Technical Efficiency and It's Determinants of Rice Production: Evidence from Data Envelopment Analysis (DEA)

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ABSTRACT *This paper estimates the Technical Efficiency (TE) of rice in India considering state level panel data for 1970-71 to 2013-14 and taking into account the effect of different infrastructural, institutional, economic and demographic factors. TE is estimated by nonparametric approach of Data Envelopment Analysis (DEA) using output oriented measure and using single- output multiple- input frameworks. An increase in TE of rice over the sample period is evident. That is efficiency of rice has increased in the period of second generation reforms. A second stage panel regression suggests that nonlinear relationship with TE for some of the explanatory variables in case of rice. The major variables, which have positive and statistically significant relationship with TE, are rainfall, government irrigation, government expenditure on agricultural research and extension, agricultural loan, rural literacy and share of HYV. The inequality in the distribution of operational land holding negatively influences the TE for rice.*

Keywords: *Technical Efficiency, Indian Agricultural Sector, Data Envelopment Analysis (DEA).*

1. Introduction:

Agriculture is a very important sector in India. In case of rural India, nearly 70% of the population depends on income from agriculture. Seventy five percent of all rural poor are in households that are dependent on agriculture. The measurement of efficiency and find out its determinants involves a number of issues like the effect of rainfall, irrigation, literacy rate, feed management activity, cropping diversity, openness, etc. These points have been taken up in a number of studies made earlier in the global context as well as in Indian context [**Mythili and Shanmugam (2000)**; **Shanmugam (2002)**; **Sengupta (2000)**; **Kumar, Srinivas and Singh (2006)**;**Sengupta and Kundu (2006)** ; **Ray and Ghose (2014)**; etc.]. The perusal of the literature on efficiency in Indian agriculture suggests that all the studies have used either farm level data on agriculture for a specific region and year or used data on total food grains and non food grains production. Thus crop specific and state-wise study is lacking in the literature. So the present study has taken this point into consideration and has done crop-specific and state-wise analysis on Indian Agriculture. ***Thus the objective of the present study is to estimate the extent of inefficiency by using DEA approach and measure the effect of different infrastructural, institutional, and demographic factors on the output-efficiency of Rice in Indian agriculture. The justification for considering Rice is as follows: India is the major producer of rice in the world.***

2. Methodology and Data Sources:

Technical efficiencies (TE) can either be Input oriented or Output oriented. In case of output-oriented measure the TE of a firm can be computed by comparing its actual output with the maximum producible quantity from its observed inputs i.e. by how much can output quantities be proportionally expanded without altering the inputs quantities used. In input oriented measure, the TE of a firm can be measured by comparing its actual input in use with the minimum input that would produce the targeted output level i.e. by how much can input quantities be proportionally reduced without changing the actual output bundle .The paper uses the concept of output-oriented TE of non-parametric DEA approach following Banker, Charnes, and Cooper (1984). The output-oriented TE is estimated by using state level panel data from 1970-71 to 2013-14 in a single-output, multi-input model. The inputs included are: (i) Land; (ii) Labor; (iii)Fertilizers; (iv) Irrigated Area; (v) Diesel Engine; (vi) Electric Engine; (vii) Tractors, and (viii) Electricity used in the agriculture. In case of Rice Eleven major Rice producing States has been considered which are Andhra Pradesh(AP), Assam(AS), Bihar(BI), Haryana(HA), Karnataka(KA), Madhya Pradesh(MP), Orissa(OR), Punjab(PU), Tamil Nadu(TN), Uttar Pradesh(UP), and West Bengal(WB).

In order to find-out the factors influencing TE, this study uses different infrastructural, institutional, and demographic factors as the determinants of the TE. These factors are HYV uses (HYV), Government irrigation (GI), Rainfall (RF), Government expenditure on agricultural education, research, and extension (E), Rural-literacy rate (RL), Agricultural Loan (AL) and Distribution of Land Holding (G).

Apart from these determinants this paper have also include time dummy to incorporate the progress in the efficiency over time. For this purpose 1970-71 is taken as the benchmark year. So D_1=1 for the year 1971-72 and 0 otherwise; similarly D_2=1 for 1972-73 and 0 otherwise and so on.

A panel regression analysis has been used while estimating the parameters. The model uses seemingly unrelated regression (SUR) type framework and adjusted for contemporaneous correlation (across units) and cross section heteroscedasticity.

All the Data has been collected from the different issues of Statistical Abstracts published by Central Statistical Organization (CSO) of India, Agricultural Statistics at a Glance, Cost of Cultivation data, different publication of Research Foundation of Economy and Political Weekly.

3. Empirical Result

TE in Rice Production:

The results of estimated output-efficiency in case of rice corresponding to four decades by using DEA approach are presented in the **Table 1.**

Among the 11 major rice producing states UP has the lowest efficiency level, i.e., 0.6341. This implies that rice production can be increased by 37% (approximately) by using the same inputs in case of UP. Although WB is the largest rice producing states the output-efficiency is around 68%. A notable feature is that between the years 1981 to 1990 the output-efficiency of rice in case of WB is the lowest among all the major rice producing states, i.e., 0.5929. However, in case of WB the output-efficiency has been increased significantly from 0.5929 for 1981-1990 to 0.7543 for the year 1991-200. In case of TN the efficiency is very low, i.e., 0.5563 for the year 1971-80 and this efficiency have been increased gradually to 0.9588 for the year 2001-2013, i.e. in the period of second generation reforms by the Government of India. For the year 1991-2000 the efficiency scare is low in case of MP and this is 0.6302.

If one considers all the states together the output-efficiency of rice is 0.8463 for the period 1971-2013. One notable result is that for most of the sates considered in this study the efficiency of rice has been fallen for the period 1981-1990 from the initial decade. However this efficiency has been increased from 0.8004 for the period 1981-1990 to 0.8431 for 1991-2000 and 0.9046 in case of 2001-2013.

The Factors Influencing TE of Rice:

From the results of Table 3 one can conclude that rainfall and agricultural loan have non linear effect on the output-efficiency of rice. For these variables there exists positive and significant effect on output-efficiency in the first stage but the higher stage these variables has reverse and significant impact implying that all these variables have a threshold limit. It is well known that too much rain can damage production of rice and hence it may decrease the efficiency. On the other hand agricultural loan may increase the efficiency in the first stage because by getting agricultural loan farmers may purchase the HYV seeds, electricity, modern inputs etc. but given the budget constraint disbursement of too much loan may adversely affect the supply (or availability) of other very crucial inputs like government-expenditure-on-research-and-extension and can have negative impact on TE. The role of government irrigation on the output-efficiency is positive and significant. Another finding is that Government-expenditure-on-agricultural-education-research-and-extension and rural-literacy has a positive and significant role on the efficiency because they provide more information about technical knowledge to the farmers. The role of HYV seeds is positive and statistically significant implying that after the green revolution the efficiency of rice have increased significantly. The coefficient of gini is negative and significant effect on output-efficiency in the first order polynomial and positive and significant in the second stage. So it can be concluded that this variable also has a threshold limit. The From the results it can be concluded that the output-efficiency of rice may increase if the policy of land reforms is implemented up-to a certain limit as distribution of land holding has a negative and statistically significant effect on the efficiency in the first stage but second order has a positive and significant role on efficiency. This result also supports the general theory of agency particularly in case of general and share tenancy literature.

From the Table 4 one can conclude that the net marginal effect of rainfall, government irrigation, government-expenditure-on-agricultural-research-and-extension, agricultural-loan, rural-literacy and HYV is positive implying that these determinants have positive role on the output-efficiency of rice. On the other hand gini of distribution of land holding have a negative role on the rice efficiency implying that too small land holding may decrease the efficiency of rice.

4. Conclusion:

Thus heavy dependence on the rainfall can be one of a main constrain to achieve the targeted efficiency level of rice in Indian agriculture. On the other hand effective size of land distribution may increase the efficiency. The Government intervention in irrigation and more expenditure-on-rural education, agricultural-extension-and-research may also increase the efficiency of rice in India.

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TABLE 1
Output Oriented TE Of Rice

	AP	AS	BI	HA	KA	MP	OR	PU	TN	UP	WB	Average of States
OVER ALL (197172 to 2013-14)	1.0000	1.0000	0.7226	1.0000	0.9978	0.8536	0.7563	0.8778	0.7902	0.6341	0.6766	0.8463
1971-80	1.0000	1.0000	0.6423	1.0000	0.9913	1.0000	0.9367	0.7464	0.5563	0.6511	0.6824	0.8370
1981-90	1.0000	1.0000	0.6386	1.0000	1.0000	0.7841	0.6535	0.8014	0.7316	0.6021	0.5929	0.8004
1991-2000	1.0000	1.0000	0.7223	1.0000	1.0000	0.6302	0.6515	0.9632	0.9139	0.6385	0.7543	0.8431
2001-2013	1.0000	1.0000	0.8871	1.0000	1.0000	1.0000	0.7836	1.0000	0.9588	0.6445	0.6766	0.9046

TABLE 2
Determinants of TE of Rice

Variable	Coefficient	t-Statistic	Variable	Coefficient	t-Statistic
C	0.673205	21.34340*	**T21**	0.040973	3.007617*
RF	0.157068	4.246592*	**T22**	0.038224	2.352906*
GI	0.234788	3.541720*	**T23**	0.009842	0.546328
E	0.001101	5.291439*	**T24**	0.004479	0.214509
AL	0.037874	5.720450*	**T25**	0.027107	1.722728***
RL	0.003016	6.533969*	**T26**	0.055394	3.832797*
G	-0.328081	-6.205721*	**T27**	0.076247	6.382045*
HYV	0.347396	6. 629972*	**T28**	0.066719	4.118825*
RF2	-0.029625	-3.741743*	**T29**	0.117488	7.239493*
AL2	-0.001861	-8.246785	**T30**	0.069100	4.091287*
G2	0.137888	4.315579*	**T31**	0.065634	4.553883*
T1	0.020643	7.530260*	**T32**	0.006798	0.563490
T2	0.041061	9.981169*	**T33**	0.025610	2.413719*
T3	0.032513	6.689743*	**T34**	0.036628	5.790663*
T4	0.002814	0.493160	**T35**	0.004510	6.820567*
T5	0.031204	4.830751*	**T36**	0.043637	7.607907*
T6	0.030185	3.958134*	**T37**	0.017710	4.920791*

T7	0.104510	7.880567*	**T38**	0.003148	5.834850*
T8	0.093637	8.260797*	**T39**	0.027754	6.643595*
T9	0.077710	7.092791*	**T40**	0.088407	4.711740*
T10	0.073148	6.334850*	**T41**	0.011033	5.422361*
T11	0.077754	7.164395*	**T42**	0.034656	4.543276*
T12	0.038407	2.871140*	Adjusted R-squared		
T13	0.051033	3.734261*			
T14	0.044656	3.255476*	0.89149		
T15	0.077599	5.776341*			
T16	0.123743	9.020249*			
T17	0.085802	6.641113*			
T18	0.065354	5.302804*			
T19	0.042426	3.682004*	F-statistic		780.879100*
T20	0.060634	4.988593*	Prob(F-statistic)		0.000000

***Significant at 1%; ** significant at 5%, *** significant at 10%**

TABLE3
Net Marginal Effects In Case Of Determinants of TE of Rice

VARIABLES	MARGINAL EFFECTS
RF	0.02741
GI	0.2347
E	0.0011
AL	0.01208
RL	0.0030
G	-0.1660
HYV	0.34739