Research Article

Technical Efficiency of Wheat Growers in District Swabi of Khyber Pakhtunkhwa, Pakistan

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Abstract | This study was conducted to estimate the technical efficiency of wheat growers in Swabi district of Khyber Pakhtunkhwa, Pakistan. A four stage random sampling technique was used to collect data from 160 respondents. Stochastic frontier production (SFP) function was used to analyze the technical efficiency of wheat growers. The Maximum Likelihood estimates of the model-1 showed that seed quantity, urea, chemicals (Pesticides and weedicides), labor and tractor hours were statistically significant with the coefficients of -0.027, 0.090, 0.060, 0.223 and 0.056, respectively. The estimated results of SFP model-2 revealed that household's education level was having negative and significant effect on technical inefficiency. Among the sampled respondents owners were technically more inefficient as compared to the tenants. Farm size was having negative and significant effect on inefficiency while age and farming experience of the sampled respondents were statistically insignificant. It is recommended that extension department should train farmers to improve their farming skills and provide them formal as well as informal education to enhance the technical efficiency of wheat growers.

Received | February 26, 2019; **Accepted** | October 20, 2019; **Published** | November 26, 2019
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Citation | Ali, S., Farhan, Murtaza, N. Andaleeb and A. Ali. 2019. Technical efficiency of wheat growers in district Swabi of Khyber Pakhtunkhwa, Pakistan. *Sarhad Journal of Agriculture,* 35(4): 1336-1343.
DOI | http://dx.doi.org/10.17582/journal.sja/2019/35.4.1336.1343
Keywords | Wheat, Stochastic frontier production function, Technical efficiency, Khyber Pakhtunkhwa, Pakistan

Introduction

Pakistan being an agrarian country, is blessed with fertile lands, well irrigation system and suitable agro-climatic conditions. Agriculture plays an important role in the economy of Pakistan, sharing 18.9 percent to the Gross Domestic Product (GDP) and employs almost 42.3 percent of the total labour force. In Pakistan majority of the people live in rural areas and are involved in agriculture directly or indirectly through production, processing, transportation and distribution of different agricultural commodities. Being the most important sector of the economy, it facilitates many industries with raw materials and is also a main source of export earnings. Agriculture sector is further divided into four subsectors such as crops, livestock, forestry and fisheries; each of which plays a significant role in the country's economy (GoP, 2018).

Among the major cereal crops grown in Pakistan, wheat (Triticum aestivum) is of great importance and is a staple food in Pakistan. The self-sufficiency of wheat is very much important to sustain the food security. Increasing productivity of the small farmers in the major wheat producing areas of the country is the way to secure the food availability (Mazhar et al., 2007). It is an important source of carbohydrates.

Globally it is the source of vegetal protein in human food, having a protein content of about 13%, which is high than other cereal crops. Wheat is also a source of multiple and dietary fibre (Wikipedia, 2018). Wheat is grown on more land area than other food crops (GoP, 2018).

In 2016 wheat was cultivated on an area of 9.143 million hectares and ranked at 8th position worldwide. Wheat production in Pakistan was recorded as 26.005 million metric tons (MMT), ranked at 8th position in world while yield was estimated as 2779 kg/hectare, counted at 67th position worldwide (FAO, 2016).

Wheat is also an important crop in the Khyber Pakhtunkhwa Pakistan. Wheat is grown in an area of 772.30 thousand hectares with estimated wheat production of 1400.50 thousand tonnes and yield of 1,813 kg/hectare (GoP, 2016). Khyber Pakhtunkhwa has become the 3rd largest wheat producing among the province of Pakistan. In term of Area it has the 3rd position, and in term of yield it has ranked as 4th number among the province of Pakistan (FAO, 2016).

Farmers in most of the cases use the same technology and inputs but the level of output varies among them. This variation in the output might be due to the inefficiency of the farmers and is defined as the failure to get the maximum level of output with the existing given technology (Farrell, 1957). Efficiency is generally divided into two parts namely the technical and allocative efficiencies. So, far we are concerned with the technical efficiency, is defined as the ability to achieve the maximum level of output with the existing given technology. The question associated with the achievement of maximum output is that, whether we should improve the available technology or develop new technologies? Bravo-Ureta and Evenson (1994) guaranteed the improvement of existing technology to be better than introducing the new technologies. Improvement in existing technology is somehow related to the improvement of technical efficiency.

The best way to improve the productivity of wheat is to improve the technical efficiency of the wheat growers which will result in the fulfilment of the current demand for wheat and will ensure higher net returns to wheat growers but the consistent increase in the prices of essential production inputs frightened the survival of the farmers that resulted in lower profits of farmers.

Among the major district of Khyber Pakhtunkhwa, district Swabi is ranked as 9th in terms of cultivated area and production. Swabi district is blessed with fertile land having high yielding potentials. In Swabi district wheat was cultivated on an area of 37,195 hectares with approximate production of 68,085 tonnes and the recorded yield was 1,830 kg/hectare (GoKP, 2016). Yield in district Swabi is comparatively low than the other districts. This low yield might be due to inefficient allocation of resources (over or under use of inputs), lack of better farming skills, poor agronomic practices and the technical inefficiency of the farming community. This study was therefore designed to estimate and examine the effect of major determinants that affect wheat yield and technical efficiency of wheat growers in district Swabi.

Materials and Methods

Universe of the study

This study was carried out in Swabi district of Khyber Pakhtunkhwa, Pakistan (Figure 1). Its total area is 1,543 km^2 (GoPK, 2017). The population of Swabi district is 1,826,804 (GoPK, 2017). Swabi has fertile land and greatest capacity to grow different crops, tobacco, wheat, maize and sugarcane etc. Swabi district is ranked as 9th in wheat production, yield and area under wheat crop.

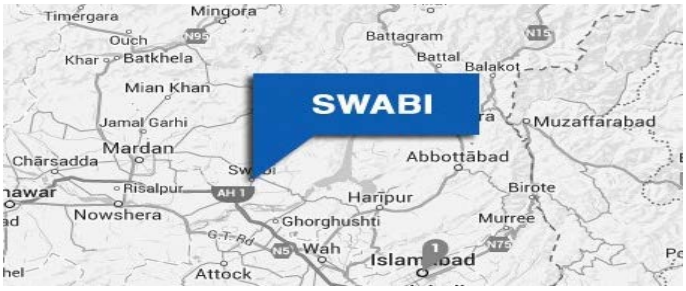

Figure 1: *Location of the study.*

Sample size and sampling technique

A four stage random sampling technique was used for selection of sampled respondents. District Swabi was purposively selected in 1st stage. Swabi has 4 tehsils namely Swabi, Razzar, Lahore and Topi. Out of 4 tehsils in Swabi, tehsil Razzar was randomly selected in 2nd stage. In stage 3rd, major wheat producing villages, six villages were selected randomly (Yar-Hussain, Shewa, Turlandi, Permuli, Kalu khan, Asota) (Table 1). A random sample of 160 (31%) respondents were selected randomly in final stage, using proportional allocation formula (Cochran, 1977) as follows:

$$n_i = n * (N_i/N) \quad \ldots(1)$$

Where;
n_i = Wheat growers from ith village; n= Sample size; N_i = Total wheat growers in ith village; N= Total wheat growers in all selected villages.

Data collection

Primary and secondary data were used in this study. Primary data was collected from 160 wheat producer through a well-designed interview schedule. Secondary data was obtained from Food and Agriculture Organization (FAO), Government of Pakistan (GoP) and Extension department of Swabi. Wheat growers were interviewed at their fields and guest houses (locally known as Hujra). Questions were designed in English language but during the collection of data it was translated into Pushto language for convenience of farmers.

Table 1: *Sample size and sampling technique.*

District	Tehsil	Villages	No. of wheat growers	Sample size
Swabi	Razzar	Yar-Hussain	120	38
		Shewa	90	28
		Turlandi	90	28
		Permuli	70	22
		Kalu Khan	80	25
		Asota	60	19
		Total	510	160

Source: *Extension department Swabi, 2018.*

Conceptual framework

The descriptive statistics were used to obtain the socioeconomic characteristics of farm households. Stochastic frontier production function was used to analyze the technical efficiency of wheat producer in district Swabi. SFP function was first introduced by Farrell (1957). According to Farrell, technical efficiency refers to the ability to produce on the frontier isoquant. The essential idea behind the stochastic frontier model is that ε is a "composed" error term (Aigner et al., 1977; Meeusen and Van den Broeck, 1977). These error terms consist of two different random disturbances having dissimilar characteristics. The general form of the model is given as follows:

$$y_i = F(x_i ; \mathcal{B}_i) + e_i \quad \ldots (2)$$

Where;
y_i= Wheat produced by ith farmer; x_i= Inputs applied by the ith farmer; $\mathcal{B}_i$= Parameters to be estimated; e_i= v_i-u_i (composed error term); v_i= Error term beyond the control of farmers and distributed normally with $v_i \sim N(0, \delta^2)$; u_i= A random error arising from socioeconomic factors of farmer and half normally distributed.

Specified form of the model

$$Ln\, y = In\mathcal{B}_0 + \mathcal{B}_1 \mathrm{Inc} + \mathcal{B}_2 InT + \mathcal{B}_3 InD + \mathcal{B}_4 InU + \mathcal{B}_5 InS + \mathcal{B}_6 InL + (v_i \sim N) \quad \ldots (3)$$

Where;
y= Per acre yield (Kgs); T= Per acre tractor hours; D= DAP per acre (kgs); U= Urea per acre (kgs); C= Chemical per acre (bottles); S= Seed quantity per acres; L= Per acre amount of labour (hours); $\mathcal{B}_0$ and $\mathcal{B}_i$ = Parameters to be estimated; v_i= Normally distributed with mean 0 and constant variance δ^2; u_i= Technical inefficiency, half normally distributed ranges between 0 and 1; ln = Natural log.

Technical efficiency analysis

The ratio of actual wheat yield per acre refers to technical efficiency to the predicted yield.

Whereas the predicted wheat yield can obtained from estimated production model. Formula for estimation of technical efficiency is given below:

$$TE_i = \frac{y_i}{y_i^*} \quad \ldots (4)$$

Where;
TE_i= Technical efficiency for ith farmer; y_i = Actual wheat yield for ith farmer; y_i^*= Predicted wheat yield for ith farmer.

Estimation of technical inefficiency

The following model was used to find out the technical inefficiency of wheat growers:

$$TIE_i = \alpha_o + \alpha_1 edu + \alpha_2 exp + \alpha_3 age + \alpha_4 farm.s + \alpha_5 ten.st + \acute{\omega}i \quad \ldots (5)$$

Where;
TIE_i= Technical inefficiency; *edu*= Education of the wheat grower above 13 years; *exp*= Experience of the wheat grower (years); *age*= Age of the wheat growers in years; *farm. s*= Size of the farm holding by individual; *ten. st*=Tenure status (Owner = 0,Tenant = 1); α_0 and α_i= Coefficient to be estimated; $\acute{\omega}_i$= Random error term.

Model adequacy tests

Different tests were conducted to check the problems of normality and multicollinearity in the collected data. Histogram (normal distribution for error term v_i and half normal distribution for error term U_i) and Correlation matrix were used for checking normality and multicollinearity in data set.

Results and Discussion

Socio-economic characteristics of wheat growers

Socio-economic characteristics of the farming community including age, education, farming experience and farm-size play a vital role in the efficiency of wheat production. The results revealed that the average age of the sampled respondents in the study area was 40.8 years with the S.D, maximum and minimum of 7.8, 65 and 28 years, respectively. Mean education level of respondents was recorded as 10.5 schooling years with the maximum and minimum of 18 and 4 years, respectively. The average farming experience and land-holdings of the sampled respondents were 21.7 years and 4.9 acres, respectively. Results are presented in Table 2.

Table 2: *Socio-economic characteristics of wheat growers.*

Variables	Mean	S.D	Minimum	Maximum
Age	40.831	7.849	28	65
Education	10.531	2.608	4	18
Farming Exp	21.737	5.525	8	45
Farm-Size	4.935	2.881	1	20

Source: *Survey Data, 2018.*

Net-revenue and profitability-ratio

Wheat yield, gross revenue, net revenue and profitability ratio are presented in Table 3. On average, wheat grain yield and by-product of the wheat was recorded as 1746.25 and 3492.5 kilograms per acre, respectively. Average cost incurred on wheat production was recorded as Rs. 44,087.53 per acre while the estimated gross and net revenues of the sampled wheat growers were Rs. 68,129.21 and Rs. 24,041.68 per acre, respectively. The profitability ratio estimated for wheat production was 0.54, revealing that a one rupee investment on wheat crop would make a profit of 0.54 rupees.

Table 3: *Net-return and profitability-ratio.*

Particulars	Quantity (kgs)	Price (Rs/kg)	Amount (Rs)	Profitability-ratio
Main product	1746.25	29.93	52,265.00	= NR/TC
By-product	3492.50	4.54	15,864.21	= 24041.68 / 44087.53
Gross revenue			68,129.21	= 0.54
Total cost			44087.53	
Net revenue			24041.68	

Source: *Survey Data, 2018.*

Estimates of stochastic frontier model

Table 4 presents the estimates of Stochastic Frontier Production Model-1 for wheat yield in the study area. The estimated β`s for regressors show the response of yield with respect to change in these regressors while the summation of $\beta$`s for all the explanatory variables represent the return to scale in wheat production.

Table 4: *Estimates of stochastic frontier model.*

Explanatory variables	Coefficients	Std. Error	Z-statistics	p-values
Ln seed	-0.027	0.011	-2.45	0.004
Ln Urea	0.090	0.016	5.43	0.000
Ln DAP	0.017	0.015	1.19	0.234
Ln chem.	0.060	0.017	3.41	0.001
Ln Labour hours	0.223	0.045	4.94	0.000
Ln Tractor hours	0.056	0.021	2.68	0.007
Constant	5.991	0.225	26.58	0.000
Variance parameters				
Sigma-v	0.045	0.172	-37.04	0.000
Sigma-u	0.092	0.308	-15.46	0.000
Gamma	0.806	-	-	-
Lambda	2.042	0.021	97.238	0.000
Log likelihood	237.81	-	-	-
Wald chi^2	-	-	97.10	0.000
Technical Efficiency				
Mean TE	0.94			
Maximum TE	0.99			
Minimum TE	0.73			

Source: *Authors' estimates from survey data, 2018.*

The Maximum Likelihood estimates of the model showed that the coefficients of urea, chemicals (pesticides and weedicides), labor and tractor hours were statistically significant, showing that increase in these variables would increase the wheat yield significantly. The coefficient for chemical fertilizer (DAP) was statistically insignificant that might be due to its inappropriate use. The estimated coefficient of seed (-0.027) revealed that 1% increase in the seed quantity would significantly decrease the yield by 0.027%. Result is consistent with Hussain et al. (2012), he also found negative coefficient of seed for wheat crop in his study in Punjab, Pakistan. Negative coefficient of seed rate also imply that farmers use poor quality farm produce as seed which results into germination of more than recommended number of plants per unit area with low vigor to bear the adverse arid climatic conditions, which ultimately results into low crop production. Moreover, most of the farmers

in the study area sow seed of the crop varieties recommended for irrigated areas. An increase in chemical fertilizer (Urea) and chemicals (pesticides and weedicides) would significantly increase the wheat yield by 0.017% and 0.06%, respectively. Beshir (2016) also found that chemical fertilizer plays important role in increasing the productivity of wheat. Findings about weedicides are almost identical to Kaur et al. (2010) and Ghaderzadeh and Rahimi (2008). The estimated coefficients for both the labor and tractor hours were positive and significant, revealing that an increase in both the variables significantly increased the wheat yield by 0.223% and 0.056%, respectively. In current study labor was found positive and significant, this is consistent with study conducted by Ali (2009). Similarly, Tractor hours or Ploughings for seed bed preparation result was found consistent with Husain et al. (2012) for wheat crop. The summation of all the coefficients of explanatory variables was estimated at 0.419, showing that wheat growers in the study area were operating with the decreasing return to scale.

The variance parameter, gamma (γ) of 0.80 revealed that 80 percent of the variation in the observed wheat output and the frontier level was due to the farmer's technical inefficiency and the remaining 20 percent was due to those random factors that are beyond the control of farmers.

Results revealed that the mean technical efficiency of wheat growers in the study area was 0.94 with the minimum and maximum of 0.73 and 0.99, respectively; showing that on average the wheat growers can increase their efficiency by 5 percent to reach the maximum efficiency's level. These results are in correspondence to that of Totakhiel (2016). Battese and Coelli (1996) reported that mean technical efficiency scores of crop farmers at village level in different arid zones of India were ranged from 71.0 to 74.0 percent. Similarly, a decrease in the technical efficiency level of the wheat farmers can be conceived over time by comparing results of present study with the finding of the study conducted by Ahmad and Qureshi (1999) in rain-fed zone of the Punjab province of Pakistan. They reported that mean technically efficiency score of the crop farmers was 62.0 percent.

Frequency distribution of technical efficiency of wheat growers among the villages

Figure 2 presents the frequency distribution of the wheat growers among the six villages in district Swabi. The results revealed that 2 wheat growers were having technical efficiency ranging from 70-80, 26 were having efficiency ranging from 81-90 and 132 were having the efficiency above 90 percent. The minimum level efficiency (0.73) was estimated in village Yar-Hussain while the maximum efficiency level (0.99) was estimated in village Kalu Khan. The mean technical efficiencies in villages Yar-Hussain, Shewa, Turlandi, Permuli, Kalu Khan and Asota were recorded as 0.93, 0.94, 0.93, 0.95, 0.96 and 0.97 respectively.

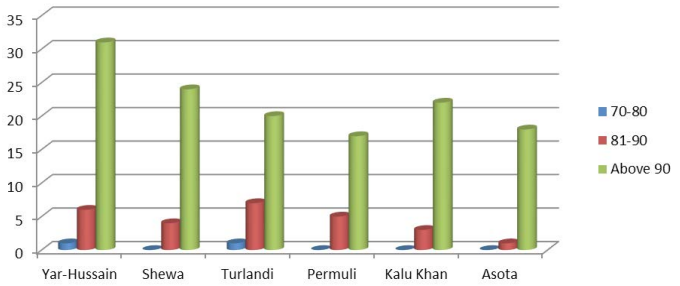

Figure 2: *Frequency distribution of technical efficiency of wheat growers among the villages.*
Source: *Authors' estimates from survey data, 2018.*

Estimated SFP Model-2 for inefficiency in wheat production

Table 5 portrays estimated results of SFP model-2. The age coefficient in the inefficiency model is negative and statistically significant at 1% as was expected. This shows that older farmers tend to be more efficient than younger ones. Older farmers may take benefit of their experiences to use inputs more efficiently in wheat production. Hence, age of farmers is an important factor in improving the efficiency of farms. This result is in line with the study by Chiona et al. (2014) and in contrast with other studies (Yami et al., 2013; Simonyan et al., 2011).

The coefficient of education in years of schooling is negative in wheat cultivation as a priori expectation. The level of education is statistically significant at 1% in affecting the technical inefficiency in wheat production. Education improves the ability of the household to make informed decision about production inputs. Educated farmers more often have better access to agricultural information and higher tendency to adopt and utilize improved inputs (like fertilizers and crop varieties) more optimally and efficiently. This result is in line with the study by Geta et al. (2013) and Yami et al., 2013.

Table 5: *Estimated SFP model-2 for inefficiency in wheat production.*

Explanatory variables	Coefficient	Std. Error	Z-statistics	p-values
Age years	0.034	0.024	1.41	0.160
Education year	-0.630	0.084	-7.46	0.000
Experience years	-0.049	0.040	-1.21	0.226
Tenure status	0.599	0.317	1.88	0.059
Total land	-0.108	0.057	-1.87	0.061

Source: *Authors' estimates from survey data, 2018.*

Land tenancy was included in the inefficiency model to appraise its effect on overall inefficiency in production. It is assumed that leasing motivates farmers for work hard to meet lease obligations and increase efficiency. Family farms are less dependent on external capital. On the other hand, Giannakas et al. (2001) referring to agency theory has reported negative relationship between land tenancy and production efficiency because of monitoring problems and adverse incentives between the parties involved. Both positive and negative sign for this variable has been reported in various studies. In current study land tenure was found positive but statistically non-significant. It is evident from various empirical studies that land tenure system has influence on agricultural production efficiency. According to Iqbal et al. (2001), Abdulai et al. (2011) and Oladele et al. (2011) farmers operating under fixed land-rent system are more efficient than owner operators. On the other hand, Gavian and Ehui (1999) and Ali (2009) reported that share cropping has a significant negative impact on agricultural productivity. They give the reason that share cropping discourages investment in productivity enhancing measures.

Table 6: *Correlation matrix.*

	Ln Seed	Ln Urea	Ln DAP	Ln Chem	Ln Labour	Ln Trac. hrs
LnSeed	1.000					
LnUrea	-0.107	1.000				
LnDAP	0.049	0.031	1.000			
LnChem.	-0.065	0.095	0.025	1.000		
LnLabour	0.206	0.177	0.033	0.173	1.000	
LnTrac.hrs	-0.107	0.293	0.069	0.169	0.199	1.000

Source: *Authors' estimates from survey data, 2018.*

Model adequacy tests results

Correlation matrix: Table 6 shows the results of correlation matrix to detect the problem of multicollinearity. The results showed that the linear relationship in almost all the explanatory variables was less than 30 percent, revealing that there was no serious problem of multicollinearity in the collected data.

Normal and half-normal distribution of the composite error term: Figure 3 shows the distribution of both the error terms (v_i and U_i), checked by histogram. The results showed that the error term v_i is normally distributed with mean zero and constant variance while the error term U_i is half-normally distributed.

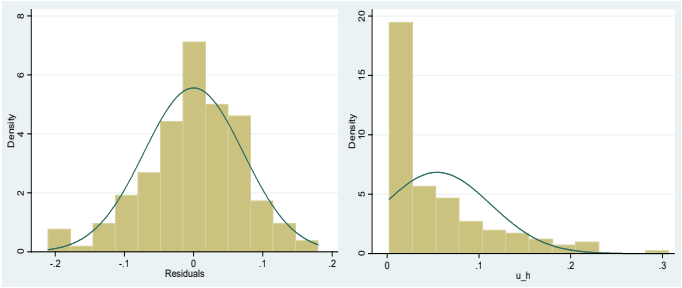

Figure 3: *Normal distribution of error term (v_i) and Half-normal distribution error term (u_i)*

Source: *Authors' estimates from survey data, 2018.*

Conclusions and Recommendations

This study was designed to estimate and examine the effect of major determinants that affect wheat yield and technical efficiency of wheat growers in district Swabi. Findings of the study revealed that wheat growers in the study area were highly profitable in wheat production and were operating with the decreasing return to scale. The results of the SFP model-1 revealed that the coefficients for explanatory variables like urea, chemicals (Pesticides and weedicides), labor and tractor hours were statistically significant, showing that increase in these variables would increase the wheat yield significantly while the coefficient for chemical fertilizer (DAP) was statistically insignificant. The estimated results of SFP model-2 revealed that farmers' education level was having negative and significant relationship with the technical inefficiency. Among the sampled respondents owners were technically more inefficient as compared to the tenants. Farm size was having negative and significant relationship with the inefficiency while age and farming experience of the sampled respondents were statistically insignificant. It is recommended that extension department should educate wheat farmers of the study area

about overutilization of seed and underutilization of urea, pesticides and weedicides, labor and tractor hours. Provincial government in collaboration with extension department also needs to train the farmers regarding efficient utilization of inputs and provide them both the formal and informal education to enhance the technical efficiency of wheat growers.

Novelty Statement

The study employed latest techniques of stochastic Frontier Analysis. The findings of the study provide useful guidelines for policy makers and wheat growers.

Author's Contributions

Shahid Ali developed main theme of this study in collaboration with Farhan, specified model and supervised overall research work. Farhan collected the data, punched in excel file and also helped in writing abstract and conclusions. Murtaza analyzed the data and estimated technical efficiency and inefficiency parameters. Neelum Andaleeb reviewed literature, proposed relevant model for analysis and helped in suggesting recommendations. Amjad Ali compared results with other studies and corrected references.

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