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Technical Inefficiency in Rice Production and Its Relationship with Farm-Specific Socio-Economic Characteristics

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India is facing challenges to feed its growing population. It is estimated that about 260 million tonnes (MT) of foodgrains are to be produced annually by the year 2030 to meet the food requirements. Rice is one of the major foodgrain crops in India occupying 44.4 million ha. with a production of 84.9 MT. Inefficiency is the inability of the farmer to produce maximum possible output that can be produced by the resources available with him. The available evidence suggests that farmers in the developing countries fail to exploit full potential of a technology and/or make allocative errors (Tayler and Shonkwiler, 1986; Ali and Flinn, 1989; Kalirajan and Shand, 1989; Bravo-Ureta and Evenson, 1994; Banik, 1994; Shanmugam and Palanisami, 1994; Sharma and Datta, 1997; and Thomas and Sundaresan, 2000). Increasing the efficiency in production is one of the means through which output can be increased. It is a very important factor of productivity growth, especially in developing agricultural economies where resources are meager and opportunities for developing and adapting better technologies are less. Under these circumstances reducing the inefficiency is the best option to enhance productivity. An estimate on the extent of inefficiency can also help to decide whether to improve efficiency or to develop new technology to raise agricultural production.

The purpose of this paper is to contribute to the literature by quantifying technical inefficiency in rice production and investigating the influence of farm specific socio-economic characteristics on inefficiency.

METHODOLOGY

The present study was undertaken in the Sone canal command area of the State of Bihar. A sample of 270 farms comprising 207 marginal (< 1 hectare), 31 small (1-2 hectares), 22 semi-medium (2-4 hectares) and 10 medium (4-10 hectares) farms were selected from different locations of the canal command through stratified random sampling method. Data pertaining to the agricultural year 2001-2002 were collected through personal interview method.

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Technical inefficiency of the individual farm was estimated through stochastic frontier production function analysis. The specific stochastic frontier production function model estimated was

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + (V_i - U_i)$$

where

Y = Yield of rice in kg,
$\beta_0 \ldots \beta_9$ = parameters to be estimated,
X_1 = Land in hectares,
X_2 = Seed in kg,
X_3 = Human labour in man-days,
X_4 = Bullock labour in bullock pair days,
X_5 = Machine labour in hours,
X_6 = Supplemental irrigation in rupees,
X_7 = Fertilisers in kg,
X_8 = Plant protection chemicals in rupees,
X_9 = Manures in tonnes,

V_i = Random error having zero mean which is associated with random factors (e.g., measurement errors in production, weather etc.,) which are not under control of the farmer

U_i = One-sided inefficiency component.

This type of stochastic frontier was independently proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). The random errors, V_i , i = 1,2, …., were assumed to be independently and identically distributed as N $(0,\sigma_v^2)$ random variable, independent of U_i's which were assumed to be non-negative truncations of the N $(0, \sigma_u^2)$ distribution (i.e., half normal distribution).

Given the assumptions of the above stochastic frontier model, inference about the parameters of the model can be based on the maximum likelihood estimation because the standard regularity conditions hold. Aigner *et al.* (1977) suggested that the maximum likelihood estimates of the parameters of the model can be obtained in terms of the parameterisation $\sigma^2 + \sigma_v^2 \equiv \sigma_s^2$ and $\gamma = \sigma/\sigma_v$. Rather than using the non-negative parameter γ the parameterisation of Battese and Corra (1977) who replaced σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$ was utilised. The parameter γ must lie between 0 and 1. Technical inefficiency of an individual farm is defined as

Technical inefficiency = $1 - (\exp(-U_i))$.

$$= 1 - (Q_i / Q_i^*)$$

where Q_i^* is the maximum possible output.

To study the effect of socio-economic factors on inefficiency, the sample farms were grouped into various categories based on each factor. Then the average inefficiency of each group was worked out and compared. Analysis of variance was carried out to know whether various groups differ significantly in their inefficiency levels or not. Besides this correlation analysis was also carried out to know the relationship. Correlation coefficients between inefficiency and socio-economic variables were worked out and tested for their significance using t-ratios. Various factors studied were farm size, age of the farmer, experience of the farmer in crop production, education of the farmer, contacts of the farmer with extension agencies,

number of family members working on the farm, location of the farm in the canal command, fragmentation of the land, percentage of good land in the farm and caste of the farmer.

RESULTS

The estimated coefficients of frontier production function are given in Table 1. All independent variables considered have positive coefficients except human labour. Area, fertilisers, plant protection chemicals, bullock labour and machine labour were positively significant. These positive and significant values indicate that there is scope for increasing production of rice by increasing the level of these inputs. Coefficient value of human labour was -0.2055, which was significant at 5 per cent level. This gives an indication that farmers are using excess human labour in rice production. Easy availability of human labour especially family labour may be the reason for using higher doses of human labour than required. The sum of the estimated coefficients of independent variables (Σb_i) was 1.0405. Gamma value was found to be 0.8336 indicating the presence as well as dominance of inefficiency effect over random error.

TABLE 1. COEFFICIENTS OF STOCHASTIC FRONTIER PRODUCTION FUNCTION FOR RICE

Variable (1)	Coefficient (2)	Standard error (3)
Intercept	8.7216	0.7642
Area	0.9358**	0.1669
Seed	0.1411	0.1166
Fertilisers	0.0249**	0.0056
Plant protection chemicals	0.0109**	0.0041
Irrigation charges	0.0022	0.0039
Human labour	-0.2055*	0.1036
Bullock labour	0.0572*	0.0222
Machine labour	0.0173**	0.0063
Manures	0.0566	0.0635
Σ bi	1.0405	
Sigma squared	0.1974	0.0305
Gamma	0.8336	0.0705
Log-likelihood function	-55.5472	

** and * Significant at 1 and 5 per cent level, respectively.

Technical Inefficiency

Table 2 depicts the values of technical inefficiency in rice production as well as distribution of farms based on technical inefficiency. Technical inefficiency of sample farms ranged between 6.67 and 66.42 per cent with an average of 25.55 per cent. The analysis indicates the scope to increase physical production of rice by 25.55 per cent with the judicious use of existing resources and technology.

The highest number of farms (91) was found in 10-20 per cent class followed by 20-30 per cent class (70) and 30-40 per cent class (48). Thus technical inefficiency of

bulk of the farms (209) ranged between 10 and 40 per cent. Only 24 farms recorded less than 10 per cent and 37 farms recorded more than 40 per cent technical inefficiency in rice production. This analysis clearly indicates that most of the farms are technically inefficient in rice production.

TABLE 2. DISTRIBUTION OF SAMPLE FARMS BASED ON TECHNICAL INEFFICIENCY IN RICE PRODUCTION

Technical inefficiency (per cent) (1)	Number of farms (2)	Percentage (3)
0-10	24	8.89
10-20	91	33.70
20-30	70	25.93
30-40	48	17.78
40-50	20	7.41
50-60	12	4.44
60-70	5	1.85
>70	0	0.00
Total	270	100.00
Average		25.55
Maximum		66.42
Minimum		6.67

Role of Socio-Economic Factors

The effect of each factor on technical inefficiency is given in Table 3 and Table 4 presents the results of correlation analysis.

1. *Farm Size*

Technical inefficiency in rice production decreased with increase in farm size. The average technical inefficiency was highest in marginal farms (27.28 per cent) followed by small farms (22.05 per cent). Minimum average and technical inefficiency was observed in medium group. Analysis of variance revealed that the difference in technical inefficiency among various size-groups was significant at one per cent level. Negative correlation coefficient between farm size and technical inefficiency also indicates that as farm size increases inefficiency will reduce. This result clearly indicates that bigger farms provide opportunity for better utilisation of inputs and machinery making them more efficient. The marginal and small farms whose farm size is less than 2 hectares dominate the study area. As there is no scope to increase farm size as such, co-operative type of farming, where farmers bring their resources together including land should be encouraged to increase the farm size.

2. *Age of the Farmer*

To study the effect of age, the farmers were grouped into four categories, i.e., below 40 years, 40-50 years, 50-60 years and above 60 years and their average technical inefficiency was compared. The farmers belonging to age group 40-50 years

TABLE 3. INFLUENCE OF SOCIO-ECONOMIC FACTORS ON TECHNICAL INEFFICIENCY

Particulars (1)	Technical inefficiency (2)	Particulars (1)	Technical inefficiency (2)
1. Farm size		6. Location	
Marginal	27.28	Head-reach	26.10
Small	22.05	Middle-reach	24.43
Semi-medium	19.62	Tail-reach	26.11
Medium	13.62	F-value	0.4885
F-value	6.6145**		
2. Age		7. Caste	
< 40 years	23.28	Lower	25.62
40-50 years	22.48	Higher	25.52
50-60 years	29.48	F-value	1.6181
> 60 years	31.53		
F-value	7.1075**		
3. Education		8. Fragmentation of land	
Illiterate	27.52	Low	20.26
Primary	28.87	Medium	27.89
Secondary	24.78	High	29.89
College	23.16	Very high	31.88
F-value	2.6578*	F-value	3.4715**
4. Experience		9. Number of farm workers	
< 5 years	23.25	1--2	25.56
5-10 years	22.91	3--4	25.29
10-15 years	25.89	5 and above	26.77
> 15 years	30.29	F-value	2.0978
F-value	3.7667**	10. Percentage of good land	
5. Extension contacts		< 25	29.62
Farms without extension contacts	27.18	25-50	26.28
Farms with extension contacts	21.66	50-75	23.14
F-value	10.368**	> 75	17.81
		F-value	7.5974**

** and * Significant at 1 and 5 per cent level, respectively.

TABLE 4. CORRELATION OF SOCIO-ECONOMIC FACTORS WITH INEFFICIENCY IN RICE PRODUCTION

Variable (1)	Correlation co-efficient (2)	T-ratio (3)
Farm size	-0.1756**	-2.9201
Age	0.2044**	3.4183
Experience	0.0851 (-0.1369)	1.3986 (-2.2618*)
Education	-0.1816**	-3.0232
Extension contacts	-0.1826**	-3.0404
Number of farm workers	0.1092	1.7984
Caste	-0.0855	-1.4048
Location	0.0802	1.3172
Fragmentation of land	0.2102**	3.5198
Percentage of good land	-0.2460**	-4.1549

Note: ** and * Significant at 1 and 5 per cent level, respectively.
Figures in the parentheses are values of partial correlation.

showed lowest technical inefficiency in the production of rice followed by the farmers belonging to below 40 years age group. Technical inefficiency of the farmers belonging to 50-60 years age group and above 60 years age group was comparatively higher than that of younger age groups. Analysis of variance revealed that the difference in technical inefficiency was significant. If we examine carefully it will be clear that the inefficiency level of the farmers below 50 years of age is comparatively lower than that of farmers above 50 years. This variable was positively and significantly correlated with technical inefficiency indicating that as the age of the farmer increases he will become more inefficient. As the age increases farmers become more risk averters and hesitate to adopt new technologies making the production process less efficient. If we see both the results together, it will be clear that after certain age inefficiency will increase with increase in age.

3. *Education of the Farmer*

Technical inefficiency reduced significantly with the increase in the level of education. Correlation coefficient between education and technical inefficiency was also negative and significant. Lowest technical inefficiency in rice production was found with the college educated farmers (23.16 per cent) followed by secondary educated farmers (24.78 per cent). Technical inefficiency of illiterate and primary educated farmers was 27.52 and 28.87 per cent respectively, which was comparatively high. If we examine carefully it will be clear that inefficiency of secondary and college educated farmers was markedly lower than the others. Inefficiency of primary educated and illiterate farmers was almost the same. Many of the primary educated farmers were not able to read and write and they were practically at par with the illiterates. So primary level education had no effect on inefficiency. Hence at least secondary level education is needed to carry out production in an efficient manner. Doraiswamy (1992) also found that at least middle level school education is needed to have significant impact on farm productivity. The well-educated farmers can understand production technology better. Moreover they can get information from various sources and can maintain relationship with extension agencies giving an edge over the illiterate farmer. Hence they can reduce their inefficiency to a great extent.

4. *Experience in Rice Production*

Farmers based on their experience in production of rice, were classified into three groups, viz., below 5 years, 5-10 years, 10-15 years and above 15 years. The farmers having 5-10 years experience recorded lowest technical inefficiency (22.91 per cent) in rice production, followed by the farmers with experience less than 5 years (23.25 per cent). The farmers with experience above 15 years recorded the highest technical inefficiency (30.29 per cent). Analysis of variance revealed that these differences were statistically significant. This variable was positively correlated with inefficiency

that was statistically insignificant. Though the relationship was insignificant it indicates that as experience increases inefficiency will also increase, which sounds illogical. This may be due to the effect of age of the farmer that is masking the actual effect of experience as these two variables are highly correlated. To eliminate the effect of age, partial correlation coefficient was calculated, which was -0.1369 and significant at 5 per cent level. This clearly indicates that experience is negatively correlated with inefficiency and as experience increases inefficiency in rice production will reduce.

5. *Extension Contacts*

To know the influence of extension contacts, inefficiency of the farmers who have contacts with extension agencies was compared with those who do not have contacts with extension agencies. Technical inefficiency in rice production was significantly low (21.66) with the farmers who have contacts with extension agencies. Contacts of the farmers with extension agencies was also found to be negatively correlated with inefficiency in rice production indicating that farmers having contacts with extension agencies were more efficient than those who do not have contacts. The farmers who had contacts with extension workers agencies will get the right suggestions at the right time making themselves more efficient. This analysis highlights the role of extension services in improving the efficiency of the farmers and in increasing the productivity and production of crops.

6. *Location of the Farm*

Farms situated in different locations of canal command did not differ significantly in their inefficiency levels. Middle reach farmers showed slightly lower technical inefficiency than the others. Analysis of variance revealed that the difference in inefficiency between the farms of various locations was not significant. Correlation coefficient between location and inefficiency was statistically not significant.

7. *Caste of the Farmer*

Farmers based on the social order of their cast were grouped into lower (SC, ST, BC) and higher (OC) groups and their average inefficiency was compared. Analysis of variance revealed that there was no significant difference between inefficiency levels of lower and higher caste farmers in the production of rice. But higher caste farmers registered slightly lower technical inefficiency when compared with lower caste farmers in rice production. The correlation coefficient was negative but not significant indicating that inefficient farmers are distributed in both higher as well as lower castes.

8. *Level of Fragmentation*

To study the effect of fragmentation, fragmentation index was developed which considers the number of fragments into which the farm land is divided and the area of the farm. Fragmentation index was calculated with the following formula.

$$\text{Fragmentation index} = \frac{\text{Number of fragments}}{\text{Area}}$$

The sample farms were classified into low, medium and highly fragmented categories based on this index. Technical inefficiency in rice production was lowest in low fragmented farms while it was the highest in very highly fragmented farms. Inefficiency increased significantly with increase in fragmentation level. Fragmentation of land exhibited positive correlation with inefficiency in rice production. This may be due to the fact that highly fragmented land inhibits the use of improved technologies, making farms more inefficient.

9. *Number of Farm Workers in the Family*

Lowest technical inefficiency was found on the farms where there were 3-4 farm workers in the family. But the differences among various groups were not significant. Increase or decrease in farm workers brought an increase in technical inefficiency in rice production. This variable has showed insignificant positive relationship with inefficiency. It indicates that as the workers in the family increases technical inefficiency also increases. This may be due to the fact that farmers are already using excess human labour in rice production. Alternative employment opportunities for farm labour is very limited in this area. Hence human labour utilisation increases with increase in the number of farm workers in the family. This will increase the inefficiency of the farm. The negative coefficient of human labour in the production function also indicates the same thing.

10. *Percentage of Good Land on the Farm*

Percentage of good land on the farm influenced inefficiency in rice production significantly. Farms having high percentage of good land recorded less inefficiency than those of having less percentage of good land. This variable was assessed based on the judgment of the respondent himself. Analysis of variance revealed that this effect was significant. The percentage of good land on the farm showed negative and significant relationship with inefficiency in rice production indicating that increase in good land reduces inefficiency significantly. Good land due to its inherent capacity give higher yields than the inferior land thus reducing the inefficiency level.

CONCLUSIONS

The study reveals the existence of technical inefficiency in the production of rice in the study area. Yield of rice can be considerably improved without increasing the level of inputs in the study area if the inefficiency is reduced. Technical inefficiency in the production of rice is negatively related with farm size, education of the farmer, experience, extension contacts and percentage of good land and positively related with age and fragmentation of the land. Caste of the farmer and location of the farm in the canal command do not have any influence on inefficiency. Similarly the number of farm workers in the family does not show any pattern with inefficiency. To reduce inefficiency in the production of rice and wheat measures like encouraging co-operative type of farming, land consolidation, improving literacy rate, strengthening extension services and providing alternate employment opportunities should be taken up in this area.

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