ESTIMATING THE TECHNICAL EFFICIENCY IN RAPESEED AND MUSTARD PRODUCTION: A CASE STUDY OF DISTRICT OKARA

Abdul Hannan Jaffar, Maqsood Hussain*, Sarwat Zia, Muhammad Ayub, Habib Anwar** and Muhammad Ali Imran*

ABSTRACT

Rapeseed and Mustard are the third most important oilseed crops grown all over the world. These are also the most important oil producing crops in Pakistan grown in Rabi season. Pakistani farmers grow different varieties of Rapeseed and Mustard to meet domestic demand and commercial use. Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. The present study was conducted at the Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan during the year 2013-14. It measured the technical efficiency and sources of inefficiency in Rapeseed and Mustard production. District okara was selected as study area. A well structured questionnaire was constructed to collect the information from the farmers. Primary data (120 respondents) were collected and stochastic production frontier was used to measure the technical efficiency and sources of inefficiency. The results demonstrated that mean technical efficiency was 86.01 percent. Maximum sufficiency score was 99.74 and minimum score was 62.8. Average measure of 86.01 percent of technical efficiency implies that technical efficiency can be increased by 14 percent by improving their technical and allocative efficiency.

KEYWORDS: Technical efficiency; Seasonality; Rapeseed and Mustard; Okara, Pakistan.

INTRODUCTION

Rapeseed (Brassica napus) is a bloomy, bright, yellow flowering member of Brassicaceae (mustard or cabbage family). Mustards have several species belonging to the genus Brassica but the species mostly cultivated in South Asian region is Brassica juncea. Rapeseed is also being produced in china through ages. The Chinese word for rapeseed was first recorded 2500 years ago.
ago, and many of oldest discoveries of the seed dated back as far as to 5000 BC (19).

Rapeseed and Mustard are grown for producing of vegetable oil, animal feed and biodiesel. These are the third largest source of vegetable oil in the world and also the world's second largest source of protein meal. The rapeseed is the most valuable harvested component of the crop. This crop is also grown as a winter-cover crop. It provides an excellent cover to the soil in severe winter season and it also limits the nitrogen run-off from the soil. The plant can be ploughed back in the soil or can be used as bedding. Processing of rapeseed for oil production also gives rapeseed meal as by-product. This meal is very nutritious, high protein animal feed. Rapeseed's oil cake can also be used as a fertilizer, and even may be used for ornamentals, such as Bonsai, as well. Rapeseed and mustard's leaves and stems are edible too.

Rapeseed and mustard are the most prominent oil producing crops in Pakistan grown in Rabi season. These are major sources of edible oil in Indo-Pak subcontinent and China for centuries (7). The cultivated area of rapeseed and mustard crop in Pakistan during 2012-13 was 194 thousand hectares with a total production of 168 thousand tones (6). The low area under rapeseed and mustard is mainly due to the over-lapping sowing season of major cereal crops like wheat, barley and oats. As wheat is the staple food crop of Pakistan, oilseed crops of Rabi season are given relatively lesser attention. Therefore, mustard is mainly grown in rain fed, water deficient and less fertile areas. Consequently, insufficient edible oil is produced that can't fulfill even the domestic requirements.

Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if it is producing maximum output from minimum quantity of inputs, such as labour, capital and technology (5).

Battese and Hassan (4) used the stochastic frontier production function to estimate the technical inefficiency of farmers growing cotton in mixed cropping zones of Punjab. Technical inefficiency was found to be lesser for the farmers who first irrigated their cotton crop and done rogging. Nevertheless, with increase of inter-cultural operations, the inefficiency increased. They argued that if the crop is sown on proper time, yield can be increased significantly.

Tonye et al. (17) estimated the technical efficiency of peanut and maize farms in Cameroon using stochastic frontier production function. The study

showed that technical efficiency could be increased by improved management and technical practices. Secondly, relationship between technical efficiency and farms was examined by Tobit regression model. Factors having significant effect were found to be the level of education and association with farmer's organization. They argued that policies should be designed to increase the farmer's technical and management abilities and efficient farmer's organization system. They further suggested that for this purpose, private sector should be involved.

Narala and Zala (8) studied the effect of socio-economic variables in estimating the technical efficiency of rice farms in Gujrat. Technical efficiency of the farms was estimated using the stochastic frontier production function, while the influence of socio economic factors was assessed by regression analysis. The study showed that average technical efficiency was 72 percent indicating immense potential of increasing production and 28 percent without using any extra input, just using same set of resources more efficiently. Major reason contributing to inefficiency was low education level of the farmers.

Nyagaka, et al. (9) used the data from Nyanduara North District of Kenya to estimate the resource use technical efficiency and to identify the factors causing inefficiency. They used the dual stochastic parametric decomposition technique to derive the technical efficiency parameters. They observed very low mean technical efficiency i.e. 67 percent. They suggested innovative institutional developments to enhance extension services, farmer training, farm credit, farmer's membership in farmer's organization, for raising production efficiency.

Unakitan and Fatma (18) measured the technical efficiency of canola oilseed production in Trakya region of Turkey. They used the data envelopment analysis technique for the determination of technical efficiency. Important input variables in the study were land, seed, diesel, nitrogen, labor, pesticides and tractor. The total efficiency was 0.7544, while the technical and scale efficiencies were 0.8120 and 0.9268 respectively.

This study is intended to analyze the technical efficiency of rapeseed farmers and identify possible sources of inefficiency. If the farmers are not operating on the frontier, then in the light of study, policies will be suggested to enhance technical efficiency. Purpose of using frontier model in this analysis is that it gives us a frontier instead of an average production function (3).
MATERIALS AND METHODS

This study was conducted at the Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan during the year 2013-14. Primary data were collected from district Okara using random sampling technique. The information regarding factors of production, prices of input/output, and management practices was collected from rapeseed and mustard farmers on a well-structured questionnaire. About 120 respondents from Okara district were selected. For the purpose of analysis, the statistical software FRONTIER 4.1 was used to generate the valuable results. Stochastic production function was used to determine the factors affecting technical efficiency as it is regarded as a better measure than other techniques.

Stochastic production function is given as:

\[ Y_i = f (X_i; \beta_i) + \varepsilon_i \]

Here \( Y_i \) measures the quantity of output; \( X_i \) is a vector of the input quantities; \( \beta_i \) is a vector of parameters to be estimated and \( \varepsilon_i \) is an error term.

\[ \varepsilon_i = \nu_i - \mu_i \]

Here \( \nu_i \) is two-sided random error that is independent of \( \mu_i \), where \( \mu_i \) is the non-negative random variable related with the technical inefficiency. The inefficiency was calculated as:

\[ \mu = \delta_o + \Sigma \delta_d w_d + w \]

Here \( w_d \) are the variables explaining inefficiency like weather, extension services, tractor, farm experience and education.

RESULTS AND DISCUSSION

To analyze the data econometrically, the general form of Cobb-Douglas type of stochastic production frontier was used. Maximum likelihood estimates (MLE) were used to calculate the factors of stochastic production frontier and inefficiency effects. All model specifications include basic factors information and managerial factors. The factors of stochastic production frontier were approximated using FRONTIER version 4.1 (5). In the most cross sectional
analysis, the technical inefficiency results were assumed to be independently and identically distributed half normal or exponential random factors. However, expressing the predicted inefficiency impact in terms of regression design involving other explanatory factors, is not consistent with identically distributed inefficiency results in stochastic frontier. Battese and Gill (3) proposed a design in which inefficiency results, in a stochastic development frontier, were a normal function of other explanatory variables.

Estimation of Frontier Production Function: Cobb-Douglas Model

The value of coefficient for rapeseed and mustard area (acres) is 0.012. This indicates that one percent improvement in the area will improve rapeseed and mustard production by 0.016 percent which is statistically significant at 5 percent level of significance. The coefficient of seeds cost (Rs/kg) is 0.11 that is significant at 5 percent level of significance. This implies that with one percent improvement in seeds application production would improve by 0.11 percent. These findings are in line with those earlier workers (10, 11, 15). The coefficient of hired labor cost was negative which suggested that any increase in labour is not benefitting the farmer rather it is decreasing the farmers share in gross margin (Table 1). The coefficient associated with land preparation cost was positive and statistically significant (0.09). The results showed that if land preparation cost is increased, production efficiency can be increased.

Table 1. Maximum likelihood estimate of stochastic frontier function.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>OLS Estimates</th>
<th>Maximum Likelihood Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>( \beta_0 )</td>
<td>3.94 (2.297)</td>
<td>6.54 (8.252)</td>
</tr>
<tr>
<td>Ln (Seed Cost)</td>
<td>( \beta_1 )</td>
<td>0.13 (6.609)</td>
<td>0.11 (8.941)</td>
</tr>
<tr>
<td>Ln (Land Holding)</td>
<td>( \beta_2 )</td>
<td>0.031 (1.897)</td>
<td>-0.02 (1.344)</td>
</tr>
<tr>
<td>Ln (Fertilizer Cost)</td>
<td>( \beta_3 )</td>
<td>0.085 (2.734)</td>
<td>0.042 (1.996)</td>
</tr>
<tr>
<td>Ln (Land Preparation Cost)</td>
<td>( \beta_4 )</td>
<td>0.35 (5.527)</td>
<td>0.09 (1.337)</td>
</tr>
<tr>
<td>Ln (Labor Cost)</td>
<td>( \beta_5 )</td>
<td>-0.59 (-3.417)</td>
<td>-0.6 (-5.656)</td>
</tr>
</tbody>
</table>

Variance Parameters

<table>
<thead>
<tr>
<th></th>
<th>OLS Estimates</th>
<th>Maximum Likelihood Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigma-square ( \sigma^2 )</td>
<td>0.020</td>
<td>0.008 (6.999)</td>
</tr>
<tr>
<td>Gamma ( \gamma )</td>
<td></td>
<td>0.060 (0.3296)</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>67.24</td>
<td>119.33</td>
</tr>
</tbody>
</table>

Source: Author Own Calculation
The coefficient of fertilizer is 0.09, which is positive and significant at 5 percent. It indicated that production can be raised by using more fertilizer. The detailed analysis depicts that rapeseed and mustard farm owners were using nitrogenous fertilizer only ignoring other nutrients such as phosphorous and potash. It is also noted that no farmers was using potash nutrient in rapeseed and mustard fields. Rahman (13) also discovered a weak relationship of manure use and technical efficiency among Bangladesh farm owners. Abdulail and Huffman (1) noted adverse indication for rice farm owners in Northern Ghana.

**Sources of inefficiency**

In order to calculate factors of inefficiency, efficiency design was approximated where inefficiency was assumed to be dependent variable. The coefficients of socioeconomic and demographic factors which affect the efficiency, are of particular interest to this analysis. The outcomes of inefficiency effect model are summarized in (Table 2).

The inefficiency effect was examined as a function of various farms specific and socioeconomic factors. The results from profit frontier program indicated that inefficiency in rapeseed and mustard production was positively influenced and there exists upward biasness in inefficiency. Farm household and managerial practices, showed direct effect on production particularly age, higher education, high experience, tractor and extension facilities all significantly improved efficiency and increased technical efficiency in rapeseed and mustard production. Weather also affected the technical efficiency of the farmers.

The coefficient related to the experience of farmer was positive (0.006581) and statistically significant. Old farmers were inefficient and were likely to be more conservative and showed less reception to new technology and practices, thereby having more inefficiency in production of rapeseed and mustard. These findings are in line with those of previous workers (2, 3, 16). The results of inefficiency effect model indicated that coefficient of farm experience has positive sign. This implies that higher the experience of farmers, higher the technical inefficiency in rapeseed and mustard production.

The coefficient of weather was also positive (0.0114) and significant at ten percent level of significance. The positive sign indicates that weather contributed to the inefficiency of the farm. However, if the crop is sown at proper time, inefficiency due to weather can be avoided. Similarly, coefficient
of tractor was negative (-0.02092) indicating that possessing own tractor helps reduce inefficiency of the farm and get better gross margin. That's why the large farmers were more efficient because all of them possessed their own tractor. The education of farmer was statistically significant with negative sign (0.0002050) which indicated that increase of school years would improve the efficiency of rapeseed and mustard. If the farmers are more educated and more skilled they will use better farm practices and will be efficient in all domestic and farm level operations. Therefore education play crucial role in increasing the efficiency of farm and gross margin of the farmer.

The estimated coefficient associated with the extension services was significant and had a negative sign (-0.02374) which showed that access to extension services helped reduce the technical inefficiency in rapeseed and mustard production. These results confirm the fundings of earlier scientists (13, 16). Coefficient associated with ownership of tractor was 0.21 with a negative sign.

Table 2. Inefficiency effect of stochastic frontier function.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>Coefficients</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inefficiency model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>$\delta_0$</td>
<td>0.1125</td>
<td>1.846</td>
</tr>
<tr>
<td>Weather</td>
<td>$\delta_1$</td>
<td>0.0114</td>
<td>10.50</td>
</tr>
<tr>
<td>Extension Services</td>
<td>$\delta_2$</td>
<td>-0.02374</td>
<td>1.110</td>
</tr>
<tr>
<td>Tractor</td>
<td>$\delta_3$</td>
<td>-0.2092</td>
<td>5.845</td>
</tr>
<tr>
<td>Farm Experience</td>
<td>$\delta_4$</td>
<td>0.006581</td>
<td>4.336</td>
</tr>
<tr>
<td>Education</td>
<td>$\delta_5$</td>
<td>0.0002058</td>
<td>0.0908</td>
</tr>
</tbody>
</table>

Source: Author Own Calculation

Technical efficiency estimates of the rapeseed and mustard farmers

The data (Table 3) revealed that mean technical efficiency is 86.01 percent. Maximum efficiency score is 99.74 and minimum score is 62.8. The average value of 88.01 percent of technical efficiency implies that production can be improved by 17.9 percent by enhancing their technical and allocative efficiency. There are only 16.0 percent farm owners who have below 70 percent efficiency. The 24 percent farm owners have efficiency in the range of 71-80 percent. The 35.8 percent of farmers’ efficiency is in the range of 81-90 percent. About 23 percent of farm owners are operating near the prospective outcome i.e. 91-100 percent of technical efficiency. Farmers exhibit a wide range of production inefficiency ranging from 4.3 percent to 56.4 percent. Rahman (14) reported mean technical efficiency level of 77
percent for Bangladeshi grain farm owners. The mean technical efficiency for the large farmers was greater than the medium and small farmers because they mostly have easy access to the inputs, latest technology, and credit can avail better extension services.

Table 3. Technical efficiency estimates of the rapeseed and mustard farmers.

<table>
<thead>
<tr>
<th>Efficiencies</th>
<th>Frequency</th>
<th>Relative frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 70 percent</td>
<td>16</td>
<td>13.33</td>
</tr>
<tr>
<td>71 percent-80 percent</td>
<td>27</td>
<td>22.5</td>
</tr>
<tr>
<td>81 percent-90 percent</td>
<td>51</td>
<td>42.5</td>
</tr>
<tr>
<td>91 percent-100 percent</td>
<td>26</td>
<td>21.66</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>

Overall Efficiency

<table>
<thead>
<tr>
<th></th>
<th>86.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean efficiency score</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>99.74</td>
</tr>
<tr>
<td>Minimum</td>
<td>62.8</td>
</tr>
</tbody>
</table>

Source: Author Own Calculation

CONCLUSION

The results demonstrated that mean technical efficiency was 86.01 percent while maximum efficiency score was 99.74 and minimum was 62.8. Average measure of 86.01 percent of technical efficiency implies that technical efficiency can be increased by 14 percent by improving their technical and allocative efficiency. There were only 16.8 percent farmers who had below 70 percent efficiency, 24 percent farmers had 71-80 percent efficiency and 35.8 percent farmers’ 81-90 percent efficiency. About 23 percent farmers were operating near potential output i.e. 91-100 percent of technical efficiency. Farmers exhibited a wide range of technical inefficiency ranging from 4.3 percent to 56.4 percent.

The mean technical efficiencies of rapeseed and mustard farmers according to farm size were also estimated. Efficiency increases with size of farm. The mean technical efficiency of large farmers was 85 percent. The mean technical efficiencies of medium and small farmers were 82 percent and 80 percent respectively. Large farms operated at the highest level of efficiency when compared with medium and small farms. The reason behind that large farmers are more efficient in rapeseed and mustard farming was due to better education, easy access to credit, more finance to purchase inputs like pesticide, fertilizer, irrigation, plant protection measures, etc. alongwith better
managerial practices and extension facilities. The timing of fertilizer application is nearly optimal and application of pesticide is not relatively late because they can easily hire permanent labor compared to small and large farmer. All these factors have contributed significantly to higher level of technical efficiency of large farmers when compared with medium and small farmers.

RECOMMENDATIONS

1. As extension services had significant effect on the technical efficiency of rapeseed and mustard farmers so government has to take serious step towards strengthening the Extension Department. There should be proper training and checking system of extension workers, so that extension staff provide seamless awareness to rapeseed and mustard farmers about timely sowing of crops and application of plant protection measures. Extensive extension programs should be launched providing both the formal and the informal type education in rural areas. Scientific knowledge and technical information also need to be disseminated properly and regularly.

2. Education of rapeseed and mustard farmers reduces the inefficiency and enables the farmers to operate closer to the optimum levels and measures should be advanced to promote education above the primary level and education system should be improved in the rural areas.

3. The technical and managerial skills of farmers have important role in farm efficiency. Timely sowing of rapeseed and mustard crop, proper and timely application of chemical fertilizers, best possible preparation of land and taking other basic decisions effectively, tremendously increase the technical efficiency. It requires that all should farmers pay maximum attention to timely and proper application of inputs.

4. Another major problem is the water and energy crisis prevailing in the country. There is a severe deficit of water for irrigation. However, available water could be used more efficiently by lining of courses and prevention of water theft. Moreover, improving the efficiency of irrigation department, devising new methods of irrigation to save water extensive research in this sector are some of inevitable needs of the time. Electricity rates for agricultural purposes should be subsidized.

5. Availability of credit is a very crucial factor in production of any crop. Unfortunately in our country credit system is not efficient. Either the credit facilities are not available or the conditions for loan are too strict that people hesitate. Secondly, due to domestic problems credit is often not
used for production purpose rather it is used for non-agricultural purposes. So, a system of credit should be devised with easy conditions and less interest rate. Moreover, there should be a monitoring mechanism that should check whether the credit is being used for agricultural purpose or not.

REFERENCES

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CONTRIBUTION OF AUTHORS:

Abdul Hannan Jaffar : Planned the research, prepared research instrument, analyzed the data.
Maqsood Hussain : Participated in focus group discussion and prepared writeup.
Sarwat Zia : Helped in writeup and in data collection.
Muhammad Ayub : Helped in data collection
Habib Anwar : Chosen research model.
Muhammad Ali Imran : Reviewed the manuscript.