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Analysis of Technical Efficiency of Rice Farmers under Farmer Producer Organisation (FPO) in Guntur District of Andhra Pradesh

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study investigated the Technical efficiency (TE) of rice farmers under Farmer Producer Organisation (FPO) in Guntur District of Andhra Pradesh using Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) from a sample size of 40 farmers. The results from DEA and SFA revealed that the mean TE of rice farmers was 98.7 per cent and 86 per cent respectively. The mean TE from DEA is indicating that they can reduce their input by 1.3 per cent to produce the same level of output and SFA revealed that the coefficients of seed (0.7543), urea (0.877), MOP (0.979) and machine hours (0.877) were positive and highly significant, implying that these inputs are productive enough whereas DAP (0.877), PPC (0.765) and human labour (0.988) were positive but non-significant implying that they are comparatively less productive. From the results of DEA and SFA, the mean efficiency of rice farmers through DEA (0.98) was more than SFA (0.86). The

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results from Garrett ranking revealed that price versatility, high input prices, lack of proper labour supply, lack of adequate capital and storage facilities etc., are the major constraints faced by rice farmers under FPO in Guntur district and they need to be strengthened.

Keywords: Farmer producer organisation; technical efficiency; data envelopment analysis; stochastic frontier analysis; garrett ranking technique.

1. INTRODUCTION

"Agriculture has always been a lifeline of the Indian economy, providing livelihood to millions of farmers. It contributes to 14.6 per cent of GDP (2018) and provides employment to above 56 per cent population of our country" [1]. Presently, Indian agricultural sector is facing various challenges like increasing population, small and fragmented land holdings result in declining agricultural land availability, urbanization and industrialization etc., To overcome these challenges there are various alternatives, but one of the potential alternatives is Farmer Producer Organization (FPO). Both Central and State governments are stressing on promoting FPOs as an important strategy for creating an ecosystem for enhancing farmers' profits [2]. "These FPOs helps in efficient farming, information sharing, delivery of inputs, marketing and profit making by mobilizing farmers for group action, that are useful to take collective decisions for income enhancement through agricultural development at the local level. The farmers' producer organizations and producer companies were very much beneficial to improve the value chain of agricultural produce and thereby proved to be in getting good prices for their produce" [3].

A total of 147 FPOs are functional in Andhra Pradesh and majority of these i.e.,24 is present in Guntur district (DRDA office, Guntur). For effective production and marketing of rice, one FPO is functional in Guntur district and was selected for the study. As rice is one of the major and staple crops, it is cultivated in India in an area of 457.6 lakh hectares, with annual production of about 1243 lakh tonnes and its productivity of about 2717 kg/ha [4]. In Andhra Pradesh, rice is cultivated in an area of 25.52 lakh hectares, annual production of 130.89 lakh tonnes and productivity of 5130 kg/ha. Guntur district was selected for the study as it stands 7th position in Andhra Pradesh regarding area, production and productivity of 25.52 lakh hectares, 130.89 lakh tonnes and 5130 kgs/ha respectively (Agriculture and Statistics at a Glance: Ministry of Agriculture & Farmers Welfare, GOI, 2021) [4].

"Rice being a staple food crop, increasing Technical Efficiency (TE) contributes to higher productivity of the farmers. However, TE is quite low for rice farmers in Andhra Pradesh due to inadequate supply of inputs, lack of financial support from government and high transaction cost. The government intervention was required to create a policy environment that would ensure a mutually beneficial relationship between the farmers and organized sector" [5]. Therefore, Government of Andhra Pradesh has introduced FPOs that helps in efficient farming, information sharing, delivery of inputs, marketing and profit making by mobilizing farmers for group action, that are useful to enhance the income of rice farmers at local level. so, to boost the technical efficiency of rice, FPO's are considered as one of the major support systems and hence it is prudent to conduct the study on "Analysis of technical efficiency of Rice farmers under Farmer Producer Organisation in Guntur District of Andhra Pradesh".

During the difficult times, when the world struggled under the COVID-19 pandemic, Farmer Producer Organisations (FPOs) helped farmers with provision of inputs, advisory and marketing services and income support to its' members. In this context, the Government of India puts greater emphasis on FPOs, as is evident from its various policy guidelines and recommendations for the states. But there was a significant gap in the potential of the Farmer Producer Organizations and its' progress [6]. It could be due to a lack of efficient business plans, more administrative controls, limited knowledge of the promoting institutions, lack of adequate infrastructure etc. [7,8]. It was observed that FPOs faced many threats, such as increased competition from existing private companies, lack of self-sustainability, and more administrative controls by the CEOs offer less opportunity to expand their business activities and lack of professional expertise and low involvement of the members as major weakness of FPOs [9]. In this background Garrett Ranking was used to study the constraints faced by the rice farmers under FPO in Guntur District of Andhra Pradesh and measures to strengthen them.

2. MATERIALS AND METHODS

In Andhra Pradesh, Guntur district was purposively selected for the study as it consists of highest number of FPOs and one functional FPO dealing with effective production and marketing of rice with the objective of adequate and timely supply of inputs, forward and backward linkages, market access, better information sharing etc. was selected for the study. Primary data was collected through pre-structured schedules whereas Secondary data was collected from directorate of economics and statistics regarding area, production and productivity of the study area. Data was collected from a sample of 40 farmers using simple random sampling design in the study area.

2.1 Data Envelop Analysis (DEA)

DEA was used to estimate the efficiencies of the selected farmers (Technical, Allocative and Economic efficiencies). The DEA methodology assists with various outputs and inputs in the production process. The methodology behind efficiency measurement begins with the work of Farrell (1957). Farrell introduced the notion of relative efficiency in which the efficiency of a particular Decision-Making Unit (DMU) (Rice fields in the present study) may be compared with another DMU within a given group.

DEA is a non-parametric approach, was first introduced by Charnes et al. [10]. DEA has several advantages: it can handle multiple outputs and inputs, as well as it can handle single output and multiple inputs or single output and single input. In the present study, DEA model is carried as input-oriented model and with Variable Returns to Scale (VRS). DEA was carried out using DEAP version 2.1 [11] which generates the technical, economic and allocative efficiencies.

2.1.1 DEA model for estimation of technical efficiency

Suppose there are 'n' homogenous Decision-Making Units (DMUs) and in order to produce 'r' number of outputs (r=1,2,3…. k) 's' number of inputs are utilized (s=1,2,3…m) by each DMU, i (i=1,2,3…n). Assume also that the input and output vectors of i^{th} DMU are represented by xi and yi respectively and the data for all DMUs be denoted by the input matrix (X) m*n and output matrix (Y) k*n. The DEA model for variable returns to scale (VRS) which was developed by Banker, Charnes and Cooper (BCC) [12] was used. The input minimisation process to measure technical efficiency for each DMU could be expressed as equation

$$min\theta,\ \lambda\phi \text{ Subject to } -yi+Y\lambda\leq 0$$
$$\phi xj+X\lambda\geq 0$$
$$N1\lambda=1$$
$$\lambda\geq 0$$

Where, N = no. of Decision-Making Units.
k = inputs, m = outputs.
xi and yi = input and output vectors respectively for ith DMU.
λ = N x 1 vector of weights, of ith DMU.
ϕ = TE score, $0 \leq \phi \leq 1$.

Min, λ, xi* wi' xi*
Subject to -yi + Yλ ≥ 0,

xi* - Xλ ≥ 0 N1'λ =1
λ ≥ 0,

where, wi is vector of input price of firm and xi* is the cost-minimizing vector of input bundles of i^{th} farm, given the input price wi and the output levels yi.

where,

Y = Yield of rice (kg/ha), X1 = Quantity of seed (kg/ha), X2 = Quantity of Urea (kg/ha), X3 = Quantity of DAP (kg/ha), X4 = Quantity of MOP (kg/ha), X5 = Quantity of Plant protection chemical applied (kg/ha), X6 = Machine Labour (hrs/ha), X7 = working days of employed labour (man-days/ha)

2.1.2 Technical efficiency (TE)

Technical efficiency (TE) measures the ability of a DMU to produce the maximum feasible output from a given bundle of inputs (output oriented).

2.1.3 Estimation of Economic efficiency (EE)

Economic efficiency is the ratio between minimum cost and observed cost.

Economic Efficiency = minimum cost/observed cost

2.1.4 Estimation of Allocative efficiency (AE)

Allocative Efficiency was obtained by dividing economic efficiency with technical efficiency.
Allocative Efficiency = Economic Efficiency / Technical Efficiency

2.2 Stochastic Frontier Analysis (SFA)

The present study uses the stochastic frontier production function approach was used to measure the technical efficiency of rice farmers. frontier production function can be defined as the maximum feasible or potential output that can be produced by a firm with a given level of inputs and technology.

Variables are the same for both DEA and SFA for measuring the technical efficiencies of rice farmers under FPO in Guntur District of Andhra Pradesh.

The general specification of the frontier production function considered is defined by

ln(Yi) = β0+ β1 ln (X1i) + β2 ln (X2i) + β3ln (X 3i) + β4 ln (X4i) + Vi-Ui

2.3 Garrett Ranking

Garett Ranking technique was applied to study the constraints faced by the rice farmers under FPO in accessing inputs, information, adoption of new technology, linkages etc.,

The major advantage of this technique as compared to simple frequency distribution is that here constraints are arranged based on their importance from the point of view of respondents.

Garrett's formula for converting ranks into percent

$$Percent\ position\ = \frac{100(Rij - 0.5)}{Nj}$$

Where,

Rij = Rank given for i^{th} constraint by j^{th} respondent.

Nj = Number of items constraints ranked by j^{th} respondent.

The per cent position of each rank was converted to scores by referring to tables given by Garret and Woodworth [13]. Then for each factor, the scores of individual respondents were summed up and divided by the total number of respondents. The mean scores for all the factors were ranked.

3. RESULTS AND DISCUSSION

3.1 Data Envelopment Analysis (DEA)

From Table 1 of descriptive statistics analysis the estimated average output per farmer is 5535.5 kg/ha. On an average, 53.16 kg/ha of seed, 236.9 kg/ha of urea, 189 kg/ha of DAP, 165.5kg/ha of MOP, 3.6125 lit/ha of PPC, 16.18 hr/ha of machine hours, and lastly man days of about 113.345 are used as inputs per farmer.

From Table 2, we can summarize the mean TE of rice farmers is 98.7 percent. This means the rice farmers can reduce their input by 1.3 per cent to produce the same level of output. 65 per cent of the farmers are fully efficient and they are not using excessive amount of fertilizers. 35 per cent of the farmers are highly technically efficient and they are using only 0.1-0.01 per cent of excessive amount of fertilizers. The mean Allocative Efficiency (AE) of rice farmers is 81.8 per cent which indicate that the farmers should allocate their inputs in more efficient way at a given cost and can reduce the cost of inputs by 18.2 per cent to meet the same level output. Majority of the farmers (40 per cent) are utilising high priced inputs to produce same level of output. Hence, they have to allocate resources properly to reduce input costs to produce same level of output. The mean Economic Efficiency (EE) of rice farmers is 80.8 per cent which implies that the farmers should reduce the cost of production by 19.2 per cent to produce the same level of output. Majority of farmers (32.5per cent) employs more costs to produce same level of outputs which leads to increase in cost of cultivation.

3.2 Stochastic Frontier Analysis (SFA)

From Table 3, the estimated values of the coefficients of seed (0.75), Machine hours (0.88) and Urea (0.87) were positive and highly significant at 1 per cent and 5 per cent level of significance respectively. It implies that seed, Machine hours and Urea were important contributors to technical efficiency of rice cultivation. Sigma-squared is significant which indicates the appropriateness of the model and it satisfies distributional assumptions of the error term. Gamma value was 0.77 means 77 per cent of variations in rice output was attributed to variations in technical efficiencies of farmers. Log likelihood value was 0.64 per cent which indicates the goodness of fit, that is higher the value, better the model. It lies between -α to +α.

Table 1. Summary statistics of inputs and output

Variables	Mean	Standard deviation	Maximum	Minimum
Output				
Yield (kg/ha)	5535.5	785.7895	7125	4375
Input				
Seed (kg/ha)	53.16	3.296603	62	50
Urea (kg/ha)	236.7375	31.5593	351.25	182.5
DAP (kg/ha)	189	34.48011	263.75	130
MOP (kg/ha)	165.593	17.20211	195	120
PPC (lit/ha)	3.6125	0.849113	5.25	2.5
Machine hours (hr/ha)	16.1875	6.638261	28.75	5
Man days	113.345	28.0823	173.3	63.8

Table 2. Frequency distribution and percentage of Technical, Allocative and Economic efficiencies of Rice farmers under FPO in Guntur district of Andhra Pradesh

DEA score	Technical efficiency		Allocative efficiency		Economic efficiency	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	26	65	2	5	2	5
0.9-0.99	14	35	8	20	8	20
0.8-0.89	0	0	16	40	8	20
0.7-0.79	0	0	6	15	13	32.5
<0.69	0	0	8	20	9	22.5
SUM	40	100	40	100	40	100
Maximum	1		1		1	
Minimum	0.917		0.578		0.561	
Mean	**0.987**		**0.818**		**0.808**	

Table 3. Results from stochastic frontier analysis

Variables	Coefficient	Standard Error	t-ratio
Constant	0.99	0.42	2.34
Seed	0.75**	0.24	3.12
Urea	0.87*	0.37	2.34
DAP	0.87	0.71	1.23
MOP	0.98	0.57	1.75
PPC	0.77	0.53	1.43
Machine hours	0.88**	0.19	4.57
Human labour	0.99	0.42	2.35
Sigma-squared	0.17*	0.07	2.46
gamma	0.77*	0.33	2.30

*Note: ** and * Significant at 1% and 5% level of significance respectively*

From Table 4, it is summarized that the mean TE of all farmers was 86 per cent, implying that on an average, the sample farmers tend to realize around 86 per cent of the technical potential in terms of rice production. The mean TE of all farmers was 86 per cent, implying that on an average, the sample farmers tend to realize around 86 per cent of the technical potential in terms of rice yield. Hence, on an average, approximately 14 per cent of technical yield potential was not realized. That means farmers are using 14 per cent of excessive inputs, that can be reduced to produce the same level of output. Therefore, it may be possible to improve the yield of rice crop by 14 per cent. Majority of the farmers 35 per cent operated at TE levels between 61 to 65 per cent. Only about 12.5 per cent of the rice farmers were found between 81 to 85 per cent of the TE level. About 7.5 per cent and 5 per cent of sample farmers were operating closer to frontier with the TE of above 91 per cent and above as they are using inputs efficiently. Hence, a majority the sample rice farmers were found to be with lesser technical inefficiencies which could be mainly attributed to their efficient use of the resources.

Table 4. Distribution of sample farmers under different levels of technical efficiency

Technical efficiency (%)	No. farmers	% total
61-65	15	37.5
66-70	4	10
71-75	2	5
76-80	6	15
81-85	5	12.5
86-90	3	7.5
91-95	3	7.5
>95	2	5
Total farmers	40	100
Mean efficiency (%)	**86%**	

Table 5. Comparing the results of both DEA and SFA

TE	DEA		SFA	
	Frequency	Percentage	Frequency	Percentage
60-65	0	0	15	37.5
66-70	0	0	4	10
71-75	0	0	2	5
76-80	0	0	6	15
81-85	0	0	5	12.5
86-90	0	0	3	7.5
91-95	3	7.5	3	7.5
>95	37	92.5	2	5
Total farmers	40	100	40	100
Mean	**0.987**		**0.86**	

Table 6. Ranking the constraints faced by the rice farmers under FPO

S. No.	Constraints	Total mean	Rank
1	Price versatility.	77.75	I
2	High input prices.	63.4	II
3	Lack of adequate capital.	51.15	III
4	Lack of proper labour supply.	49.5	IV
5	Lack of quality inputs.	41	V
6	Lack of information.	40.45	VI
7	Poor infrastructure facility.	40.25	VII

3.2.1 Comparison of both DEA and SFA

3.2.1.1 Technical efficiency results from both SFA and DEA

From Table 5, it is concluded that the comparative results of DEA and SFA showed that mean technical efficiency score obtained from the DEA was higher than SFA result. Highest score obtained from DEA model with a score of (0.987) and SFA (0.86). DEA is explaining more variability in terms of technical efficiency than SFA.

3.3 Garrett Ranking Technique

From Table 6 mentions the constraints faced by rice farmers under FPO in Guntur District of Andhra Pradesh according to the Garrett mean score. it was found that respondents faced problems like Price versatility (77.75), High input prices (63.4), Lack of adequate capital (51.15), Lack of proper labour supply (49.5), Lack of quality inputs (41), Lack of information (40.45), Poor infrastructure facility (40.25).

4. CONCLUSION AND SUGGESTIONS

The results of the present study concluded that the mean technical and economic efficiencies obtained from the DEA was better than the result obtained from SFA, as DEA efficiency scores have greater variability than the SFA measures. Johansson, H. [14] concluded through his study on entire dairy that DEA is more appropriate to

use since it does not require any particular parametric form to be chosen. The results obtained by using DEA were 0.98,0.81 and 0.80 for technical, allocative and economic efficiency of rice farmers respectively. The results revealed by using SFA that the coefficients of seed (0.7543), urea (0.877), MOP (0.979) and machine hours (0.877) were positive and highly significant, implying these inputs are productive enough for boosting rice production. DAP (0.877), PPC (0.765) and human labour (0.988) were positive but non-significant implying that they are comparatively less productive in contributing to profit. By Comparing both DEA and SFA for technical efficiencies of paddy farmers, the results obtained shows that mean efficiency of rice farmers through DEA (0.98) was more than the mean efficiency of rice farmers through SFA (0.86).

Major constraints faced by sample FPO farmers in Guntur district are price versatility, high input prices, lack of proper labour supply, lack of adequate capital and storage facilities etc., so, efforts should be made to strengthen backward and forward linkages so as to gain access to input and output markets, strengthen market infrastructure, financial management of FPO etc., Deepa et al. [15] in their study found that the key strength of the FPOs was to prevent the intermediaries from taking away the largest share in marketing channel. Rythu Bharosa Kendras (RBK's) acts as a best alternative after FPOs as they facilitate interaction between farmers, agriculture scientists, and agriculture extension officers right at the village level and also facilitates better market prices and information.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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