Estimation of Technical Efficiency and its Determinants among Maize Producers in Jammu Region of J and K State (India)

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Abstract: This paper presents measures of the technical efficiency and factors influencing technical efficiency among maize growers in Jammu region of Jammu and Kashmir State by using frontier production model. The results revealed that the mean technical efficiency was 42 percent and the study implied that the average output of maize could be increased by 58 percent by adopting proper technology. The stochastic frontier analysis also showed that 85 percent of the observed inefficiency was due to the farmer’s decision making and 15 percent of inefficiency was due to the random factor outside the control of the farmers. So for increasing the productivity of maize in this area, it is of utmost importance that the existing technologies should be properly utilized.

Key words: Examination of efficiency · Factors affecting on efficiency and Policy Implications

INTRODUCTION

Maize is one of the most important food grains in the world as well as in developing countries and emerging as third most important crop after rice and wheat. Maize occupies an area of about 6 million ha with an average productivity of about 1.6 tonnes / ha which was less than the world’s average of 4.3 tonnes/ha [1], but now the area and productivity of maize increased in India i.e. 7.7 million ha and 1.78 tonnes/ha means that it is going to increase as compared to last years. The State of Jammu and Kashmir comprises of three regions Kashmir, Ladakh and Jammu. Maize occupied an area of 0.32 million ha with annual production of 0.48 million tonnes during the year 2006-07 and the average yield of 1.50 tonnes/ha, which was marginally lower than the national average (1.78 tonnes/ha). Being a prominent crop of sub-tropical and intermediate zones, Jammu region covers 0.21 million-hectare land, with 0.38 million tonnes production and 1.73 tonnes/ha productivity, which was more than the national average. The area, production and productivity of maize in Doda was 0.05, 0.10 and 2.10, tonnes per ha respectively in the year 2006-07 [2]. This discerns that average yield of Doda district of Jammu region is more than that of national average.

Due to its diversified uses for corn, starch industry, corn oil production, baby corns, popcorns, etc. and potential for exports has added the demand of maize all over world. India is the second most populous country of the world. Due to the faster growth, the availability of human food in general and proteinase food, in particularly is always decreasing. So, the policy makers of India are facing problems to make policies regarding the solution of the problem of malnutrition. India needs to increase productivity of its limited lands, Thus, we need a crop which yields at a higher rate than rice and wheat and can easily supplement human food, as well as supply feeds and fodder. So that high yield potential cereal can be produced from the same land for livestock and poultry, supply fuel and also can be used as a raw material in the industry. Maize can be grown successfully under rain fed environment and required less capital may meet this additional food requirement.

In this regard the name of the maize appears at first instance. The versatile adaptable characteristics of this crop in terms of production seasons, different agro-climatic factors and economic benefit on investment have opened the new arena before the farmers to choose maize for preferential treatment amongst other crops. Thus, if maize can be adopted in the existing cropping pattern the food deficiency and required
nutritional intake of the low income earning people can be overcome substantially.

Increased demand for food has already started disruption of the natural resource base in India. To meet the growing demand, per hectare yield of maize is estimated to rise to 2.36 tonnes against 1.7 tonnes currently by the end of 2020. If we compare the yield differences of maize crop in Jammu region between research farm (3.7 tonnes/ha) and farmers field (2.1 tonnes/ha) was realized to be (1.6 tonnes/ha). Whereas, yield differences between demonstration field (3.4 tonnes/ha) and farmers field (2.1 tonnes/ha) was found to be 1.3 tonnes/ha. andTherby indicated that the existing potential is yet to be realized. Keeping in view the above related facts, the objectives considered for this study are to examine the technical efficiency of maize in Doda district of Jammu region and to identify the factors influencing technical efficiency in maize production. This study might give direction of adjustments required to improve the level of economic efficiency by resource allocation. Therefore, this study is expected to provide valuable information and may be useful both at micro and macro level and helpful to policy makers for formulating appropriate policy for widespread cultivation of maize in the Jammu region. Several studies have suggested that skills of the farmer may be the key factor explaining farm production. In most studies of the technical efficiency, characteristics of the farm have been used to estimate the determinants of efficiency and inefficiency. Few attempts have been made to determine the contribution to the efficiency of the farm of immeasurable characteristics such as farmer experience, credit access, off-farm income, technical assistance, age and education. This study is aimed at opening a new dimension to farmers and policy makers that how to increase maize production by determining the extent to which it is possible to raise efficiency of maize farms with the existing resource and productivity in the state could be achieved by using Stochastic production frontier function. The specific objectives of the study are:

- To examine the technical efficiency of maize under Jammu region
- To identify the factors influencing technical efficiency in maize production

**Stochastic Production Frontier and Technical Efficiency:**

Following Farell suggestion's [3], the efficiency of a farm can be defined and measured as the ratio of observed output to maximum feasible output from a frontier. If the frontier is the production function, i.e. the maximum potential output for a given set of inputs, the ratio will measure technical efficiency. Suppose that the observed input-output values from a sample of traditional and non-traditional crop producing farms are below the production frontier; then these farms are considered inefficient. This implies that the farms did not reach the maximum output possible for the inputs used, given the level of technology. Traditional crop farmers may be using traditional technologies either due to lack of access to modern inputs related to new technologies, lack of knowledge, or higher costs of adopting the new technologies. A measure of technical efficiency for crops is given by \(y/y^*\), where \(y^*\) is the frontier output associated with the level of inputs \(x\).

A general stochastic production frontier can be given by:

\[
\ln y_i = \alpha + \beta \ln x_i + \nu - u_i, \quad i = 1, \ldots, n
\]

Where \(\ln\) represents the natural logarithmic \(y_i\) is the output produced by farm \(i\), \(x\) is a vector of factor inputs, \(\nu\) is a vector of unknown parameters, \(\beta\) is the stochastic error term. \(u\) is a one-sided non-negative random variable associated with the technical inefficiency in production. This one-sided term can follow such distribution as half-normal, exponential, truncated and gamma. In this study, it is assumed that \(u\) to be independently distributed and follows a truncated u normal distribution. The technical efficiency (TEFF) of the ith farm in the context of the stochastic production frontier is defined as

\[
\text{TEFF}_i = \exp(-u_i)
\]

Following Battese and Coelli [4] the influence of the inefficiency component can be measured by \(\gamma = \sigma_i^2 / \sigma^2\) where \(\sigma^2 = \sigma_i^2 + \sigma_u^2\). The inefficiency effects in the production function and the effects of the variables included in the inefficiency effects model can be tested using the likelihood ratio. There are several functional forms used to develop the production frontier. The most common are the Cobb-Douglas and the translog production functions. The Cobb-Douglas functional form is used to specify the stochastic production frontier function chosen to perform the efficiency analysis. The parameters of the stochastic production frontier are estimated by maximum likelihood techniques, using the computer program FRONTIER Version 4.1 as described by andBattese and Coelli [4]. The estimation of the maximum value of the logged likelihood function is based on a joint density function for \(u\) and \(\nu\). Technical efficiency of each farm can be obtained from:
\[
TEFF_i = E(\exp(-u_i)|\epsilon_i) = \frac{1 - \Phi(-\mu_i/\sigma^2)}{1 - \Phi(-\mu_i/\sigma^2)} \times \exp(-\mu_i + \sigma^2/2)
\]

where \( \sigma^2 = \sigma^2_x + \sigma^2\epsilon \), \( \mu_i = (\sigma^2_x \epsilon_i + \mu \sigma^2) / \sigma^2 \)

and \( \Phi \) is the standard normal distribution function.

\section*{MATERIALS AND METHODS}

\subsection*{Description of the Study Area:} The district Doda (JandK) falls between 32 degree-53' and 34 degree-21' north latitude and 75 degree-1' and 76 degree-47' east longitude. Spread over an area of 11,691 Sq.Kms. The altitude varies from 8,000 ft. to 15,000 ft. The average rainfall is 35 inches per annum which is lowest as compared to other district of the division. Agriculture is the main occupation of the rural people and topography, climate and soil are the main factors affecting agriculture in the District. The main variety of crops of this region can be classified under the following categories:

- Food Crops: Rice, wheat, maize, millets and pulses
- Commercials: Crops: Zera, Potato etc
- Horticulture Crops: Apple and apricot etc
- Other Crops, Potato, Chillies etc

\subsection*{Sampling Selection:} This study was based on different samples of farmers in three blocks in which six villages are taken under study. From each village twenty farmers are selected randomly. We collected the data of 120 farmers living in different villages. Detailed crop input-output data were collected from the households for the crop year 2008.

\subsection*{Empirical Estimation:} The Cobb-Douglas functional form of the stochastic production frontier model is defined as

\[
\ln y_i = \beta_0 + \beta_1 \ln L + \beta_2 \ln P + \beta_3 \ln K + \beta_4 \ln M + V_i - U_i \quad (i = 1, 2, \ldots, n)
\]

Where:

- Subscript \( i \) refers to the observation of the \( i \)th farmer and
- \( Y_i \) = Yield of maize in the the \( i \)th farm (q/ha)
- \( L \) = Human labour use in maize crop (man-days/ha)
- \( P \) = Quantity of fertilizer (N+P+K) used (kg/ha) in maize crop
- \( K \) = Capital which includes overhead expenditure on animal and machine labour, seeds and pesticides (Rs/ha)
- \( M \) = FYM manure used in maize crop
- \( V_i - U_i \) = Random error-term.

\section*{RESULTS AND DISCUSSION}

\subsection*{Determinants of Technical Efficiency:} The source of efficiency differential that is observed among farmers is an issue of overriding concerns. Studies of sources of technical efficiency are concerned with the role of farmer’s characteristics.

In this study the following model is used to study the socio-economic factors influencing the technical efficiency at the farm level. MLE (Maximum likelihood estimators) estimates of technical efficiency will be regressed on rental value of per gross cropped area (Proxy for land quality), proportion of females in total agricultural workers in the family, proportion of children in the family, education dummy for the household having family adult member with education above primary level and farm size. As the technical efficiency variable varies between 0 and 1, the variable will transformed into \( \ln (\text{TE} / (1 - \text{TE})) \) so that the later transformed variable now varies between 0 and \( -\infty \), which will facilitate estimation of the parameters by using the OLS technique.

The following linear regression model used to identify the socio-economic factors that condition technical efficiency of sample farms

\[
L_{ni} [\text{TE} / (1 - \text{TE})] = \beta_0 + \beta_1 X_{ni} + \beta_2 X_{ni} + \beta_3 X_{ni} + \beta_4 X_{ni} + U_i
\]

Where:

- \( \text{TE}_i \) = Technical efficiency for \( i \)th farm on \( j \)th farm
- \( \beta_0 \) = Intercept/Constant
- \( \beta_1 \) = Regression coefficients,
- \( X_{ni} \) = Age of the head of family
- \( X_{ni} \) = Proportion of female workers in total agricultural workers in the family
- \( X_{ni} \) = Dummy for adult members/ having education above primary level
- \( X_{ni} \) = Farm size and
- \( U_i \) = Error term.

\subsection*{Estimates of OLS and Frontier Production Function:} Sample of 120 farms were considered to estimate the technical efficiency. The dependent variable included in the model was output of maize crop. The inputs included human labour, fertilizer, capital and manure. The estimate of \( \lambda \) was 1.961 and \( \sigma \) was 0.206, which were significantly different from zero indicating a good fit and the correctness of the distributional assumptions specified.
Table 1: Estimates of Cobb-Douglas and Frontier functions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cobb-Douglas Production function (OLS)</th>
<th>Frontier production function estimates (MLE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.812</td>
<td>-0.812</td>
</tr>
<tr>
<td>Labour</td>
<td>-0.300 (2.688)*</td>
<td>0.300 (2.440)****</td>
</tr>
<tr>
<td>Capital</td>
<td>0.286 (2.500)**</td>
<td>0.286 (2.346)****</td>
</tr>
<tr>
<td>N</td>
<td>0.241 (3.165)**</td>
<td>0.241 (3.402)**</td>
</tr>
<tr>
<td>P</td>
<td>0.092 (1.874)</td>
<td>0.092 (1.715)*</td>
</tr>
<tr>
<td>K</td>
<td>0.077 (2.112)**</td>
<td>0.077 (1.741)*</td>
</tr>
<tr>
<td>FYM</td>
<td>0.003 (2.105)**</td>
<td>0.003 (1.820)*</td>
</tr>
</tbody>
</table>

R² = .99

Variance parameters:
\[ \sigma_{\gamma}^2 = .020 \]
\[ \sigma_{\zeta}^2 = .120 \]
\[ \sigma = .206 \]
\[ \lambda = 1.961 \]
\[ \lambda (\sigma_{\gamma}^2 / \sigma_{\zeta}^2 + \sigma_{\zeta}^2) = 0.85 \]
\[ \ln (\text{Likelihood}) = 40.990 \]

Figures in parentheses are the t-values, *Significance at .025 level, **Significance at .01% and **** Significance at .05%.

The value of \( \lambda \) was more than one, implying the dominance of one-sided component \( U_i \) in \( E_i \) and thus indicated high degree of technical inefficiency. In other words the inefficiency component was not dominated by the random factors. The variance ratio \( \gamma \) showed that the farm specific variability contributed more to the variation in yield, which means that variation in output from frontier is attributed to technical inefficiency. The value of \( \gamma \) was 0.85. This means that about 85 percent of the differences between the observed and the maximum production frontier outputs were due to the factors, which were under farmer’s control. The stochastic frontier analysis further showed that 85 percent of the observed inefficiency was due to farmer’s inefficiency in decision making and only 15 percent of it was due to random factors outside their control.

The result shows that the estimated values of the coefficients of all the variables were positive both in OLS and MLE estimates. As expected the co-efficient of all variables were almost similar in both the estimates. Statistically significant and positive values of estimated coefficients indicated that farmers could increase per hectare yield by implying more units of these inputs. The estimated values of \( \sigma_{\gamma}^2 \) and \( \sigma_{\zeta}^2 \) are 0.020 and 0.120 respectively. These values indicate that the differences between the observed and frontier output are due to inefficiency and not due to chance alone.

The co-efficient of multiple determinations (\( R^2 \)) indicates that 99 percent of the variation in the yield could be explained by the variables considered in the model for the maize crop.
Table 2: Distribution of maize growers under different levels of technical efficiency

<table>
<thead>
<tr>
<th>Efficiency levels (%)</th>
<th>Number of farms</th>
<th>Per cent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>40-60</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>60-80</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>80-100</td>
<td>59</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: Determinants of technical efficiency in paddy farms

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.856</td>
<td>1.771</td>
</tr>
<tr>
<td>Education</td>
<td>0.055</td>
<td>0.569</td>
</tr>
<tr>
<td>Age</td>
<td>0.245</td>
<td>0.667</td>
</tr>
<tr>
<td>Female workers</td>
<td>-0.260</td>
<td>-1.521</td>
</tr>
<tr>
<td>Farm size</td>
<td>-0.362</td>
<td>-4.309*</td>
</tr>
</tbody>
</table>

* Significance at 1% level

Technical Efficiency of Sample Farms: The farm specific technical efficiencies were estimated and the frequency distribution is given in the above Table. The minimum technical efficiency was found 10 percent and the mean technical efficiency was 42 percent. The maximum number of farms came under the category of 80-100 percent technical efficiency. The study implied that the maize output of the “average farmer” could be increased by 58% by adopting proper technology by the farmers.

A linear regression model used to identify the socio-economic factors that condition technical efficiency of sample farms. The association between technical efficiency and farm size is negative and highly significant i.e., more area under maize crop is comparatively more efficient. The coefficient of age and education was 0.055 and 0.245 which was positive but insignificant. The positive sign implies that due to increase in age and education the experience of farmer also increased which would increase the yield by 0.055% and 0.245%. This finding is important given the fact that an overwhelming majority of the maize farms in Jammu state are small and often lack capital to invest in yield enhancing measures. In other words, smallholders need policy support in terms of credit, technical advice and extension etc. The proportion of female workers in total agricultural workers in the family has a negative and non significant coefficient indicating that technical efficiency is low on the farms having more female workers. This could happen that more women labor used in agriculture in India.

CONCLUSIONS AND POLICY IMPLICATIONS

The yield of maize in Jammu being much lower than the national average, the study has assumed importance in its attempt to decipher the various determinants of technical and its implications in the state. In this study, the technical efficiency of individual farms has been estimated using farm level data of maize in Doda district of Jammu region of Jammu state for the production period 2008. The mean technical efficiency has been found 42 percent among the sample farms and across regions, which indicates that on average, the realized output can be raised by 58 percent without any additional resources in the maize growing regions. Various socio-economic, biophysical and technological factors may be responsible for the observed difference in efficiency in the farms. The results showed that even under the existing technology potentials exists for improving the productivity with proper allocation of the existing resources. Hence proper extension strategies need to be taken to educate the estate owners about rational use of inputs. The technical efficiency of the maize growers in the Jammu region of Jammu state can be improved by increasing the adoption level of the improved package of practices. This can be made possible by providing good quality seeds of improved paddy cultivars and easy and cheap credit for the purchase of critical inputs like fertilizers, plant protection, chemicals, etc. Except of this an assured market for their output through forward linkage with agro processing industries will indirectly reduce the price volatility in maize produce and increase the socio-economic status of these farmers.

REFERENCES