ith farm

divided by the rice output prices; Z_{ik} = Level of fixed input of the ith farm and K are the number of fixed inputs and $i = 1, 2, 3 \dots n$ number of sample farmers; ε_i = error term is supposed to be consistent with frontier model (Ali and Flinn, 1989).

$$U_i = \delta_0 + \sum_d \delta_d W_{di} \dots (2)$$

V_i = estimate the random effects like statistical noise, measurement errors, omitted explanatory variables; U_i = estimate the profit inefficiency. It is Non-negative one sided error term; U_i is supposed to be identically distributed with mean is defined as:

$$U_i = \delta_0 + \sum_d \delta_d W_{di} \dots (2)$$

and variance $\delta^2 u$. W_{di} is the dth independent variables which is connected with ith farm inefficiency and δ_0 and δ_d are the unknown parameters.

The profit efficiency of firm i is defined in the form of stochastic frontier profit function as:

$$EED = E[\exp(-u_i/\varepsilon_i)] = E[\exp(-\delta_0 - \sum_{d=1}^D \delta_d W_{di})/\varepsilon_i] \dots (3)$$

E shows the expectation error. For estimating the unknown parameters maximum likelihood estimates are used in the SFA frontier and inefficiency effects model, simultaneously. According to Battese and Coelli (1995) variance parameters in the maximum likelihood function is defined as:

$$\delta^2 = \delta^2_u + \delta^2_v \text{ and } \gamma = \delta^2_u / \delta^2$$

δ^2 estimates the total deviation from the frontier which can occur due to profit inefficiency (Battese and Coelli, 1995). The parameter γ shows the inefficiency share from the total variance errors. γ value lies between 0 and 1. Value of 1 show that frontiers are deterministic and 0 signifies the sign in accordance of OLS estimation. Under the SFA model the test of test-statistic is measured as:

$$LL = -2 \left[\frac{\ln L(H_0)}{\ln L(H_1)} \right] = -2 [\ln L(H_0) - \ln L(H_1)] \dots (4)$$

The log likelihood values $L(H_0)$ and $L(H_1)$ under the condition of null and alternative hypothesis.

Empirical model

This study has estimated flexible translog profit function. The functional form of translog profit function is given in the following equation as:

$$\ln \pi' = \alpha_0 + \sum_{i=1}^6 \alpha_i \ln p'_i + \frac{1}{2} \sum_{i=1}^6 \sum_{j=1}^6 \varphi_{ij} \ln p'_i \ln p'_j + \sum_{i=1}^6 \sum_{k=1}^2 \tau_{ik} \ln p'_i \ln z_k + \sum_{k=1}^2 \beta_k \ln z_k + \frac{1}{2} \sum_{k=1}^2 \sum_{l=1}^2 \theta_{kl} \ln z_k \ln z_l + v_i - u_i \dots (4a)$$

Where;

$$u_i = \delta_o + \sum_{d=1}^D \delta_d \omega_{di} + \omega_i \dots (4b)$$

Where;

$\varphi_{ij} = \varphi_{ji}$ for all j and i ; π' = restricted normalized profit is explained as total revenue- total variable cost divided by farm specific rice price (P_j); P_i (P_j) = Price of variable inputs, normalized by rice price (P_j); P_p = Pesticide cost normalized by rice price (P_j); P_s = Seed cost normalized by rice price (P_j); P_{irr} = Irrigation cost normalized by rice price (P_j); P_w = Weedicide cost normalized by rice price (P_j); P_L = Labor cost normalized by rice price (P_j); P_F = Fertilizer cost normalized by rice price (P_j); Z_{CI} = Capital Intensive cost measured as (sum of animal cost + mechanical power) in farm j ; Z_{AR} = Area under rice crop (hectare under rice) in farm j ; U_i = inefficiency effects; V_i = unknown random variable; ω_d = 6 variables clarifying inefficiency effects describes as; ω_1 = Age (years); ω_2 = Education (farmer years of schooling); ω_3 = Experience (No of farming experience); ω_4 = Access to extension service (Dummy variable 1 if farmers have a contact to extension officer otherwise zero); ω_5 = Household size (measured as no of working person in the family); ω_6 = Tenancy status (Dummy variable if farmer is an owner otherwise zero which represents farmer status as a tenant).

$\ln$ is the natural logarithm and $\alpha_0, \alpha_i, \varphi_{ij}, \tau_{ik}, \beta_k, \theta_{kl}, \delta_o, \delta_d$ are the estimated parameters. This model is adopted from Rehman (2002) with certain amendments.

Results and Discussion

Descriptive analysis of TRP and DRS systems

The socio-economic characteristics of farmers are presented in Table 1. The average age of traditional farmers and direct seeded farmers is 50 and 45 years, respectively which suggests that majority of sample farmers engaged in farming activities are older. The average education of conventional and direct seeded sample farmers is about primary level which is the same for both types of farmers indicating low level of academic qualification due to limited availability of education in the selected areas. The average farm size of conventional famers is between 5 to 15 acres while direct seeded rice farmers' ranges between 5 and 10

acres. The average years of farming experience between conventional and direct seeded sample farmers is 35 and 40 years, respectively. The average size of farmers' households for both TRP and DRS is approximately 8 to 11 people in each home.

Table 1: Socio-economic characteristics of rice farmers.

S.#	Variables	Conven- tional field Average	Direct seeded field average	Unit
1	Age	50	45	Years
2	Education	5	5	Years
3	Experience	35	40	Years
4	Farm to market distance	5	4	KM
5	Farm size	5-15	5-10	Acre
6	Household size	8-11	8-11	Number of person in each household

This study also estimates the comparative gross margin analysis of transplanting and direct seeded rice. For computing the descriptive analysis results in this study, SPSS 20 is used. The results are given in Table 2. The average gross margin of rice from a transplanted rice field is Rs.20001.00, and Rs.30407.09 from a direct seeded field. This demonstrates that broad variation exists in the gross margin of rice produced from transplanted and direct seeded fields. One of the reasons is the direct seeded rice fields, on average, require 22 units of irrigation per hour per acre while transplanted field requires 15 units of irrigation per hour per acre. Thus, DRS fields saved 7 units of irrigation per hour per acre compared to transplanted rice fields. On the other hand, TRP fields required an average of 5-6 kg of seed per acre while DRS fields needed of 15-16 kg per acre. Overall results disclose the high yielding capacity of DRS field conditioned upon appropriately managing weedicide issues. Therefore, the results indicate that the potential rice productivity from direct seeded fields is higher than that of a TRP field.

Empirical results and discussion

Hypothesis testing for TRP and DRS systems: Table 3 presents a different hypothesis regarding various inefficiency conditions by utilizing likelihood

Table 2: *Comparative gross margin analysis of transplanting rice and direct seeded rice.*

Gross margin analysis of transplanting rice					Gross margin analysis of direct seeded rice				
Inputs	Unit	Average quantity	Price	Value	Inputs	Unit	Average quantity	Price	Value
Leaser leveller	Rs	1	2100	2100	Leaser leveller	Rs	1	2100	2100
Motivator	Rs	1	2000	2000	Rotavator	Rs	1	2000	2000
Ploughing	Rs	4 to 5	656	3280	Ploughing	Rs	3 to 4	660	2640
Planking	Rs	1 to 2	597	1194	Planking	Rs	1 to 2	564	1128
Tractor	Rs	1	2000	2000	Tractor	Rs	1	1750	1750
Seed	Cost	5-6 kg	96	576	Seed	Cost	15-16 kg	90	1440
Urea	Price per 50kg/ bag	1 to2	1800	3200	Urea	Price per 50kg/ bag	2	1800	3600
DAP	Price per 50kg/ bag	1 to 2	3800	7600	DAP	Price per 50kg/ bag	1 to 2	3800	7600
FYM	Rs/per trolley	4 to 5	1200	6000	FYM	Rs/per trolley	4 to 5	1200	6000
Weedicide	Cost	2-3 litre	648	1944	Weedicide	Cost	5 to 6 litre	1600	9600
Insecticide	Cost	2-3 litre	2100	6300	Insecticide	Cost	2 litre	2045	4090
Pesticide	Cost	2-3 litre	884	1768	Pesticide	Cost	3 to 4 litre	1700	6800
Irrigation	#	22	1400	30800	Irrigation	#	15	1200	18000
Total variable cost				70762	Total variable cost				66748
Price of rice straw	Rs			8820	Price of rice straw	Rs			9112
Total price of conventional rice output	Rs			81389.943	Price of rice output	Rs			88043.09
Gross margin effect				20001	Gross margin effect				30407.09

Table 3: *Testing of hypothesis.*

Likelihood ratio statistics calculation				
Hypothesis	Transplanting rice test statistics values	Direct seeded rice test statistics values	Critical value	Decision
$H_0 = \gamma = 0$	31.88	69.42	$\chi^2_{(1, 0.95)} = 1.58$	Rejected
$H_0 = \delta_o = \delta_d = 0$	16.08	37.09	$\chi^2_{(6, 0.95)} = 11.07$	Rejected

ratio test statistics. The first null hypothesis $\gamma = 0$, is rejected at 5% significance, indicating that inefficiency exists in the profit frontier model. It confirms that variability occurs in farmers' profit level due to technical and allocative inefficiencies.

The second null hypothesis, rejected at 5% significance, indicates farm level inefficiencies are not affected by the independent variables included in the profit model. Thus confirming the inefficiency affected by the explanatory variables included in the profit model.

Profit frontier estimates for TRP and DRS systems:

The maximum likelihood estimates of the profit frontier results are presented in Table 4. The estimated parameters of pesticide and weedicide costs are negative and significant at 1% in both TRP and DRS

systems. This implies that an increase in pesticide and weedicide cost would lead to significant reduction in farmer profits. This occurs because of unlimited usage of pesticides and weedicides thereby, harming rice crops, thus reducing rice productivity. Rahman (2002) and Hyuha et al. (2007) demonstrated the same results.

The estimated parameters of seed cost are also positive and significant at 1%, indicating that increase in seed cost would lead to increased farmer profit in both TRP and DRS systems. An increase in seed usage has a significant impact on rice productivity, and this result meets the theoretical expectation. Consequently, farmers achieve higher profits by sale of rice productivity in the market. Ansah et al. (2014) displayed same results.

Table 4: Profit frontier results.

Maximum likelihood estimates of profit frontier function						
		Transplanting rice			Direct seeded rice	
	Variables	Parameters	Coefficient	t-ratio	Coefficient	t-ratio
	Constant	α_0	28.30	28.24***	7.491	7.645***
1	$\ln P_p$	α_p	-30.04	-29.11***	-60.99	-65.57***
2	$\ln P_s$	α_s	23.26	23.02***	122.83	124.1***
3	$\ln P_{irr}$	α_{irr}	6.054	6.809***	5.329	7.12***
4	$\ln P_w$	α_w	-7.034	-7.536***	-1.596	-1.812*
5	$\ln P_L$	α_L	-6.867	5.729***	-3.647	-3.763***
6	$\ln P_F$	α_F	2.013	1.835*	1.5424	1.7831*
7	$\ln Z_{CI}$	β_{CI}	-9.663	-7.020***	-2.6443	-4.5738***
8	$\ln Z_{AR}$	β_{BR}	25.58	27.91***	5.294	5.886***
9	$1/2 \ln P_p \times \ln P_p$	ϕ_{pp}	-105.61	-11.77***	-88.57	-92.04***
10	$1/2 \ln P_s \times \ln P_s$	ϕ_{ss}	13.13	12.48***	-3.551	-3.62***
11	$1/2 \ln P_{irr} \times \ln P_{irr}$	ϕ_{irrirr}	-0.623	-10.72***	-4.183	-2.107**
12	$1/2 \ln P_w \times \ln P_w$	ϕ_{ww}	-0.1734	-0.8721 ^{ns}	1.182	1.381 ^{ns}
13	$1/2 \ln P_L \times \ln P_L$	ϕ_{LL}	71.86	72.89***	0.387	0.867 ^{ns}
14	$1/2 \ln P_F \times \ln P_F$	ϕ_{FF}	0.2517	0.4391 ^{ns}	0.328	0.227 ^{ns}
15	$1/2 \ln Z_{CI} \times \ln Z_{CI}$	θ_{CICI}	0.1920	1.8223*	0.212	1.45 ^{ns}
16	$1/2 \ln Z_{AR} \times \ln Z_{AR}$	θ_{ARAR}	65.47	73.87***	1.905	2.479*
17	$\ln P_p \times \ln P_s$	ϕ_{ps}	2.370	6.624***	3.211	8.425***
18	$\ln P_p \times \ln P_{irr}$	ϕ_{pirr}	-6.452	-15.59***	-2.274	-5.008***
19	$\ln P_p \times \ln P_w$	ϕ_{pw}	69.19	63.17***	10.51	14.61***
20	$\ln P_p \times \ln P_L$	ϕ_{pL}	-4.162	-9.277***	-0.253	-0.452 ^{ns}
21	$\ln P_p \times \ln P_F$	ϕ_{pF}	-3.945	-8.663***	-3.63	-6.658***
22	$\ln P_p \times \ln Z_{CI}$	τ_{PCI}	-0.5458	-1.141 ^{ns}	1.58	4.431***
23	$\ln P_p \times \ln Z_{AR}$	τ_{PAR}	-34.71	-36.91***	-7.936	-10.67***
24	$\ln P_s \times \ln P_{irr}$	ϕ_{sirr}	20.51	11.79***	8.397	9.674***
25	$\ln P_s \times \ln P_w$	ϕ_{sw}	-203.58	-20.88***	-36.81	-42.49***
26	$\ln P_s \times \ln P_L$	ϕ_{sL}	11.76	12.21***	-0.192	-0.283 ^{ns}
27	$\ln P_s \times \ln P_F$	ϕ_{SF}	11.85	10.83***	12.98	16.98***
28	$\ln P_s \times \ln Z_{CI}$	τ_{SA}	2.817	2.073**	-5.647	-7.161***
29	$\ln P_s \times \ln Z_{AR}$	τ_{SL}	104.88	10.95***	30.88	34.49***
30	$\ln P_{irr} \times \ln P_w$	ϕ_{irrw}	-0.996	-0.1363 ^{ns}	0.452	0.892 ^{ns}
31	$\ln P_{irr} \times \ln P_L$	ϕ_{irrL}	0.520	1.942*	0.0458	0.222 ^{ns}
32	$\ln P_{irr} \times \ln P_F$	ϕ_{irrF}	0.3870	3.469***	-0.097	-1.213 ^{ns}
33	$\ln P_{irr} \times \ln Z_{CI}$	τ_{irrCI}	-0.3529	-3.8117***	0.2434	1.979**
34	$\ln P_{irr} \times \ln Z_{AR}$	τ_{irrAR}	-0.4568	-0.5698 ^{ns}	-0.226	-0.674 ^{ns}
35	$\ln P_w \times \ln P_L$	ϕ_{wL}	-1.886	-6.793***	-0.541	-1.876*
36	$\ln P_w \times \ln P_F$	ϕ_{WF}	-0.1379	-1.0551 ^{ns}	-0.0294	-0.237**
37	$\ln P_w \times \ln Z_{CI}$	τ_{WCI}	-0.2677	-2.336**	-0.0294	-0.1298 ^{ns}
38	$\ln P_w \times \ln Z_{AR}$	τ_{WAR}	4.8499	6.8082***	0.403	1.149 ^{ns}
39	$\ln P_L \times \ln P_F$	ϕ_{LF}	-6.5334	-7.4704***	0.653	1.384 ^{ns}
40	$\ln P_L \times \ln Z_{CI}$	τ_{LCI}	-0.8397	-0.8210 ^{ns}	-0.788	-2.197**
41	$\ln P_L \times \ln Z_{AR}$	τ_{LL}	0.0207	0.0215 ^{ns}	-0.063	-0.469 ^{ns}
42	$\ln P_F \times \ln Z_{CI}$	τ_{FCI}	-0.1668	-0.7821 ^{ns}	-0.179	1.5778 ^{ns}
43	$\ln P_F \times \ln Z_{AR}$	τ_{FAR}	-0.5718	-3.1364***	-0.206	2.774***
44	$\ln Z_{CI} \times \ln Z_{AR}$	ϕ_{AL}	1.5796	1.3395 ^{ns}	-0.781	-1.914*
Variance parameter						
	$\delta^2 = \delta_u^2 + \delta_v^2$	δ^2	0.6906	12.15***	0.0689	11.05***
	$\gamma = \delta_u^2 / \delta^2$	γ	0.9456	38.05***	0.9789	65.05***
	Log likelihood		-81.70		70.43	
	No of observation	N	150		150	

Note: *** Significant at 1 percent level; ** Significant at 5 percent level; * Significant at 10 percent level.

Table 5: Factor explaining inefficiency.

Inefficiency Model		Transplanting rice		Direct seeded rice	
Variables	Parameter	Coefficient	T-ratio	Coefficient	T-ratio
Constant	ω_0	-12.38	-26.71***	-6.137	-3.991***
age	ω_1	-0.028	-3.285***	-0.939	-2.598***
Education	ω_2	-0.092	-2.247**	-0.058	-2.603***
Experience	ω_3	-0.043	-3.675***	-0.011	-1.967**
Extension Service	ω_4	-0.138	-1.706***	-0.125	-1.903*
Household size	ω_5	0.059	3.116***	0.013	1.923*
Tenancy Status	ω_6	-1.104	-4.420***	-0.292	2.403**
Number of observation	300	150		150	

Note: *** Significant at 1 percent level; ** Significant at 5 percent level; * Significant at 10 percent level.

The coefficient of irrigation cost, fertilizer cost and dummy variable area under rice crop are positively significant at 1%. This is the expected result as the variables significantly contribute to increased rice productivity in both TRP and DRS systems and are also given by [Aung \(2011\)](#).

The coefficient of labor cost is negative and significant at 1% in the TRP system and in the DRS system, and is in line with the theory. Huge amount of labor is required for the transplantation of rice in the TRP system. Hence, an increase in number of labor would significantly contribute to increased profit under the TRP and DRS systems.

The coefficient of capital intensive cost is negative and significant at 5%-indicating an increase in capital intensive cost leads to reduced farmer profit in both the TRP and DRS systems. The same results are seen in [Rehman \(2003\)](#) and [Akramove and Malek \(2012\)](#).

The square term pesticide cost in the profit frontier model, is statistically significant at 1% and maintains a negative sign at both initial and later stages. The result points out to the continued increase in pesticide cost leading to decrease in rice output at initial and later stages under both the systems. The square term of seed cost is negative and significant at 1% in the DRS system and positively significant in the TRP system indicating that an increase in seed cost would significantly contribute to increased rice productivity under the TRP system, therefore, TRP farmer profit will tend to increase.

The square terms of irrigation are negative and significant under the TRP system and positively

significant under the DRS system, suggesting that increase in irrigation hours will increase rice productivity at both initial and later stages in the TRP system. Conversely, an increase in irrigation hours will adversely impact rice productivity at later stages under the DRS system thus, lowering its farmer profits.

Area under rice crop square term is statistically significant and positive both at initial and later stages under the two systems. On the other hand, the square terms of weedicide cost, labor cost, fertilizer cost and capital intensive cost are insignificant under both TRP and DRS systems.

The frontier model is having two statistically significant interaction terms, with positive and negative signs of cross-terms. The negative value of a cross term indicates the existence of substitute relationship between two input costs. Furthermore, the positive terms indicate complementary relationship between two input costs.

The hypothesis test that inefficiency effects are not random errors, is shown in the second part of the [Table 3](#). The value of key parameter $\gamma = \delta^2 u / \delta^2$ which is the ratio of error and it varies between zero and one. When $\gamma = 0$, no inefficiency is present and $\gamma = 1$ shows absence of random noise. The value of γ is close to 1, as shown in the [Table 4](#) revealing the high inefficiency in rice farming. Moreover, in [Table 4](#) the estimated gamma parameter (γ) 0.9456 in TRP system and 0.9789 in DRS system are highly significant at 1% level. This implies that one-sided random inefficiency component strongly dominates the measurement errors and other random disturbance indicates (94 percent under TRP system and 98 percent under DRS

system) the variation in actual profit from maximum profit (profit frontier) between farms which primarily arise from differences in farmers' practices rather than random variability (Kolawole, 2006).

Profit inefficiency model of TRP and DRS systems:

Inefficiency model results are reported in Table 5. The estimated parameter of farmer age carries a negative sign and is statistically significant at 1% in both TRP and DRS profit inefficiency indices. The result show that higher the farmer age, lower the farmer profit inefficiency will be, implying that Pakistani farmers falling in higher age brackets will demonstrate significantly more profit than younger farmers. The reason behind the results may be due to older farmers having more information about their land and traditional practices (Aung, 2011).

The coefficient of education is also significant and carries the negative sign in both TRP and DRS profit inefficiency index. The scale of the estimated parameter reveals the profit inefficiency of farmer being reduced as number of famer education increases. In the targeted area, average number of farmers' education is up to the level of primary. According to Abdulrahman et al. (2015) Efficiency of farmer is positively and significantly related with education. Farmer's decision making and inclination towards adoption of innovative technologies, can increase crop production, is effected by literacy rate. Moreover, education not only enhances productivity but also enable farmers to cope up with latest technologies, resultantly efficiency increases, thus increasing profit. The results are harmonious with Huffman (1974) from United States, Ali and Flinn (1989) from Pakistan, Kumbhakar and Bhattacharya (1992) from India.

The estimated coefficient of the farmer's experience is also significant but carries negative sign in both TRP and DRS. This result reveals that profit inefficiency of farmers reduces as number of farmers' experience increases and is in accordance with findings of Abedullah (2007). Experience on the farm is another factor to enhance productivity (Fatima et al., 2011). The experienced farmers could manage various farm practices with better level of efficiency.

The estimated parameter of extension contact is significant and negative in both TRP and DRS systems. In the area under study, the trend of farmers'

availing extension services is very slow. If farmers' visits towards extension services center increases than farmers' knowledge about new farm practices, adoption of new seed varieties and adoption of new ideas might be increased and these are in line the findings of Abeduallah et al. (2007), and Fatima and Khan (2015).

The estimated parameter of household size is significant and carries positive sign in both TRP and DRS systems meaning that an increase in the farmer household size would significantly lead to increase profit inefficiency of farmers. The same results are found by (Oladeebo and Oluwaranti, 2014; Munir et al., 2015).

The estimated parameter of tenancy status is significant at 1% level with negative sign in both TRP and DRS system. The results point out that tenants are efficient as compare to owner. So, they get high profit as compared to owner and Rehman (2002) obtained the same results. Small area under cultivation is one of the limitations tenants face, which puts the pressure of rent payment. The situation becomes even more challenging for them because of facing high variable cost and maintaining economic security of the families, alongside. In the presence of these factors, it becomes all the more difficult to achieve higher production levels.

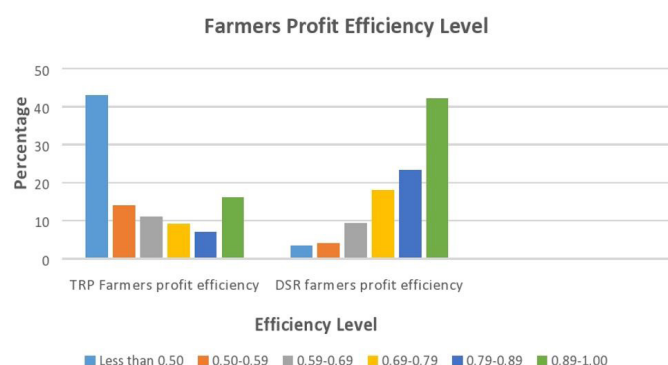


Figure 1: Transplanted and direct seeded farmers profit efficiency levels.

Farm specific profit efficiency estimates: The summary statistics of the profit efficiency estimates are presented in Figure 1. The direct seeded rice farmers are more proficient as compared to transplanting rice farmers. The average profit efficiency of direct seeded and transplanted rice farmers is 0.83 and 0.57, respectively showing that on average direct seeded and transplanting rice farmers can increase profit by improving technical and allocative efficiencies.

Around 42.9 percent transplanted rice farmers face profit efficiency less than 50%. While, 42 percent direct seeded rice farmers may attain profit efficiency ranging up to even 90-100%. Hence, there exists broad variation between direct seeded and transplanted rice farmers profit efficiency. On average, Direct seeded rice farmers have 26% more profit efficiency as compared to transplanted rice farmers.

Conclusions and Recommendations

The results entail that direct seeded farmers' profit efficiency is high comparative to transplanted rice farmers. Through adopting direct seeded technique, farmers can get higher economic return. Furthermore, the results of inefficiency model suggest that government should focus on increasing the educational level of farming communities by opening more educational institutes in rural areas and develop policies to extend support to educated farmers by providing attractive incentives. Moreover, the government should allocate more funds to strengthen the agriculture department and improve the network of extension services in the rural areas.

Novelty Statement

This study finding will make an imperative contribution in the existing literature in the sense that it will help to comprehend the farmers regarding rice cultivating techniques that will gives the farmers more advantage in terms of cost effectiveness and yield. Moreover, this study will also help to draw conclusions for promoting a right package of technology that sustenance the rice growers to get higher economic returns.

Author's Contribution

The main idea, investigation, result and discussion, and methodology are done by Dr. Hina Fatima (Corresponding Author). Overview, estimation, methodology and literature review is done by Sania Shaheen. Technical input and supervision is provided by Professor Dr. Lal K. Almas. Introduction and References are done by Sehrish Haroon.

Conflict of interest

The authors have declared no conflict of interest.

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