AN ANALYSIS OF TECHNICAL EFFICIENCY OF STRAWBERRY GROWERS AT KHYBER PAKHTUNKHWA (AN APPLICATION OF STOCHASTIC FRONTIER ANALYSIS)

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ABSTRACT

The mean technical efficiency of strawberry farmers was assessed using a stochastic frontier approach in the districts of Charsadda and Mardan in Khyber Pakhtunkhwa. By using multistage sampling technique, 382 respondent's data was collected. Cobb Douglass functional form was chosen for stochastic frontier analysis by using a generalized log-likelihood ratio test. Respectively the estimated result indicated that farmers had an average technical efficiency of 81 percent in the research area, with minimum and highest values of 0.42 and 0.98. Showing that by utilizing the available resources efficiently, productivity can be increased

by 19%. The farmers with less education or uneducated farmers were less efficient as compared to farmers with more years of schooling. According to the study, farmers with larger farm sizes were also shown to be less technically efficient. Farmers with more credit and expertise were also shown to be more efficient than farmers with less experience. Credit, education, experience, and farm size were also statistically significant inefficiency factors. The overall inefficiency factors show expected negative signs, except the cultivated area, which shows a positive sign. All factors of production were positively linked to yield excluding strawberry. Partial elasticity of Fertilizer, FYM, labour, pesticide, seedling, and tractor was not elastic.

Keywords: *Khyber Pakhtunkhwa, strawberry farmers, Fertilizer, Pakistan, Export.*

Introduction:

Agriculture is the main sector of Pakistan's economy playing a vital role. Manufacturing and services sectors contribute a gradual increase in the gross national products however, the agriculture sector contributes more than other sectors in Pakistan`s economy. The agriculture sector accounts for more than 20% of GDP and employs 44% of the total workforce. (Government of Pakistan, 2011-12). From the last few years, fruits and vegetables production trend to increase whereas the total area under production of fruits and vegetables has also increased. In the domestic market fruits like pomegranate, peach and persimmon have strong demand. Amongst the citrus fruit, Kino has the highest volume and earnings in fruit crops by foreign exchange. The majority of our exports go to the Gulf and adjacent nations like Afghanistan, India, and the United Kingdom, and are based on fruits and vegetables. (Government of Pakistan, 2010-11). While on the other side strawberry, is a berry fruit and is usually grown in three major countries USA, Japan and Italy. Whereas the USA produces 1292780 metric tons per annum and leads the table of strawberry producers (FAO, 2010). Pakistan's climatic condition for the production of strawberries possesses very suitable. Varsities of Chandler, Cruz Pocahontas and Tufts are best cropped in Islamabad and Honey, Chandler, Gorella and Corona are best cropped in charsadda and Swat. During the spring season, strawberries can be harvest and fetch a higher price (Asad, 1997). Major cities in Pakistan like Charsadda, Lahore, Mardan and Islamabad are producing strawberries and distribute them to the other cities of the country. Due to high demand, it makes a higher profit in the future so production of strawberries is very bright generally in Pakistan and particularly in KPK (SMEDA, 2009).

New techniques have been developed because of innovation, and by utilizing these modern post-harvest techniques, varieties of strawberry can be preserved for longer shelf lives and exported to other nations after meeting local demand. There is no validity in the availability of data about exported strawberries, although there are very limited export over private fruit exporters in Pakistan. Due to the seasonal advantage in Pakistan in comparison to other countries around the world, the European market has the potential to grow strawberry and run market in Pakistan. Germany has a significant demand for strawberries, with 6000 metric tons exported per week leading the table. France, the United Kingdom, and Japan all can absorb 10,000 tons each week. The potential of strawberry cultivation, processing and export in Pakistan is very bright as this opportunity is available from March to July whereas in other countries producing strawberries is freezing. (Aslam and Rasool, 2012). Across the different farms, Strawberry yield differs from 3000 to 5000 kilograms. Due to managerial capabilities, a substantial gap in the field of research stations and farmer's fields reveals underutilization of resources (Sindh Developmental Fund, 2009). Khan (2003) stated that farmers with less experience and education obtained low yield where strawberry yield differs in a socioeconomic characteristic of farmers.

There are many works of literature on estimating the technical efficiency of producing strawberry. From these studies, we can conclude that at the farm level average strawberry production is low as compared to potential output, among the different farms yield also varies. In 2009, a research study done by Sindh Development Fund demonstrated a significant difference in yield between farmer's fields and research stations. Since the discrepancy in managerial abilities specifies a presence of technical inefficiency and causes a significant difference in yield between different farms and low productivity. Technical efficiency measurements have a major significant role in making strategies to boost productivity, particularly where farmers face more problems in a low level of efficiencies. By enhancement in managerial practices, education and skill development, Production may be increased by efficient use of the same technology and inputs. Literature reveals that for the production of strawberry, inefficiency assessment has been done. The objective of this paper is to evaluate the mean technical efficiency and inefficiency parameters for the production of strawberry in the district area of Charsadda, Khyber Pakhtunkhwa, Pakistan.

Methodology

The primary data was gathered in the research area through conducting the samples and surveys from the sampled respondents. By using multistage sampling technique, about 382 respondents were chosen. Using the multistage sampling technique,

however, multiple steps were included in the data collection process. Charsadda and Mardan were purposefully selected for the first stage district. Three strawberry-producing villages were selected from the districts of Charsadda and Mardan. Jandai from Mardan, Sarkai from Charsadda, and Tebana Dhere from Charsadda were chosen at random. In the final step, we used the proportionate allocation approach to choose a sample of 382 respondents as of the three hamlets mentioned above. For a selection of sample size within three different villages via a proportionate allocation approach, the $\boldsymbol{n_i = \mathcal{N}_i / \mathcal{N} * n}$ (Cochran, 1977) formula was used. Through proportional allocation, method the number of respondents selected from the respective village is presented below Table.

District	Village	Farmers in the Village (Total)	Selected Sample Size
Mardan	Jandai	325	137
Charsada	TebanaDhere	260	111
	Sarkai	305	134
Total		890	382

Source. Survey data

The majority of the literature proposes using either Data Envelopment Analysis (DEA) or a stochastic approach to evaluate technical efficiency, in which the uncertainty is taken into account and the output is a function of the input and error term both. We apply the Stochastic Frontier Analysis Approach presented by (Meeusen and Broeck, 1977) and (Aigner, Lovell, and Schmidt, 1977) because the Data Envelopment Analysis (DEA) has the drawback of not measuring the uncertainty included in the process of production, and the agriculture sector includes a lot of uncertainty. For the assessment frontier output Model used as $\boldsymbol{\Upsilon_i = f(Y_i;\ \alpha) + e_I}$.

In this study, Cobb-Douglass and Translog forms of production function both were analyzed to determine the best functional form. The following are the empirical models:

$$LnYi = \alpha o + \alpha_1 lnY_1 + \alpha_2 lnY_2 + \alpha_3 lnY_3 + \alpha_4 lnY_4 + \alpha_5 lnY_5 + \alpha_6 lnY_6 + \alpha_7 lnY_7 + \alpha_8 lnY_8 + \alpha_9 D + ei$$

(Cobb Douglass)

$$LnYi = \alpha o + \alpha_1 lnY_1 + \alpha_2 lnY_2 + \alpha_3 lnY_3 + \alpha_4 lnY_4 + \alpha_5 lnY_5 + \alpha_6 lnY_6 + \alpha_7 lnY_7 + \alpha_8 lnY_8 + \alpha_9 D + \alpha_{11} (lnY_1)^2 + \alpha_{22} (lnY_2)^2 + \alpha_{33} (lnY_3)^2 + \alpha_{44} (lnY_4)^2 + \alpha_{55} (lnY_5)^2 + \alpha_{66} (lnY_6)^2 + \alpha_{77} (lnY_7)^2 + \alpha_{88} (lnY_8)^2 + \alpha_{12} lnY_1 lnY_2 + \alpha_{13} lnY_1 lnY_3 + \alpha_{14} lnY_1 lnY_4 + \alpha_{15} lnY_1 lnY_5 + \alpha_{16} lnY_1 lnY_6 + \alpha_{17} lnY_1 lnY_7 + \alpha_{18} lnY_1 lnY_8 + \alpha_{23} lnY_2 lnY_3 + \alpha_{24} lnY_2 lnY_4 + \alpha_{25} lnY_2 lnY_5 + \alpha_{26} lnY_2 lnY_6 + \alpha_{27} lnY_2 lnY_7 + \alpha_{28} lnY_2 lnY_8 + \alpha_{34} lnY_3 lnY_4 + \alpha_{35} lnY_3 lnY_5 + \alpha_{36} lnY_3 lnY_6 + \alpha_{37} lnY_3 lnY_7 + \alpha_{38} lnY_3 lnY_8 + \alpha_{45} lnY_4 lnY_5 + \alpha_{46} lnY_4 lnY_6 + \alpha_{47} lnY_4 lnY_7 + \alpha_{48} lnY_4 lnY_8 + \alpha_{56} lnY_5 lnY_6 + \alpha_{57} lnY_5 lnY_7 + \alpha_{58} lnY_5 lnY_8 + \alpha_{67} lnY_6 lnY_7 + \alpha_{68} lnY_6 lnY_8 + \alpha_{78} lnY_7 lnY_8 + ei$$

(Translog)

Where, lnγi represent the Natural log of output per acre obtained by the i-th farmer, lnY1 represents the natural log of pesticide's liters per acre lnY2 indicate the natural log of NPK per acre in kilogram, lnY3 represent the FYM is used per acre as a natural log if the value of FYM is greater than zero, the value of zero is assigned if the use of FYM is zero, lnY4 represent labor days per acre as a natural log, lnY5 represent the natural log of Land preparation hours per acre (include tractor and bullock hours), lnY6 represents the natural log of seedlings per acre, lnY7 represents the natural log of the number of irrigations per acre, lnY8 represents the natural log of acres of strawberry-growing land, Dm represent the dummy variable for FYM (0 if FYM is greater than 1 and 1 if FYM is equal to 0), $\boldsymbol{e}$i= $\boldsymbol{v}$I + $\boldsymbol{u}$i analyzing the impact of both pure random shock and inefficiency factors

Farm and farmer-specific parameters determine $\boldsymbol{u_i}$. and in this paper denoted as $\boldsymbol{u_i}$ **= (β, X) + Wi** and will be calculated as $\boldsymbol{u_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + E_i}$,. Where; X_1 represents the number of years of a farmer in strawberry cultivation, X_2 represents the number of years in schooling, X_3 represents the total size of farm in acres, X_4 represents the dummy variable for credit (yes=1 and No=0) according to (Battese and Collie, 1993)

The maximum likelihood ratio method is utilized to assess the farm technical efficiency and inefficiency by stochastic frontier approach 4.1 mention by Tim Coelli of the University of New England, Australia.

Furthermore, an appropriate production function functional form must be chosen, and null hypotheses should be tested using the generalized likelihood ratio test. The

general form of likelihood ratio test can be denoted as $LR = -2[ln (LH_0) / (LH_1)]$ and $LR = -2[ln (LH_0)-ln (LH_1)]$. Where LHo and LH1 are the likelihood function values for the null hypothesis and alternate hypothesis, respectively. The statistic test adopted is based on the asymptotic Chi-square distribution, which has the same degree of freedom and variations in several parameters relating to limited and unconstrained models is equal.

Results

Selection of suitable functional form and Hypotheses Testing

To evaluate the stochastic frontier production function and inefficiency function, the Computer program frontier 4.1 the maximum likelihood estimation technique is applied. Generalized likelihood ratio statistics are applied to test hypotheses and to select appropriate functional forms. The degree of freedom and discrepancy between the numbers of parameters among both models is equal. Respectively Cobb-Douglas and Translog functional forms of frontier functions were –56.85 and -75.28 values of the log-likelihood function. The test statistics are determined as:

$$LR = -2[ln (LH_0)-ln (LH_1)]$$

$$LR = -2[- 75.28+ 56.85]$$

$$LR = 36.86$$

With 36 degree of freedom, the critical value is 43.77 of the chi-square value which is greater than the value computed from the likelihood ratio test that is 36.86. Therefore, we reject the alternative hypotheses and Cobb-Douglas functional form as more suitable to selected for the present study. Different limitations were imposed on the model to test null hypotheses. The First hypothesis is $H_0: \gamma=\alpha_0=\alpha_1=\alpha_2=\alpha_3=\alpha_4=0$ indicating technical inefficiency. Since we conclude that the production function assessed for productivity as well as efficiency analysis assessed by OLS are similar. When this constraint was applied to an initial model, the log-likelihood function declined to -94.96, which is less than the actual model's value. This value is added to the generalized log-likelihood ratio test, the test statistics attained is 39.36. We accept the alternative hypothesis of technical efficiency since it exceeds the 12.59 critical value. We also have another hypothesis of $H_0: \alpha_1=\alpha_2=\alpha_3=\alpha_4=0$, which declares that variables contained in the model have no impact on farmer's level of technical inefficiency. A limitation imposed, we obtained the value of -84.32 for the log-likelihood function. Through log-likelihood ratio 19.32 value is

estimated. As the critical value of 9.48 and the value of 19.32 we obtained is greater so we accept the alternative hypothesis.

Parameter Estimates of Stochastic Production Frontier

Variables	Parameters	Cobb-Douglass		Translog	
		Co-efficient	T - value	Co-efficient	T - value
Intercept	α_0	4.799**	2.05	8.190***	18.2
Ln Pesticide	α_1	0.073*	1.84	-0.052^{ns}	-0.38
Ln NPK	α_2	0.309***	3.86	0.203^{ns}	1.43
Ln FYM	α_3	0.005 ^{ns}	0.21	0.012^{ns}	0.25
Ln Labor	α_4	0.034 ^{ns}	0.42	0.572**	2.31
Ln land prep	α_5	0.336***	3.88	0.320**	2.08
Ln Seedling	α_6	0.070^{ns}	0.30	1.014^{ns}	1.62
Ln Irrigation	α_7	0.045^{ns}	1.13	-0.033^{ns}	-0.58
Ln Area	α_8	-0.047**	-2.27	-0.051^{ns}	-1.18
Dummy FYM	α_9	0.008^{ns}	0.27	0.052**	2.01
Intercept	β_0	0.426***	2.76	0.401***	2.57
Years of schooling	β_1	-0.056***	-2.94	-0.063***	-3.1
Farm size	β_2	0.210***	3.31	-0.252***	4.00
Credit	β_3	-0.177*	-1.80	-0.180*	-1.71
Experience	β_4	-0.031***s	-4.92	-0.032***	-7.31
Variance	σ_s^2	0.044***	3.60	0.031***	4.95
parameters	γ	0.958***	4.28	0.994***	3.77

The table shows the production function in its functional form and the findings of the Cobb-Douglass form of production are explained and evaluated in this study. A total of 17 parameters was estimated in stochastic frontier model estimation. At the 1%, 5%, and 10% levels, 12 factors were statistically significant. The coefficient of pesticides with 0.07 value is positively significant at 10 percent which means by increasing pesticide one percent it will be increased by 0.07 percent. The coefficient of NPK is similarly positively significant at the 1% significance level, including a value of 0.23 indicating that a 1% increase in fertilizers use will rise 0.23 percent increase in production. Both parameters of FYM are insignificant however, it shows a positive correlation with productivity. The coefficient of labor is positively insignificant. Land preparation practices have major importance in the production of strawberry, so using tractors efficiently plays an essential role in productivity. The land preparation coefficient is significant at a 1% significance level along with a positive sign as it helps to improve productivity. The coefficient of seedlings is positively insignificant related to productivity. The coefficient of irrigation is also positively insignificant but another side the coefficient of the area under strawberry is negatively statistically significant, indicating that growers of strawberry tackling diminishing returns to scale. The parameters of $\boldsymbol{\sigma_s^2}$and $\boldsymbol{\gamma}$- linked to random variables $\boldsymbol{v_i}$ and $\boldsymbol{u_i}$- are significant. The $\boldsymbol{\gamma}$ value is 0.95 shows that management variance has a significant influence on farmer productivity.

The inefficiency model variables of parameter estimates are also represented in Table. In the present study, variables significantly affect inefficiency. The education with a negative sign indicates an inverse relationship with technical inefficiency. The t-value is significant at a 1 percent level with a -2.94 value that indicates that more efficient farmers are with greater education than farmers with less education level. It might be due to high levels of education leads to best managing practices and implementation of up-to-date technology. Variable of experience has an inverse relationship with technical inefficiency with a 1% significance level and negative sign. Conclude that more experience of farmers can efficiently allocate resources. The causes behind maybe, that with more experience, managerial skills increases, and chances of error may be decreased. From available resources, farmers can utilize their resources technically more efficient way and by this productivity increases. The estimated result explains that Farm size is positively correlated to technical inefficiency with significant at 1% significance level. Implying that farmers with large scale are inefficient in comparison to small scale farmers. Small-scale farmers may utilize scarce resources more efficiently as a result of economic pressure.

The coefficient of credit is negatively significant at the 10% level. This indicates that credit and technological inefficiency are inversely related. Due to an increase in the relaxation of financial constraints, productivity farmers did not obtain credit and become less efficient as compared to Farmers who obtained credit.

Frequency Distribution of Technical Efficiency of the Sample Respondent

Technical efficiency	Frequency	Percentage
<0.60	12	10.00
0.60 – 0.69	33	27.50
0.70 – 0.79	4	03.33
80 – 0.89	16	13.33
>0.90	55	45.83
Maximum	0.98	
Minimum	0.42	
Mean	0.81	
Efficiency Gap	0.56	

The frequency distribution of technical efficiencies of strawberry produces can be shown in the Table. The average technical efficiency of farmers is 81 percent, ranging from 42 percent to 98 percent. If resources are more technically efficient, they have the potential to increase production by 19%. Among the 120 survey respondents, a total of 12 farmers have a technical efficiency of less than 60 percent, accounting for 10 percent of the whole sample size. However, the 33 farmers are technically efficient between 60 to 69%, which makes 27.50% of the respondent of the overall sample. Approximately 3.33% of farmers have technical efficient between 70 - 79 percent. There is a 56 percent efficiency gap between the lowest efficient farmer and the highest efficient farmer. The difference in the level of efficiency showings that strawberry cultivators with low efficiency are squandering their resources. Strawberry yields can be increased if they are harvested in more effective ways.

Conclusion

In developing countries, low productivity is one of the utmost important issues. The major concern for researchers and organizations related to research and development is to increase productivity. Most studies in the literature show that in developing countries Farmers do not get the most out of the resources, they have, and they are

technically inefficient. Therefore, up to today, as a result, estimating technical efficiency has piqued researchers' interest in increasing production by minimizing the use of resources. The mean technical efficiency of strawberry farmers was assessed using a stochastic frontier approach in the districts of Charsadda and Mardan in Khyber Pakhtunkhwa. By using multistage sampling technique, 382 respondent's data was collected. Cobb Douglass functional form was chosen for stochastic frontier analysis by using a generalized log-likelihood ratio test.

Respectively the estimated result indicated that farmers had an average technical efficiency of 81 percent within the research area, with minimum and highest values of 0.42 and 0.98. Showing that by utilizing the available resources efficiently, productivity can be increased by 19%. The farmers with less education or uneducated farmers were less efficient as compared to farmers with more years of schooling. According to the study, farmers with larger farm sizes were also shown to be less technically efficient. Farmers with more credit and expertise were also shown to be more efficient than farmers with less experience. Credit, education, experience, and farm size were also statistically significant inefficiency factors. The overall inefficiency factors show expected negative signs, except the cultivated area, which shows a positive sign. All factors of production were positively linked to yield excluding strawberry.

The study provides essential recommendations are suggestions for policymakers built on the findings of the study. Make appropriate policies to stimulate both formal and informal education to increase production efficiency in the short term and long term. It is also proposed that soft loans be made available to farmers in favorable conditions to help them cope with the rising cost of inputs. Government programs must motive small farmers in the research area. However, these programs should not stifle the growth of huge farms. It is advised that the extension department play a more effective role in providing training to the farming society. It is advised that the government create policies that are linked to an efficient marketing structure and the availability of appropriate packaging material at subsidized prices. Concentrate on minor crops that are related to the availability of recommended inputs and remedies to disease infestation problems.

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