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A STUDY ON TECHNICAL EFFICIENCY OF RICE PRODUCTION IN INDIA – DEA

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Abstract

Rice is the chief grains and a pre-eminent crop of India. India has the largest area under rice cultivation; it flourishes comfortably in hot and humid climate. This paper analyses the efficiency of rice production in India using DEA. Data envelopment analysis is a non-parametric technique used to evaluate technical efficiencies of "Decision Making Units" (DMU). The secondary data used in this study is obtained from the Agriculture Statistics at a Glance. The sample consists of 24 states covering all over India during 2014-2015. Each state is considered as a DMU and each DMU includes two inputs namely area and irrigations and two outputs namely production and yield. The result reveals that 12 states are efficient and 12 states are inefficient. Peer group or the reference set for each inefficient DMUs are presented. Finally, all the efficient states are ranked based on peer count summary. Tamil Nadu stood first in ranking, West Bengal and Jharkhand shares the second rank and so on.

Keywords:

Banker Charnes Cooper (BCC);

Data Envelopment Analysis (DEA);

Making Units (DMU);

Variable Returns to Scale (VRS).

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1. Introduction

India is one of the **world's largest producers** of Rice. Rice is the chief grains and a pre-eminent crop of India. Moreover, it is the staple food of the people of the eastern and southern parts of the country. India has the largest area under rice cultivation, since it is one of the principal food crops and being a tropical plant, it flourishes comfortably in hot and humid climate. Rice is mainly grown in rain fed areas which receive heavy annual rainfall. Rice is fundamentally called as a kharif crop of India. It demands temperature of around 25 degrees Celsius and above and rainfall of more than 100 cm. Rice is also grown through irrigation in the areas which receives comparatively less rainfall.

In India, rice can be cultivated by different methods based on the type of region. Here the traditional methods were used for harvesting rice. Initially the fields are ploughed and the fertilizer which consists of cow dung is applied and the field is made smoothened. The seeds are transplanted by hand and through proper irrigation, they are cultivated. Rice grows on a different variety of soils like silts, loams and gravels. It can also grow in alkaline as well as acid soils. However, clayey loam is mostly suited for raising this crop. Clayey soil is converted into mud in which rice seedlings can be transplanted easily. Proper care has to be taken because if the soil remains wet, this crop will thrive. Rice fields should be leveled and should have low mud walls for retaining water. However, in the plain areas, excess rainwater can inundate the rice fields and flow slowly. Rice raised in the well-watered lowland areas is called as lowland or wet rice. Whereas in the hilly areas, slopes are cut into terraces for the cultivation of rice. Thus, the rice grown in the hilly areas is called as dry or upland rice. The yield of upland rice is comparatively less than that of the wet rice. During summer season, almost all parts of India are suitable for raising rice provided that if the water is available.

Data envelopment analysis is a non-parametric technique, and a mathematical programming method based on a sequence of simple linear programs. It is a “data-oriented” approach used to evaluate technical efficiencies of “Decision Making Units” (DMU). Decision making units are similar type of organizations which consumes identical inputs and produces identical outputs. It includes both service sectors and production sectors. Business firms, Government agencies, Hospitals, Banks, Schools, and Industries etc., are few categories which come under decision

making units. DEA is a quantitative and analytical technique used for measuring and evaluating performance of decision making units with multiple-input and multiple-outputs. The basic DEA models are suggested by Charnes et al. (1978). A DEA model is either be defined as input-oriented or output-oriented techniques. Input-oriented means minimizing inputs while maintaining the same level of outputs whereas output-oriented is increasing outputs with the same level of inputs.

It may be needed to measure the efficiency of rice production in different states of India. This study is used to identify the factors which causes inefficiency and helps us to find the suitable ways to improve their efficiency.

To serve the above purpose, Data envelopment analysis DEA – A non-parametric method is used to calculate the technical efficiency of Rice production. The rest of the paper is organized as follows: A brief Review of Literature is presented in Section 2, Data Structure and Methodology adopted in the study is given in Section 3, Section 4 carries Empirical Investigations, Results and Conclusions are highlighted in Section 5.

2. Review of Literature

Farrel, M.J. (1957) developed the basic measure of efficiency in case of single input and single output. A.Charnes, W.W Cooper, E. Rhodes (1978), proposed the efficiency of decision - making units which is defined as the maximum of a ratio of weighted outputs to weighted inputs subject to the conditions that the same ratio for all DMUs must be less than or equal to one. It is based on the assumption of constant returns to scale. R.D.Banker, A.Charnes, W.W.Cooper (1984) extended the CCR model and proposed a new model for estimating pure technical efficiency of decision making units with reference to efficient frontier and this model admits variable returns to scale. J.Johnes (2006), measuring the efficiency of higher education institutions from UK universities through Data envelopment analysis (DEA). Tone Kaoru (2001), applied a slacks-based measure of efficiency in DEA and states that this measure has a close connection to BCC for measuring the efficiency. Bassam Aldeseit (2013) evaluates the performance of sample dairy farms using farm level technical and scale input oriented efficiencies. The results revealed that

the sampled farms were not operating at an optimal size. To increase scale of operation dairy farmers in Jordan should increase the overall degree of technical efficiency. Carr et al. (2007) and Dall et al. (2014), applied DEA in the usage of rural and urban land and evaluated its economic benefit, further this study helps to reduce the inputs that are not significant and use proper quantity of inputs for sustainable production. Elena Tomaa, Carina Dobrea, Ion Donaa, Elena Cofasa (2015), applied DEA for the assessment of agriculture efficiency on areas with similar geographically patterns. This research shows that there exist clear differences of performance between areas with similar geographical characteristics in terms of production factors (work, land and mechanization) and allocation of outputs. Mostafa Mardani, Mashallah Salarpour (2015) measures the technical efficiency of potato production in Iran using robust data envelopment analysis. This study suggests that inefficient Provinces can reduce the overall costs of potato production. R.P Sreedevi (2016) compares the technical efficiency and efficiency differences among 19 Minority Institutions under JNTUH of Telangana in India using DEA. This measure identifies the functions that improves the quality of education and brings improvement in the system.

3. Data Structure and Methodology

The secondary data used in this study is obtained from the Agriculture statistics at a Glance. The sample consists of 24 states covering all over India. The study relates to a period of 2014 – 2015 and the data provides statistical information for assessing and evaluating the performance of production of rice in various states in India. Each state is considered as a DMU and each DMU includes two inputs namely area and irrigations and two outputs namely production and yield. To add statistical flavor in this study few basic statistical measures in respect of inputs and outputs are calculated and the same is presented in the following table.

Table 1. Descriptive statistics

	Mean	**Std Deviation**	**Min**	**Max**	**N**
OP 1	3.56	4.027	0	15	24
OP 2	2144.46	644.635	971	3191	24

IP 1	1.60	1.757	0	6	24
IP 2	28.54	18.734	4	76	24

All the 24 states on an average used 1.60-million-hectare area and 28.54 % irrigation, produced average of 3.56 million tonnes of rice.

Output oriented BCC model

Banker, Charnes and Cooper (1984), introduce this model which measures the technical efficiency as the convexity constraint. In our study, we use BCC output oriented model.

Max φ

s.t $\mathbf{Y\lambda \geq \varphi Y_0}$

$\mathbf{X\lambda \leq X_0}$

$\mathbf{\sum \lambda_i = 1}$

$\mathbf{\lambda \geq 0,}$

where **φ** = efficiency measure

X = (X_1 X_2.... X_n) is the vector of inputs,

Y = (Y_1 Y_2.... Y_m) is the vector ofoutputs,

λ = (λ_1 λ_2.... λ_N) is the vector of weights,

Y_0 is the output of the observed DMU,

X_0 is the input of the observed DMU,

N is the no of DMUs.

Solving the above problem, we get the efficiency scores and peer weights for each DMU.

4. Empirical Investigations

Efficiency measurements and peers, peer weights are present in table (2).

Table 2. Efficiency measurements and Peers

S.NO	DMU	VRS-TE	PEER WEIGHT
1.	ANDHRA PRADESH	1.000	λ_1 =1.000
2.	ARUNACHAL PRADESH	1.038	λ_{15} = 0.393 λ_{16} = 0.217 λ_{17} = 0.391
3.	ASSAM	1.000	λ_3 =1.000
4.	BIHAR	1.5082	λ_9 = 0.175 λ_{20} = 0.347 λ_{24} = 0.478
5.	CHATTISGARH	1.379	λ_3 = 0.630 λ_{24} = 0.370
6.	GUJARAT	2.5839	λ_9 = 0.194 λ_{20} = 0.806
7.	HIMACHAL PRADESH	2.293	λ_{15}= 0.264 λ_{16} = 0.291 λ_{17} = 0.445 λ_{20} = 0.000
8.	JAMMU & KASHMIR	2.906	λ_{20} = 0.216 λ_{21} = 0.784
9.	JHARKHAND	1.000	λ_9 = 1.000
10.	KARNATAKA	1.164	λ_9 = 0.501 λ_{20} = 0.499
11.	KERALA	1.000	λ_{11}= 1.000
12.	MADHYA PRADESH	1.838	λ_1= 0.539 λ_{20} = 0.447 λ_{24} = 0.014
13.	MAHARASHTRA	1.597	λ_1 = 0.324 λ_9 = 0.635 λ_{20} = 0.040
14.	MANIPUR	1.848	λ_9 = 0.013 λ_{15}= 0.272 λ_{17}= 0.169 λ_{21}= 0.546
15.	MEGHALAYA	1.000	λ_{15} = 1.000
16.	MIZORAM	1.000	λ_{16} = 1.000
17.	NAGALAND	1.000	λ_{17} = 1.000
18.	ODISHA	1.046	λ_3= 0.634 λ_{24} = 0.366
19.	SIKKIM	1.000	λ_{19} = 1.000
20.	TAMIL NADU	1.000	λ_{20} = 1.000
21.	TRIPURA	1.000	λ_{21} = 1.000
22.	UTTAR PRADESH	1.206	λ_{22}= 1.000
23.	UTTARKHAND	1.2562	λ_{11} = 0.062 λ_{20} = 0.003 λ_{21} = 0.935 λ_{24} = 1.000
24.	WEST BENGAL	1.000	λ_{24}= 1.000

A DMU is said to be efficient and it lies on efficiency frontier if $\varphi = 1$, $\lambda_i = 1$ and $\lambda_j = 0$; $j \neq i$
In this study 12 states (DMUs) which lie on the efficiency frontier are considered to be efficient. and 12 states (DMUs) which lie below the frontier are inefficient. The most inefficient states in production of rice are Gujarat and Jammu and Kashmir with the efficiency scores of φ = 2.58 and φ = 2.906 respectively. The reference set based on peers for the inefficient DMUs could be formed from the non-zero lambda values.

Peer count summary and ranking of DMUs is presented in the following table.

Table 3. Peer count and Rankings

DMU	**PEER COUNT**	**RANK**
ANDHRA PRADESH	2	4
ASSAM	2	4
JHARKHAND	5	2
KERALA	1	5
MEGHALAYA	3	3
MIZORAM	2	4
NAGALAND	3	3
TAMIL NADU	8	1
TRIPURA	3	3
WEST BENGAL	5	2

From the above table, it may be observed that the state Tamil Nadu stood first in ranking because it act as a peer for 8 inefficient DMUs. West Bengal and Jharkhand stood second and so on.

In setting benchmarking goals, DEA calculates slack that specify the amount by which an input or output must be improved for the unit to become efficient. The inefficient DMU 6 (GUJARAT) should produce 158% output more than its current output level to become efficient.

5. Results and Conclusions

Under VRS model it is identified that 12 states are efficient and 12 states are inefficient as a set of 24 states considered in this study. it is observed that few efficient states are acting as peer to many inefficient states. Peer group known as reference set provides input and output targets to the inefficient DMUs for improving their efficiency.

Ranking procedure has been carried out based on peer counts. Tamil Nadu stood rank 1, West Bengal and Jharkhand shares the rank 2 and so on. Out of these states Gujarat and Jammu and Kashmir are the most inefficient DMU's.

To implement benchmarking, the management can evaluate the operations of the peer group units to determine what changes in inefficient states can be made to make them efficient.

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