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Technical efficiency of maize production by employing stochastic frontier approach

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Abstract

In India, agricultural sector undergo a large number of reforms and huge policy initiatives to improve the productivity in agricultural sector it continue to underperform due to large number of problems faced by this sector. One such crop is maize since it is important cereal crop with 15 million Indian farmers are engaged in cultivation. The maize requirement would be about 45 million tons as against current production of 24 million tons. The findings presents the mean technical efficiency more or less same for both local and improved seed variety farmers however at disaggregated level the improved seed variety farmers 23% of the farmers falls in the range of 0.71 to 1.0 of TE whilst 4.76% of the farmers for the local variety seed farmers. Therefore, we highly recommend the elimination of barriers to access to information particularly in rural areas with respect to improved technologies and information related to market ensures in augmenting the maize production.

Keywords: Technical efficiency, stochastic frontier approach

1. Introduction

In India, Agriculture sector continues to contribute about 14% of the GDP and generates employment for more than 52% of the population. Thus, it is inevitable for sustainable economic growth of the sector is sine qua non. Despite the large number of reforms in agricultural sector and huge policy initiatives to improve the productivity in agricultural sector it continue to underperform due to large number of problems faced by this sector. The Maize is the important cereal crop in India and about 15 million Indian farmers are engaged in cultivation. It is gaining more importance due to increasing industrial demand for animal feed, corn starch and corn oil production including baby corns. The maize production increased by twofold from about 12 million tons in 2000 to about 24 million tons at present. This notable production attributed to adoption of single cross hybrids, modern technology and increasing consumers demand for nutritionally enriched products. The maize crop has the potential to generate better income, gainful employment and would help in doubling the farmer's income. Karnataka state has evidenced the paradigm shift in economic activities from agriculture to non-agriculture sector in recent years. The agricultural production and productivity needs to be enhanced in the state with greater effort not only for food security but also for employment generation. The area under maize crop found to be growing at a faster rate with annual growth rate of 12.32% as against the 3.2% of the rice in last four decades (GoK, 2023). Despite the production strength, maize yields remained relatively low in India compared to other developing countries. For instance the difference in maize yield between India and World found to be 130% (FICCI, 2023). The main attributes for low maize productivity are fragmented land holding, major area is under rainfed, use of traditional techniques, non-adoption of all agronomic management practices, etc. All these factors lead to inefficient production. The consumption of Maize has increased at a CAGR of 11% in last five years and hence by 2022 the maize requirement would be about 45 million tons as against current production of 24 million tons. Thus, main question pursued in this article is why the farm economy has not responded to the demand side forces that have been unleashed on it from the rapid economy-wide growth. One more issue is that before making any policy to enhance productivity, one need to know whether resource use was efficient and practice available technologies. This article tries to find some of important factors that may influence the technical efficiency. Furthermore, maize crop has high production potential in the state, subject to availability of improved hybrids / varieties and adequate irrigation facilities (Joshi *et al*., 2005) [5]. This potential can be harnessed by improving efficiency of maize production by adopting all the recommended practices and proper combination of inputs for sustainable maize production based on the resource use efficiency analysis.

2. Methodology

2.1 Secondary Data base: The plot level data for the year 2022-23 generated under the Cost of cultivation scheme

(MSP unit) of the Economics and Statistics, Evaluation division, Ministry of Agricultural and Farmers welfare were used for present paper. Maize crop was chosen for the study in the since it stand first in the production and productivity in India. The data relating to sample size of 116 comprising of 74 farmers cultivating improved varieties and 42 farmers using local varieties in the study area.

2.2 Model specifications
In this study, Stochastic Frontier Analysis (SFA) was employed for estimating the TE in cultivation of different varieties of maize. The SFA allows the deviations from frontier to represent both inefficiency and inevitable statistic noise approach the reality given random walk of the observation. (Pitt and Lee, 1981) [8]. The model treats technical efficiency and represents the random shocks beyond the control of farmers affecting production. Furthermore, this approach considers TE as a multiplicative shift variable within a production function framework, which implies input coefficient of conventional production function and that of the frontier function are the same and only the intercept changes. However, in cross sectional data the distribution of TE must be indicated as half-normal, truncated normal or otherwise. According to Kalirajan and Flinn (1983) [6], one can calculate individual-specific TE by employing this method. Most of the previous studies used this method to estimate TE and also to determine the factors influencing efficiency of farmers in crop sector (Shanmugan and Venkataramani, 2006; Singh *et al.*, 2007; Tavva *et al.*, 2017) [12-14]. The frontier production defines potential output that can be produced by a farm with given level of resources and technology. The SFA function can be specified as:

$$Qi = f(Xi; \beta) \exp(-ui) \text{ and } 0 \le ui < \infty;\ i = 1,2,\ldots,n. \quad \ldots(1)$$

Where, Qi represents the rice yield for the i^{th} sample unit; Xi is a vector of inputs and β is a vector of parameters and implies the transformation process; f (.) is the frontier production function and u_i is a one-sided (non-negative) residual term. If production unit is efficient, its output is equal to potential output indicating that farmers adopting the good agricultural practices. Therefore, TE is the ratio of the actual output Qi and the potential output f (.) given the level of input use and the technology.

Using the above equation (1), we can write this measure as:

$$TE = Qi / f(Xi; \beta) = \exp(-ui) \quad \ldots (2)$$

Note that u_i is zero if the production unit produces the potential output and is less than zero when production is below the frontier. A random noise variable v_i (independently and identically distributed normally with mean zero and variance σ_v^2) can be incorporated in the equation (1) to capture the effect of other omitted variables having influence on the output:

$$Qi = f(Xi; \beta) \exp(v_i - u_i)$$

The maximum Likelihood Estimation (MLE) method can be used to measure parameter of the model is: $\sigma = \sqrt{(\sigma u^2 + \sigma v^2)}$, $\lambda = \sigma u/\sigma v$ (> 0) and $\gamma = \sigma u2/\sigma 2$). A significant σ (and λ) would indicate the significant variations in the output levels. The λ with more than unity would indicate that output variations due to inefficiency are higher than that due to random factors. A zero value of γ would indicate that the deviations from the frontier are due entirely to the noise and, in this case, the Ordinary Least Squares (OLS) estimates of the model are equivalent to the MLE results.

2.3 Estimation of potential yield
The ratio of average yield to technical efficiency determines the maize potential yield.

Potential yield = Average yield / Average technical efficiency

2.4 Model estimation for Technical efficiency
For estimating the TE at given level of inputs and technology, the Cobb –Douglas type of production function as specified below was used:

$$\ln Y_i = \beta_1 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 + V_i - U_i$$

Where, ln indicates the natural logarithm with base e
Yi = Maize yield (qtl ha^{-1}) for i^{th} farm per hectare
β_1 = Constant, x_1 = Machine labors (hrs), x2 = Human labor (man-days), x_3 = Seed (kgs/ha), x_4 = Expenditure on fertilizers (kgs/ha), x_6 = Animal labor expenditure (Rs.)
V_i = Symmetric component of error term which captures randomness outside the control of the farmer such as influence of drought, floods, hailstorms, etc. U_i = Non negative random variable which is under the control of farmer.

3. Results and Discussion
The summary statistics of the farmers and critical inputs used in the maize production are depicted in the Table 1 and Table 2. The variable cost as well as socio characteristics of the farmers are imperative in decision making and understanding the behavior of the farmers in the short run. Among the variables, use of fertilizer, seed, human labor, machine labor and yield level are significant across the different farmer categories at five% probability level of significant. The mean fertilizer use was found to be relatively more in the case of farmers growing improved variety (86.91kg/ha) as against 81.93 kg/ha for local seed using farmers. Similarly, there existed significant difference in labor utilization among the improved seed using farmers and local seed using farmers at 5% level of probability. This may be due to cost advantage over mechanization. The Yield realized by the farmers who growing improved variety was higher yields (43.08 qtl/ha) as against their counterparts growing local variety (40.26 qtl/ha).
The maximum likelihood estimates of the Cobb-Douglas stochastic frontier production function for both the improved and local variety growing farmers are presented in Table -3. Most of the estimated parameters are significant at five percent probability level. The coefficient for labor found to be negative and signifies the fact that improved variety growing farmers used more labor for carrying out different agricultural operations as against the local variety

growing farmers. It is evident from the Table-1 that improved variety growing farmers applied relatively higher dosage of fertilizers, seed and human labor than local variety of maize growing farmers. Excess use of family labor can be attributable to absence of alternative employment opportunities in the region. The results are in consonance with Tavva *et al*. (2017) [14] who also reported that negative marginal productivity of labor on wheat farms in Afghanistan.

The animal labor found having significant influence on maize yield under local and improved seed farmers as indicate by significant elasticity coefficients. However, elasticity percentage (coefficient) was found to be higher for local variety compared to improved variety growing farms. This implies that local seed using farmers depends more on animal power than machine labor for most of the agricultural operations because of economic advantage.

As the estimated value for the variance parameter (γ) was significantly different from zero for both the local and improved variety growing farmers implying that inefficiency effects are significant in influencing the variability of maize production. Thus output oriented TE is significant in explaining total variability in Maize output. The estimate of γ (the ratio of the variance of specific seed TE to the total variance of output) was 25% and 13% arises from the factors which were not under the control of farmers.

The distribution of farmers based on technical efficiency indicated in Table (5). It could see that about 26% local variety farmers and whilst 37% of the improved seed farmers fall in the technical efficiency of less 0.20. About 26% of the farmers fall in the range of 0.51 to 0.60 technical efficiency level and 15% of the farmers in the range of 0.61 to 0.80 technical efficiency levels. Only 2% of farmers of the improved variety achieved more than 0.91 TE and whilst none of the farmers falls under the range under the local seed farmers. The mean technical efficiency level of the overall maize farmers, local maize farmers and improved maize farmers was 0.57, 0.58 and 0.59, respectively. The mean technical efficiency of the improved maize farmers was relatively higher due to efficient utilization of the resources compared to local maize farmers. The table 6 represents the percentage of deviations of mean yield from potential yield of overall maize farmers. The highest mean yield (69.12) was observed for those farmers whose TE score between 0.81-0.90. The least mean yield of overall maize farmers was 34.23 qtl/ha because of large number of famers was operated TE score of less than 0.20. The potential yield was found to be 130 q/ha. The percentage of deviation of mean yield from potential yield was to be decreasing with TE scores. In other words, with increased technical efficiency of the farmer's deviations of mean yield from potential yield reduced. The Mean TE and Yield and% of deviations of the mean yield from the potential yield farmer growing local variety depicted in the table (7). Indicated that in the category of less than 0.20 TE the mean yield was 31.45 qtl/ha with 120.63% deviations from the potential Yield and whereas for technical efficiency range of 0.71 -0.80 a deviations was very less (1.38%) which implies that percentage deviations from the potential yield decreases with increasing technical efficiency. The table (6) represents the percentage of deviations of mean yield from potential yield of overall maize farmers. The TE in range of 0.81 to 0.90 with yield of 69.12 whilst the 34 qtl/ha of maize yield with TE of less than 0.20. The percentage of deviations of yield to potential yield decreases with increases in the TE among the farmers. This acknowledges the improvement in the TE leads to decline in the deviations.

Table 1: Descriptive statistics for maize growing farmers in the study area through ANOVA test

S. No.	Particulars	Improved maize variety		Local maize variety		Maize farmers (overall)		ANOVA test
		Mean	Std. dev.	Mean	Std.dev	Mean	Std.dev	
1	Maize area (ha)	2.57	1.99	2.11	1.75	2.42	1.92	2.35
2	Fertilizer (Kgs/ha)	86.91	49.86	81.93	63.02	85.04	54.89	3.25**
3	Seed rate (Kgs/ha)	22.93	31.59	26.17	63.2	23.59	43.98	3.78**
4	Labour (hrs/ha)	185.16	96.7	169.7	88.09	184.32	94.57	2.58**
5	Animal labor (hr/ha)	31.9	68.15	73.62	245.14	51.46	151.57	1.98
6	Machine labor (hr/ha)	18.56	39.84	12.93	47.56	16.01	41.45	5.68**
7	Yield level (qtl/ha)	43.08	12.22	40.26	20.23	42.37	11.94	2.36**
	Observations	74		42		116		

Note: ** Indicates the 5% level of significant.

Table 2: The coefficient estimation for improved and local seed farmers by stochastic frontier model

Particulars	Local			Improved			Overall		
	Coeff	Std.error	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z
Machine labour (hrs.)	0.02	0.05	0.32	-0.02	0.03	-0.67	0.005	0.03	0.18
Human labour (hrs.)	0.1	0.04	2.64	-0.32	0.05	7	0.101	0.04	2.59
Seed rate (in Kgs)	-0.12	0.05	-2.33	0.01	0.02	0.29	0.076	0.04	2.13
Fertilizer (in Kgs)	0.09	0.04	2.25	-0.16	0.06	-2.7	-0.078	0.04	-2.04
Animal labour	0.15	0.06	2.61	0.07	0.03	2.48	0.047	0.03	1.47
constant	2.8	0.56	4.99	4.41	0.45	9.8	3.512	0.23	15.47
U Sigma	-12.1	524.6	-0.02	-2.29	0.33	-7.05	-3.391	0.52	-6.49
V sigma	-3.08	0.23	-13.53	-5.48	0.84	-6.51	-3.356	0.33	-10.2
Sigma_u	0	0.62	0	0.32	0.05	6.08	0.183	0.05	3.83
Sigma_v	0.21	0.02	0.27	0.06	0.02	2.68	0.187	0.03	6.08
Lambda	0.82	0.09	8.33	0.87	0.08	10.87	0.982	0.07	13.52
Wald chi 2	16.35			25.97			16.97		
Log likelihood	4.69			0.0001			-4.53		
observations	42			74			116		

Table 3: The distribution of local and improved variety of maize growing farmers with technical efficiency level wise

	Frequency of farmers					
TE	**Local (%)**	**%**	**Improved (%)**	**%**	**Overall (%)**	**%**
<0.20	11	26.19	28	37.84	45	38.79
0.20-0.30	7	16.67	3	4.05	23	19.83
0.31-0.40	2	4.76	6	8.11	12	10.34
0.41-0.50	5	11.9	7	9.46	11	9.48
0.51-0.60	11	26.19	8	10.81	9	7.76
0.61-0.70	4	9.52	7	9.46	8	6.9
0.71-0.80	2	4.76	11	14.86	7	6.03
0.81-0.90	-		4	5.41	1	0.86
0.91-1.0	-		2	2.7	-	
Mean TE	0.58		0.59		0.57	
Observations	42		74	100	116	100

Table 6: Mean TE, yield and percentage of deviations to potential yield for overall maize

TE Scores	Mean Yield	% of deviation from potential yield
<0.20	34.23 (45)	-116.90
0.20-0.30	48.12 (23)	-54.29
0.31-0.40	48.38 (12)	-53.46
0.41-0.50	53.25 (11)	-39.43
0.51-0.60	55.25 (9)	-34.38
0.61-0.70	54 (8)	-37.49
0.71-0.80	59.25 (7)	-25.31
0.81-0.90	69.12 (1)	-7.42
Overall	74.24	
Potential yield (Mean yield /Mean TE	130	

Note: 1. Figures in the parentheses represents number of farmers range between the TE scores

Conclusions

This study mainly emphasized on assessing the technical efficiency among maize farmers between the improved and local variety seed and the factors influencing in determining the technical efficiency. The findings presents the mean technical efficiency more or less same for both local and improved seed variety farmers however at disaggregated level the improved seed variety farmers 23% of the farmers falls in the range of 0.71 to 1.0 of TE whilst the merely 4.76 in the same range for the local variety seed farmers. The main reasons for this, little knowledge among the farmers about management practices, availability of technology and other factors that may affect the use of resources, profitability and production potential the farmers. Therefore, we highly recommend the elimination of barriers to access to information particularly in rural areas with respect to improved technologies and information related to market ensures in augmenting the maize production.

References

1. Amin WM, Featherstone AM. Backyard hog production efficiency: evidence from the Philippines. Asian Econ J. 2008;22(3):267-287.
2. Aigner DJ, Lovell CAK, Schmidt P. Formulation and estimation of stochastic frontier production function models. J Econom. 1977;6:21-37.
3. Banda PK, Tembo S. A study on mobile penetration rate in a multi-simming environment: The case of Zambia. Microecon Macroecon. 2016;4:37-345.
4. Deller SC, Nelson CH. Measuring the economic efficiency of producing rural road services. Am J Agric Econ. 1991;73:194-201.
5. Joshi PK, Singh NP, Singh NN, Gerpacio RV, Pingali PL. Maize in India: production systems, constraints, and research priorities. Mexico, D.F.: CIMMYT; c2005.
6. Kalirajan KC, Flinn JM. The measurement of farm-specific technical efficiency. Pak J Appl Econ. 1983;2:256-275.
7. Maddala GS, Lahiri K. Introduction to econometrics. 4th ed. New York: John Wiley & Sons; c2009. ISBN 0470015128.
8. Pitt MM, Lee LF. Measurement and sources of technical inefficiency in the Indonesian weaving industry. J Dev Econ. 1981;9:43-64.
9. Ray SC. Data envelopment analysis: theory and techniques for economics and operations research. 1st ed. New York: Cambridge University Press; c2004. ISBN 0521802563.
10. Ray D, Ramankutty N. Recent patterns of crop yield growth and stagnation. Nat Commun.; c2012.
11. Roco L, Bravo-Ureta BE, Engler A, Jara-Rojas R. The impact of climatic change adaptation on agricultural productivity in Central Chile: A stochastic production frontier approach. Sustainability. 2017;9:1648.
12. Shanmugam KR, Venkataramani A. Technical efficiency in agricultural production and its determinants: an exploratory study at the district level. Indian J Agric Econ. 2006;61(2):1-16.
13. Singh NP, Paramatma S, Suresh P. Estimation of economic efficiency of sugar industry in Uttar Pradesh: a frontier production function approach. Indian J Agric Econ. 2007;62(2):232-243.
14. Tavva S, Aw-Hassan A, Rizvi J. Technical efficiency of wheat farmers and options for minimizing yield gaps in Afghanistan. Outlook Agric. 2017;46(1):13-19.