Estimation of Technical Efficiency and Investigation of Efficiency Variables in Wheat Production: A case of District Sargodha (Pakistan)

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Abstract
This study examined production efficiency of Wheat producing farmers in District Sargodha in Pakistan using farm level data. Data was collected from seventeen villages and eighty three farmers were interviewed. In the first step, Data Envelope Analysis Program (DEAP) was used for estimation the farm level technical efficiency scores. Two outputs variables and nine inputs variables were used for estimation of efficiency scores. In the second step, the Tobit regression model was used to explore the impact of on efficiency variables such as experience of farmer, education of the farmer, distance of village from market, no. of family members, seed variety and location of water course on efficiency. The study revealed that farm’s distance from market and size of farm effected farm’s efficiency negatively while a significant positive impact of seed variety (INQLAB-91) and location of water course (i.e. farm was near to head of water course) was found.

Key words: Technical efficiency, DEA, Allocative efficiency

INTRODUCTION
The Agriculture is the foremost sector of the Pakistani economy. It contributes nearly one-fifth of GDP to the economy and provides employment of 45% to their labour force. Almost 62% of population is still directly or indirectly connected with this sector. It also supplies raw materials to the major industries, and strengthens the market for agricultural tools, fertilizers, and insect repellent. Agriculture growth is declining rapidly as which it was 6.5% in 2004-05 and now, it is 2% only. The decline in the contribution of agriculture to the country’s GDP overtime is due to the slower growth of the sector relative to other sectors of the economy. The rate of
growth of Pakistan food production has been very low; food production grows at slower rate in recent years, while the food demand has been growing at the higher rate due to high rate of population growth of 1.9 percent. Among the food crops, wheat is the principal crop as it is key component of diet of Pakistanis. It contributes 3.1% to GDP and 15% to value added in food products (Economic survey of Pakistan 2009-10). Productivity of agriculture sector can be enhanced by introducing new technology or by improvement in efficiency or both. In Pakistan the adoption rate of new technology is very low, therefore the improvement in efficiency is the most suitable option to increase the agriculture productivity in the short run (Javed et al. 2008).

Determining efficiency is not so simple. Many researchers endeavored several years for enhancement and improvement of the methods to estimate efficiency. The methods used for estimating efficiency have a long history. First of all, Farrell (1957) gave the concept of efficiency, after that Charnes, Cooper and Rhodes (1978) used Farrell’s conceptual framework to measure efficiency by formulating and solving a linear programming under the assumption of constant returns to scale, which became known as Data Envelopment Analysis (DEA). Banker, Charnes and Cooper (1984) extended the model to variable return to scale (Forsund and Sarafoglou, 2002).

The other approach used for efficiency analysis is SFA (Stochastic frontier analysis). SFA is parametric approach used for efficiency analysis. While DEA is non-parametric approach, which does not need any functional form. Nationally and internationally many studies used these approaches for efficiency analysis, Akhtar (2002) conducted study on the efficiency assessment of forty commercial banks in Pakistan with the help of Data Envelopment Analysis (DEA) and concluded that technical efficiency of Pakistani’s banks is lower than the allocative efficiency. Private Banks in Pakistan emerged as efficient on both fronts, compared to their counterparts, the public and foreign banks.

A study conducted by Khan and Iqbal (2005), for analyzing the efficiency in the production of cotton using the Frontier Production Function. The farmer’s technical efficiency score ranged from 18 to 81 percent. The Role of education and training was studied and it was found that technical education is more significant in enhancing the agricultural productivity. The study also suggests that the quantity of chemicals and fertilizer may be reduced without any decrease in yield of Cotton.

According to Zahid et al. (1992), there was very limited exogenous technical change. The value of the technical change was generally low but statistically significant. The value of this parameter was lowest for industrial chemicals and the highest for chemical products. The Petroleum products, drugs and pharmaceuticals were also characterized by more technical change than the other indicators, whereas iron and steel and sugar displayed very little exogenous technical change.

The main objective of the study was to estimate the technical efficiency, and subsequently the determinants of inefficiency of wheat producing farms in district Sargodha.

This paper is planned into four sections as follows. In section 2, nature data set is explained and methodology to estimate the efficiency scores and to investigate the efficiency variables. Section 3 provides results and discussion on it. The last section provides the conclusion and recommendation.
2. DATA AND METHODOLOGY

2.1. DATA

In this study, primary data was used. A survey of wheat producers, conducted during April 2007 to July 2007 in District Sargodha to collect the data. Seventeen villages of the District Sargodha were visited for the collection of data, and 83 farmers were interviewed from these villages. Wheat in Pakistan is grown in Rabi season. There were two outputs. First, output of wheat which was measured in kilograms and second, was the value of citrus produced in wheat fields in Rupees. The inputs variables used in this study were total thrashing labor in munds (40 Kilograms) of wheat, total labor utilized in man days (labour utilized in harvesting and fertilizing), wheat cultivated area in acres, total seed utilized in kg, total tractor hours utilized, total nutrients (fertilizers) in kg and total number of standard load of farm yard manure (natural fertilizer), cost of weedicide in Rupees, and number of irrigation. In this study, efficiency variables such as experience of farmer, education of the farmer, distance of village from market, no. of family members, and size of the farm were also examined the impact of these variables on efficiency scores. The study also used dummy variables to explain the effect of seed variety and location of water course on efficiency.

2.2. Methodology

Data Envelope Analysis based upon Learning Programming techniques and in the second step, efficiency variables such as experience of farmer, education of the farmer, distance of village from market, no. of family members, and size of the farm were also examined to discover the impact of these variables on efficiency scores by the Tobit regression model was used. These studies focused on measuring technical efficiency and applied input oriented efficiency method. A firm is said to be technical efficient, if it produces the maximum output by utilizing given bundle of inputs (output oriented), or it produces given output by using minimum viable quantity of input (input-oriented). In case of constant returns to scale, there is no difference between output-oriented efficiency method and input-oriented efficiency method. In this study, input oriented efficiency method was used because it provides a natural breakdown of cost efficiency into its technical and allocative components.

2.2.1. Data Envelope Analysis

The DEA production frontier is constructed using linear programming techniques, which give a piece-wise linear frontier that “envelopes” the observed input and output data. Technologies produced in this way possess the standard properties of convexity and strong disposability, which are discussed in Fare et al. (1994).

The Data Envelope Analysis model was applied to at the same time to draw the frontier for production and to get the technical efficiency scores. The model showed the case where there were data on K outputs and M inputs for each of N farmers. For the ith farmer, output and input data was shown by the column vectors yi and xi respectively. The K´N output matrix, Y, and the M´N input matrix, X.
The Data Envelope Analysis model was used for calculation of technical efficiency is under:

\[
\min_{\theta, \lambda} \theta,
\]

\[
-y + Y\lambda \geq 0,
\]

**Subject to** \(\theta x - X\lambda \geq 0\), \(N1'\lambda = 1\)

“\(\theta\)” Represents a scalar, “\(N1\)” shows \(N\times1\) vector of ones, and while “\(\lambda\)” represents vector of Constants of the order \(N\) x 1. The value of “\(\theta\)” obtained is the technical efficiency score for the \(i\)-th farmer. If the value of \(\theta = 1\), then it shows that the \(i\)-th farmer is on the frontier and hence a technically efficient farm, as defined by Farrell (1957). This study estimated (linear programming problem) \(N\) times, to get efficiency score (\(\theta\)) for each farmer in the data.

The equation (1) in the DEA problem has an intuitive explanation. In the problem, the \(i\)-th farmer is bond to the input vector, \(x_i\), as much as possible. The inner boundary of this set is a piece-wise linear isoquant (SDCAS in Figure 1), which is determined by the frontier points showing the efficient farmers in the data. The radial contraction of the input vector, \(x_i\), produces a projected point, \((X\lambda, Y\lambda)\), on the surface of this technology. This projected point is a linear combination of these observed data points. The constraints shown in equation (1) make certain that this projected point must lie inside the feasible area.

**Figure 1 Technical Efficiency**

In Figure 1, the four farmers (A, B, C and D) are producing the same level of output, using various amounts of two inputs, denoted by \(x_1\) and \(x_2\). Farmers D, C and A outline the isoquant because it is impossible for them to reduce their input usage, and still remain within the
production possibility set. Farm B, however, is inefficient because it can reduce its input usage to the projected point B’, so its technical efficiency (TE) score is measured as 0B'/0B.

2.2.2. Tobit regression Model
In the second stage, the study explored the impact of efficiency variables on efficiency scores. As efficiency scores (dependent variable) are censored and range from 0 to 1. If dependent variable is censored then OLS does not yield consistent estimates of parameters. Hence, the Tobit regression model was used instead of OLS method to discover the impact of efficiency variable such as experience of farmer, distance of village from market, no. of family members, seed variety, location of water course (head or tail) and education of the farmer. SAS (Statistical analytical system) computer software was used to estimate Tobit regression model.

3. EMPIRICAL RESULTS
3.1. Descriptive Statistics
Descriptive statistics showed that there 83 farmers were interviewed. To estimate efficiency scores, the study used data of total inputs utilized in a farm and total production of the farm. The study explained two outputs i.e. wheat and citrus. As farm size, inputs, wheat cultivated, and land characteristics were different, therefore, minimum production of wheat was 9.4munds/farm and maximum wheat production was 1495munds/farm. Minimum value of citrus fruit (Kino) was Rs. 0 because either the orchard age was less than three years or sole wheat was grown at farm, while, the maximum value of citrus was Rs. 2.4 millions. In this study, nine inputs were included. The minimum and the maximum quantity of Total Area of Wheat Cultivated in Acres, Total Seed Utilized in Kg, Total Threshing Labor in Munds of Wheat, Total Labor Utilized in Harvesting and Fertilizing in Man Days, Total Nutrients in Kg, Total no. of Standard load of farm yard manure, Total Cost of Weedicide in Rupees, Total no. of Irrigation, Total Tractor Hours Consumed were shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1 Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Outputs</td>
</tr>
<tr>
<td>Total wheat production</td>
</tr>
<tr>
<td>Total value of Citrus produced</td>
</tr>
<tr>
<td>Inputs</td>
</tr>
<tr>
<td>Total farm area</td>
</tr>
<tr>
<td>Total seed used on farm</td>
</tr>
<tr>
<td>Total threshing labor (man days)</td>
</tr>
<tr>
<td>Total labor (man days)</td>
</tr>
<tr>
<td>Total nutrient used</td>
</tr>
<tr>
<td>Total farm yard manure (small trullas)</td>
</tr>
<tr>
<td>Total cost of weedicide</td>
</tr>
<tr>
<td>Total no of irrigation on farm</td>
</tr>
</tbody>
</table>
In the first step, efficiency scores were estimated by applying Linear Programming technique and Data Envelope Analysis Program (DEAP, software) was used for this purpose. The results revealed that maximum efficiency was 1, minimum efficiency was 0.6 and mean of efficiency scores was 0.87. The summary statistics of efficiency variables were shown in Table 2.

Table 2   Summary Statistics of efficiency Variables (Second Stage Variables)

<table>
<thead>
<tr>
<th>Stat</th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical efficiency</td>
<td>83</td>
<td>0.87</td>
<td>0.60</td>
<td>1</td>
</tr>
</tbody>
</table>

3.2: Determinants of technical Efficiency

To explain the variations due to efficiency variables, the efficiency scores were regressed on the farm level characteristics variables. The Tobit Model was estimated using the QLIM procedure in SAS software. The results are presented in Table 3.

Table 3   Tobit Regression Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.852266***</td>
<td>0.052843</td>
<td>16.13</td>
</tr>
<tr>
<td>Dummy of education</td>
<td>0.051474</td>
<td>0.034337</td>
<td>1.50</td>
</tr>
<tr>
<td>Farming Experience (years)</td>
<td>0.000279</td>
<td>0.000996</td>
<td>0.28</td>
</tr>
<tr>
<td>Distance of village from market (km)</td>
<td>-0.002657*</td>
<td>0.001393</td>
<td>-1.91</td>
</tr>
<tr>
<td>Family size (number)</td>
<td>-0.003909*</td>
<td>0.002187</td>
<td>-1.79</td>
</tr>
<tr>
<td>Dummy of seed variety of seed</td>
<td>0.037116</td>
<td>0.031486</td>
<td>1.18</td>
</tr>
<tr>
<td>Dummy of watercourse location</td>
<td>0.052174*</td>
<td>0.029425</td>
<td>1.77</td>
</tr>
</tbody>
</table>

Note: *** Significant at 0.01 level. ** Significant at 0.05 level. * Significant at 0.10 level.

The result showed that dummy of farmer education (if education is greater than 5 year then dummy of education is one else zero) and experience is though positively related to technical efficiency but that are not significant. While the variable of village distance from
market have significant negative on farmer's efficiency i.e. as village distance from market increases their technical efficiency decreases.

On the other hand family size showed significant negative effect on efficiency of the farmer. Because the farmer having a larger family, has to face economic and social problems as size required more food, so large proportion of farmer income is utilized for the purchase of basic necessities instead of using it for purchasing better seed, fertilizer for wheat production. The study used dummy variables for finding the impact of Seed Variety (Inqalab 91) revealed a positive but statistically insignificant impact on technical efficiency. The study also used dummy variables to investigate the importance of the location of water course i.e. head, middle, and tail. The results showed that if location of water course is at head then there is positive significant effect on efficiency.

4: Conclusion

The study tried to investigate the effects of efficiency variables on efficiency scores by using primary data collected from district Sargodha, Pakistan. In the first step, efficiency scores for each farmer were estimated. The minimum efficiency score was 0.6 and the maximum score was 1. Efficiency score which was equal to 1, showed optimal utilization of inputs, while less than one efficiency score disclosed that inputs were not used optimally.

In the second stage, the study investigate the dependence of efficiency scores on farm specific variables called efficiency variables such as experience of farmer, education of the farmer, distance of village from market, no. of family members, and size of the farm. Three dummy variables were also involved to capture the effect of seed variety, location of water course. The results revealed that distance of village from market had a negative impact on efficiency. The finding was rational as if the farm is for away from market then it difficult for formers to purchase inputs and sell outputs at reasonable price. Investigation also disclosed that farm size affected the efficiency negatively. The result seems illogical but in the Pakistani cultural prospect this finding was logical because in Pakistan, farming is not first priority of big landlords. The dummy variable used for seed variety Inqlan91 revealed that if farmers use seed variety Inqlab91, then the efficiency of the farmers was enhanced. This showed that specific seed variety according to the climatic conditions and availability of water is essential to improve the efficiency. The dummy represented Location of water course head showed positive and significant impact on efficiency. The result was quite reasonable as adequate water availability is necessary for wheat production. The study recommends that to control the shortage of water shortage for irrigation, new dams must be constructed as water is lifeline for the economy of Pakistan. It is also advocated to improve irrigation system in Pakistan so that wastage of water can be minimized.

The farmers are facing different input and output prices due to market imperfections. Input prices are extremely high as compared to yield value which shows the farmer were facing losses or earning low profit. Hence, it is propose to improve the market conditions and to minimize the roll of middle man, so that farmers can find reasonable profit in wheat growing.
REFERENCES


