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Impact of Farmer Fields Schools on Technical Efficiency of Tobacco growers: A Case Study of District Swabi Pakistan

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Abstract

Tobacco is one of the agricultural commodities which is widely produced around the world. In Pakistan out of all the provinces, KPK is famous for tobacco production and particularly district Swabi for the production of the Flue Cured Virginia tobacco; as its agronomic and environmental conditions are suitable for its production. In agriculture sector the improvements in efficiency and introduction of new technology can enhance productivity. Agricultural productivity in the short-term can be enhanced by improvements in efficiency as the acquisition rate of new technology is quite low in Pakistan. The Farmer Field School (FFS) approach is one of the ways to improve the efficiency in agriculture sector. Hence the study is conducted to examine the effect of FFS on efficiency of tobacco growers in the district Swabi. Using the stochastic production frontier approach and propensity score matching technique, the study revealed that FFS played a significant role in enhancing the efficiency of tobacco farmers in Swabi. That is, the tobacco production of the Treated group was significantly greater than that of the Control group. This difference in the efficiency was accountable to the extension visit which is a source of knowledge dissemination among the farmers.

Keywords: FFS • Tobacco • Efficiency • Stochastic frontier production • Propensity score matching

Introduction

Agriculture contributes significantly in meeting the basic needs of individuals. The general role of agriculture extension in crop productivity and the specific role in enhancing the livelihoods of people in rural areas are recognized by different international organizations and agencies [1]. Tobacco is one of the agricultural commodity which is widely produced around the world however the major tobacco producing countries are India, Brazil, China, USA, Indonesia, Pakistan, Turkey and Zimbabwe. Pakistan ranks 6th in the production of tobacco (GOP, 2014). In Pakistan amongst all food and nonfood crops, the tobacco crop has features of its own. Tobacco is an important cash crop not only in Pakistan but throughout the world. The reason being that about 30% of the government revenue comprises of receipts from the CED (Custom and Excise Duties) on tobacco [2]. Out of all the provinces, KPK is famous for tobacco production and particularly district Swabi for the production of the Flue Cured Virginia tobacco; as its agronomic and environmental conditions are suitable for its production. In agriculture sector the improvements in efficiency and introduction of new technology can enhance productivity. Agricultural productivity in the short-term can be enhanced by improvements in efficiency as the acquisition rate of new technology is quite low in Pakistan [1]. In order to attain the prolong growth in efficiency, productivity and agriculture differentials have to be diminished by enhancing the managerial skills of the farmers communities and development of infrastructure [3,4]. In this scrim, agricultural production's efficiency measurement is the important sketch in developing nations.

A small number of studies have been conducted on estimating the technical efficiency of tobacco crop in Pakistan [5]. Therefore there is a need to conduct study on investigating the technical efficiency of Pakistan's tobacco crop. The present research will assist the farmers to locate factors that influence the technical efficiency of tobacco production. Moreover for increasing the output it is necessary that the tobacco growers have better knowledge and skills about farming and proper use of machinery, sowing seed, fertilizer, irrigation and harvesting etc. Extension methods play a vital role in transmission of skills and knowledge.

In so far as the history of Pakistan's agriculture extension is considered, the Training and Visit Programme was the first Programme to be used. Many studies have shown that the Training and Visit Programme is more effective than other Programmes for agricultural extension [6,7]. The traditional agricultural extension system was facing many issues because of limited coverage, reliance on the contact farmers, sampling biasness, inadequate management and technical skills of the extension staff [8,9]. As a result of all these drawbacks; the managers of the extension system had to substitute with another strategy in order to solve the issues of farmers [10].

The Farmer Field School (FFS) methodology of agricultural expansion was the most appropriate one given the state of agricultural system globally. Owing to the success of FFS in Indonesia, many other South Asian countries introduced such a Programme [11]. FFS was introduced in Pakistan in order to educate the wheat and cotton growers about the Integrated Pest Management (IPM) practices [12].

Due to its success, the Government of Punjab also adopted it by the name of "Fruit and Vegetable Development Project", the purpose of which was to train the vegetable and fruit farmers through the approach of FFS [13]. The Programme was adopted in all the districts of Punjab where fruit and vegetables were produced including Sargodha, Vehari and Sheikhupura that specializes in the production of citrus. Despite the large investments in Asia that have been made in FFS few studies have been conducted on examining their impacts [14-17].

Given this backdrop, the study at hand is conducted to know about the effect of FFS on efficiency of tobacco growers in the district Swabi because FFS program has not been evaluated for tobacco crop in Pakistan.

Materials and Methods

This research was conducted for the district Swabi in KPK province of Pakistan. In the underlying study primary data was employed. The unit of primary data was tobacco producers. Data collection was done through a well-designed questionnaire and the various inputs like seed, labor, fertilizer, tractor and labor hours were used to obtain the output. Socioeconomics characteristics were also taken in the study.

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Model specification

Technical efficiency is measured with 2 types of techniques specifically parametric (Stochastic Frontier Analysis) and nonparametric (Data Envelopment Analysis). These two approaches have their own pros and cons. The main benefit of DEA is that apart from input and output quantities no other information is required.

Nevertheless, the estimates of DEA are sensitive to noise and errors because it characterizes all deviations from the frontier to inefficiencies and is deterministic. The strong point of SFA is that noise in data is also taken into account and statistical testing of hypothesis regarding degree of inefficiency and production structure. Therefore Stochastic Frontier Analysis (SFA) is utilized for formulating the efficiencies of tobacco farmers. In the stochastic frontier model, it is assumed that the stochastic production function bounds the output.

The stochastic frontier function has a composite error term that is farmer's inefficiency and random errors [18]. Stochastic frontier production function that is applied to measure the efficiencies of tobacco growers is described mathematically as below:

$$Y_i = f\left(X_i;\beta_i\right)+\varepsilon_i$$

i=1.........n

Whereby; Y_i is the production, Xi denotes the inputs, βis the production function's parameter whose value is unknown and βrepresents composite error term that consists of 2 components as given below (Figure 1), Source: Adopted [19].

$$\varepsilon_i = v_i + u_i$$

where;

$\mathbf{v}_i$ = is a symmetric element that depicts the output changes caused by factors which are out of farmer's control like plant disease, earthquake, breakdowns and climatic conditions.

$\boldsymbol{\mu}_i$ = is an asymmetric element that captures the deviation in the output caused by the inefficiency factors of farmers.

For the estimation of technical efficiency, following stochastic frontier production function of Cobb-Douglas form was used:

$$LnY_i = \beta_0 + Ln\beta_1\left(Seeds\right)+Ln\beta_2\left(Labor\right)+Ln\beta_3\left(Irrigation\right)+$$
$$Ln\beta_4\left(Pesticides\right)+Ln\beta_5\left(Fertilizer\right)+Ln\beta_6\left(FYM\right)+Ln\beta_7\left(Tractor\right)+D1FFS+\varepsilon_i$$

Where,

Seed = No of seed/acre

Labor = Labor days used/acre

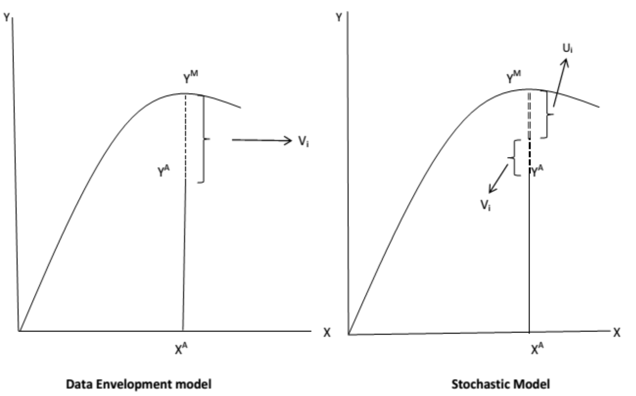

Figure 1. Variation in tobacco output due to various factors.

Irrigation = No. of irrigation for whole season

Pesticides = Pesticides used in ML/ acre

Fertilizer = Amount of fertilizer (Kg/acre)

FYM = Amount of Farm Yard Manure (Kg/acre)

Tractor = No of tractor Hours/acre

In order to investigate the factors that contribute to technical inefficiency, the stochastic frontier and inefficiency model was estimated mutually through the use of one stage maximum likelihood estimation (MLE) method utilizing frontier version 4.1 as follows [20].

$$\mu_i = \alpha_0 + \alpha_1\left(X_i\right)+\omega_i$$

whereby X_i is a vector of variables consisting of the Age of Farmers (Years), Farmers' Experience (years), Farmers education level (years), Tenurial status, number of extension visit, Land of farmer, Income of farmer, Occupation of farmer and access to credit.

Farmer field school and efficiency

OLS and propensity score matching: OLS is the basic regression design. However there are few issues with it for instance biasness of omitted variable. The coefficient will be biased if relevant variables are omitted. Secondly, controlling for variables that are affected by the variable of interest will produce prejudiced coefficient. Hence instead of doing an OLS regression, matching methods can be used. Matching method is desirable to be used when the variable takes on only two values. OLS and matching method are similar if the treatment effects are constant. However if treatment effects are distinct, they will vary as distinct weighting schemes are employed. OLS is efficient under the assumption that the treatment effect is constant, so observations are weighed by the conditional variance of the treatment status [21-25]. The treatment group and the control groups may be very different in matching and OLS. Since there are imbalances between the groups hence logistic regression is employed to cater for these discrepancies. The main advantage of a logistic regression is that it can be used to control for many variables at once. An additional method to control for imbalances is the propensity score, which is the conditional probability of a subject's receiving a particular treatment given the set of variables. For calculation of a propensity score, the variables are used in a logistic regression to predict the *exposure* of interest*, without* the inclusion of outcome.

A program that is implemented to some groups while other groups receive no treatment is known as treatment evaluation. Unlike the control group, the treated group receives the treatment. The objective of treatment evaluation is to evaluate the effect of a treatment on the treated group while using control group as a benchmark. There are 2 types of studies, first one is controlled experiments where assignment into treated and control groups is random [26-29]. However we usually have observational studies where the assignment into treated and control groups is not random i.e. some individuals decided to participate in the program while others don't. Since people who participate in the program are different than those who did not hence their outcomes cannot be directly compared. Thus it is necessary to first match them as much as possible in order to compare their outcomes. This leads us to the propensity score matching methodology.

Firstly the observations are assigned into two groups: the treated group that received the treatment and the control group that has not. In our study those who are registered in the FFS program are the treated group and those who are not registered with the FFS program are the control group. There are various types of propensity score matching such Kernel, Nearest Neighbor Matching, Radius and Stratification or Interval Matching, Inverse-probability Weights and Inverse-probability Weight Regression Adjustment. After matching we found the treatment effect (The variation amid the outcome of control and treated observations is called the Average Treatment Effect (ATE)) and compare the outcome y between treated and control group.

Results and Discussion

Table 1 shows the descriptive statistics of variables that was used in stochastic frontier Cobb-Douglas production function and propensity score matching. Following were the list of variables (inputs and determinants) used in the production function: Labor days, Seed (KG), Tractor Hours, Irrigation Number, Urea (KG) DAP (KG) NPK (KG),SOP (KG),FYM (KG) Pesticide (Liters), age, education, experience, occupation, land, tenure Status, Access to credit and Monthly Income.

Table 2 shows that pesticide, labor, tractor hours and seed quantity are statistically significant at 1 and 5 percent levels and thus are important determinants of tobacco production. In contrast the fertilizer and irrigation have no statistically significant impact on tobacco production. The reason being that both the groups use similar kind of fertilizer and the canal irrigation hence no variation in the tobacco production. Following the stochastic frontier regression, efficiency score for the whole sample was generated with minimum value of 0.5083, maximum value of 0.9604 and with mean value of 0.8070.

Table 3 shows the simple regression of output, log of output and efficiency on other independent variables. It is evident from Model 1 that FFS affects tobacco output in the absence of control variables. In order to avoid the specification bias, other determinants have also been included in model 2. The results of Model 2 indicate that the effect of FFS on tobacco output decreases in magnitude when controlled for other determinants. The R-square shows that 88 percent of the variation in output is caused by all the determinants. Similarly, Model 3 and 4 show the result of log of output which is almost similar to the results of model 1 and model 2 except that the monthly income is insignificant in model 4. The R-square of Model 3 indicates that 13 percent variation in log of output is caused by the FFS. However, the R-square of Model 4 shows that 86 percent change in log of output is caused due to the determinants which show goodness of fit of the Model. The decrease in the FFS coefficient in Model 2 and 4 is an indication that Models 1 and 3 overestimated the impact of FFS on tobacco output. Lastly, in Model 5 and Model 6 FFS significantly affects technical efficiency whereas rest of the determinants are insignificant. Table 4 shows the differences in the outcome and control variables of the treated and control group while Table 5 shows the results of the probit regression.

Table 6 shows the matching score of tobacco farmers in case of output and log of output on the basis of several characteristics using different techniques. This indicates that with these similar characteristics there is a huge difference in output of those farmers which are not registered in Farmer Field School. While Table 7 shows the different matching technique effects in case of efficiency which shows that how the registered farmers are more efficient than the non-registered farmers.

This difference in the output and efficiency between the two groups is purely due to treatment (FFS). An important question that arises that what are the potential channels through which FFS affect efficiency and output. One of the most important channel is the extension visit under FFS that significantly affects the efficiency and output of tobacco. Extension visits refer to the visits to field made by group of experts who guide the farmers to enhance their skills and efficiency. The extension visit range from 7 to 15 times in whole season. Thus the extension visit has been included as an important determinant in the model.

In Table 8 we explain the impact of extension visits on the efficiency score. With the inclusion of the variable, the remaining determinants become insignificant except for experience. However the coefficient of experience is economically negligible since its magnitude is very small. The coefficient

Table 1. Summary Statistics of the Variables Used in the Stochastic Frontier Analysis.

Variables	Units	Mean	Std. Deviation
Panel A: Inputs			
Labor	Man-days	60.29	17.024
Seed	Kilograms	108.5	109.91
Tractor	Hours	22.349	12.353
Irrigation	Numbers	13.229	2.0083
Urea	Kilograms	134.22	263.4
DAP	Kilograms	230.98	154.05
NPK	Kilograms	153.34	224.72
SOP	Kilograms	25.74	46.47
FYM	Kilograms	4868.9	2728.82
PESTICIDE	Liters	65.93	38.96
Panel b: Determinants			
Age	Years	50.467	7.3767
Education	Years	3.071	3.272
Experience	Years	21.669	8.8383
Occupation	Farmer/Govt Servant	0.1004	0.3013
Land	Acres	4.933	2.796
TS	Own/ownercum	0.2918	0.4557
Access to Credit	Yes/No	0.2583	0.4387
Monthly Income	Rupees	21401.44	6721.78

Table 2. Maximum likelihood estimates of stochastic production frontier of tobacco crop.

Variables	Coefficient	Std. Deviation
Ln Total Pesticide	0.5246***	0.0964
Ln Total Labor	0.3992**	0.1995
Ln Total Tractor Hours	0.2198***	0.0631
Ln Total Seed	0.0510***	0.0186
Ln Total Fertilizer	-0.5386	0.0331
Ln Total Fertilizer^2	0.0247	0.0566
Ln Total Irrigation	1.5818	1.628
Ln Total Irrigation^2	-0.4218	0.3415
Sigma-U	0.1696	0.2708
Sigma-V	0.2859	0.5088
Constant	6.1312	0.1688

Note: ***and ** denotes significance at 1 percent and 5 percent level of significance.

Table 3. Results of Simple regression.

Variables	Output		Log of Output		Efficiency	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
FFS	2284.17*** (476.7)	1731.2*** (176.05)	0.4115*** (0.0735)	0.3300*** (0.3031)	0.1258*** (0.0095)	0.1243*** (0.0099)
Age		-1.7638 (16.923)		0.0032 (0.0029)		-0.00007 (0.0009)
Education		36.03 (31.15)		-0.0048 (0.0051)		0.0004 (0.0017)
Experience		13.73 (13.70)		-0.0006 (0.0023)		0.0009 (0.0007)
Occupation		690.14** (283.52)		0.1183** (0.0488)		0.0043 (0.0160)
Land		1096.8*** (39.04)		0.1603*** (0.0067)		-0.0010 (0.0022)
Tenure Status		-153.80 (189.03)		0.0115 (0.0325)		-0.0085 (0.0107)
Access to Credit		632.65*** (224.77)		0.0941** (0.0387)		0.0071 (0.0127)
Monthly Income		-0.030** (0.016)		-3.04e-07 (2.77e-06)		-1.21e-06 (9.12e-07)
R-Square		0.0998		0.8675		0.4677
Adj R-Square		0.0995		0.8615		0.4436
Obser-vations		209		209		209

Note: ***, **and * indicates significance at 1, 5 and 10 percent level of significance.

Table 4. Test of Means for Unmatched Samples between Treatment and Control Groups.

Variables	Treatment	Control	Difference
Output	6392.21 (362.54)	4108.04 (244.86)	2284.16* (476.70)
Log of Output	8.6049 (0.0494)	8.1934 (0.0527)	0.4115* (0.0735)
Technical Efficiency	0.85 (0.004)	0.73 (0.009)	0.125*** (0.09)
Age	50.46 (0.724)	49.643 (0.688)	0.823 (1.036)
Education	2.8196 (0.282)	3.4252 (0.371)	-0.605 (0.458)
Experience	21.63 (0.759)	21.72 (1.016)	-0.092 (1.343)
Access to Credit	0.3032 (0.041)	0.1954 (0.042)	0.1078* (0.061)
Occupation of Farmer	0.0655 (0.225)	0.1494 (0.038)	-0.0838* (0.041)
Monthly Income	20983.6 (585.9)	21987.3 (756.2)	-1003.75 (942.9)
Tenure Status	0.2540 (0.039)	0.3448 (0.051)	-0.0907* (0.063)
Land of Farmer	5.1311 (0.267)	4.6551 (0.273)	0.4759 (0.392)
Observation	122	87	

Note: *** and * denotes significance at 1 and 10 percent respectively.

Table 5. Results of Probit Regression.

Variables	Coefficient
Age	0.0116 (0.0188)
Education	-0.0106 (0.0324)
Experience	-0.0108 (0.0145)
Land of farmer	0.0236 (0.0427)
Occupation	-0.5839** (0.2978)
Access to Credit	0.4078* (0.2420)
Tenure Status	-0.3420* (0.1970)
Monthly Income	-0.00002 (0.00001)

Note: ** and * denotes significance at 5 and 10 percent respectively.

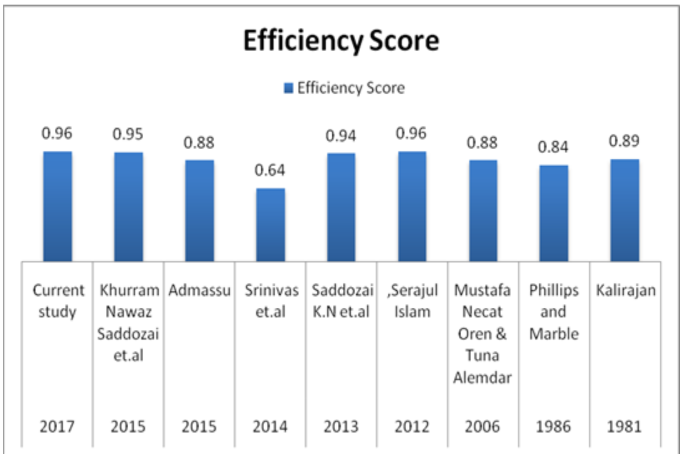

Figure 2. Efficiency scores Country wise.

Table 6. Techniques for matching score in case of Output and log of Output.

Matching Techniques	Output(Y)	Log of Output(LY)
	ATT	ATT
Nearest Neighbor Matching	2141.55*** (538.79)	0.388*** (0.098)
Radius Matching	2324.88*** (453.65)	0.420*** (0.077)
Kernel Matching	2081.02*** (433.28)	0.375*** (0.074)
Stratification Method	1734.53*** (461.23)	0.328*** (0.081)
Inverse-probability weights(ipw)	1786.64*** (203.47)	0.3319 (0.351)
IPW Regression Adjustment	1818.16*** (213.37)	0.3284 (0.374)

Note: *** denotes significance at 1 percent level of significance.

Table 7. Techniques for matching score in case of Efficiency.

Matching Techniques	Technical Efficiency
	ATT
Nearest Neighbor Matching	0.147*** (0.015)
Radius Matching	0.126*** (0.011)
Kernel Matching	0.126*** (0.012)
Stratification Method	0.128*** (0.012)
Inverse-probability weights(ipw)	0.1251 (0.1255)
IPW Regression Adjustment	0.1253*** (0.0122)

Note: *** denotes significance at 1 percent level of significance.

Table 8. Source of efficiency differences between control and treated group.

Variables	Coefficient
Extension Visit	0.1192*** (0.0107)
Age	-0.0013 (0.0010)
Education	-0.0005 (0.0018)
Experience	0.0020** (0.0008)
Land of farmer	-0.0018 (0.0023)
Occupation	0.0128 (0.0172)
Access to Credit	0.0048 (0.0135)
Monthly Income	-7.40e-07 (9.80e-07)
Tenure Status	-0.0074 (0.0114)

Note: *** and ** denotes significance at 1 and 5 percent respectively.

is 0.12 and is statistically significant at 1 percent significance level. Hence extension visits accounts for almost all the efficiency differences between both the groups.

The last table shows us the comparison between previous studies for the various crops at National and International Levels that found the efficiency with and without FFS using different tools (Table 9). A significant difference between

Table 9. Comparison with previous studies.

Year	Average efficiency %/ Productivity FFS/Non-FFS	Efficiency Score as a whole	crop	FFS	Tools	Country
2017 Current study	80/73	0.96	Tobacco	Yes	SFA& PMS	Pakistan
2015 Khurram Nawaz Saddozai et.al	85	0.95	Tobacco	No	SFA	Pakistan
2015, Admassu	61/56	0.9	Maize	Yes	SFA&PMS	Oromia,,Ethiopia
2014 Srinivas et.al	23	0.64	Potato	No	SFA	Afghanistan
2013 Saddozai K.N et.al	77	0.94	Cotton	Yes	SFA	Pakistan
2012,Serajul Islam	88	0.96	Mixed Crops	No	SFA	Bangladesh
2006, Mustafa Necat Oren & Tuna Alemdar	54	0.88	Tobacco	No	SFA&DEA	Turkey
Phillips and Marble	63	0.84	Maize	No	SFA	Guatemala
1981, Kalirajan	67	0.9	Rice	No	SFA	India

both the efficiencies scores was found and the FFS farmers were found higher mean efficiency than non-FFS farmers which means that the Farmer Field School enhanced the efficiency of the farmers in every crops and the national and the international government should start and promote the FFS in every field of agriculture.

Furthermore the Bar graph below also shows the different countries efficiency level in different crops (Figure 2).

Conclusion and Recommendation

The main theme of this study was to estimate the technical efficiency of tobacco production and to identify the factors that influence the technical inefficiency and the impact of Farmer Field School (FFS) on technical efficiency. Maximum likelihood estimation technique was used for the stochastic frontier Cobb-Douglas production function to estimate the technical efficiency. The regression analysis of tobacco yield shows that seed quantity, farm yard manure, Total Tractor hours, Labor man days, total pesticides and total seed quantity significantly affects tobacco production. The means difference between treated and control group as well as the probit regression analysis revealed that occupation, tenure status and access to credit affect the likelihood of the farmer being registered in FFS. Moreover different matching techniques were used in order to estimate the propensity score. It was found that the extension visits which is a source of knowledge dissemination among the farmers, greatly contributed in enhancing the technical efficiency.

Since FFS has been found to be effective in promoting the technical efficiency of tobacco production in the study area, thus the study suggests that the government should promote the FFS programme. In other words, the farmers should be encouraged to register in FFS. Moreover, workshops and seminars should be conducted to enhance the exposure of the farmers and ease their mindsets to remove the prejudice of the farmers regarding the third-party interference. In addition, the FFS programme should be made part of the agriculture policy in the province. The improvements in the knowledge on scientific cultivation of tobacco growers through their participation in field days, trainings and contacts with extension workers can help in achieving higher productivity through correct adoption of the recommended production technologies and thereby high gross income.

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