An analysis of technical efficiency of rice farmers in pakistani Punjab

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Research Note

AN ANALYSIS OF TECHNICAL EFFICIENCY OF RICE FARMERS IN PAKISTANI PUNJAB

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ABSTRACT

This study uses stochastic Cobb-Douglas production frontier to estimate farm level technical efficiency of rice farms. Average technical efficiency of sampled farms was estimated to be 85 percent with a minimum of 57 percent and a maximum of 96 percent. The results further showed that the visits of agricultural extension agents on the farm or farmers' visits to extension office and the availability of agricultural credit played significant role in improving technical efficiency. More experienced (aged) and educated farmers also realized high productive efficiency and thus output; however, the effect was not statistically significant. These results imply that considerable scope exists in the sampled area to increase rice output by improving farm management and providing other facilities to the farmers.

I. INTRODUCTION

Agriculture sector contributes about 24 per cent towards the gross domestic product of the economy. This sector consists of two main sub-sectors namely crop and livestock sectors. Crops share about 54 percent of the national agricultural GDP while the remaining 46 percent is shared by livestock, fisheries, and forestry (Pakistan, 1997).

Rice is and important food crop after wheat and is grown over 10 percent of the total cropped area and accounts for about 17 percent of the acreage under food grains. The total area under rice crop was 2.321 million hectares in 1997-98 as compared to 1.204 million hectares back in 1959-60 showing an increase of about 93 percent over the last three and half decades. However, the trend of area under rice during the last couple of years shows the potential of increase in area under this crop has almost been exhausted.

As regards per hectare yield of rice, it suffers stagnation and is fluctuating between 1600 to 1912 kgs during the last two decades. Moreover, this observed average yield per hectare, i.e. 1912 kgs is well below the potential yield that is of 7410 kgs per hectare (Pakistan, 1988).

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Above discussion shows that it is the yield per hectare of rice that will have to play a major role in increasing the production of rice crop to cope with the increasing demand for food of rapidly expanding population. In order to cope with these challenges, it is required that the factors which are responsible for low yield should be taken care of. One of the major factors in considered to be the low productive efficiency, which is also called management or technical efficiency. The concept of technical efficiency was first developed by Farrell in 1957. According to him, technical inefficiency arises when actual or observed output is less than the maximum achievable potential.

The study at hand will estimate the technical efficiency measures of rice farmers and identify the factors which affect the efficiency. It is hoped that the results of this study would be of great interest for the policy makers and planner to devise the policies that will in turn raise yield per hectare of rice through appropriate and efficient use of available resources.

Measurement of Technical Efficiency: A review

It was Farrell (1957) who first proposed an approach to estimate productive efficiency of observed units. Farrell's original work was extended by Charnes, Cooper and Rhodes (1981), Fare, Grosskopf and Lovell (1985), and banker, Charnes and Coopper (1984), among others. The procedure used to estimate efficiency in all of these studies was non-parametric methodology. This methodology has also been extended to parametric models. These models include deterministic and stochastic frontiers. In deterministic models any deviation from the frontiers is due to inefficiency. On the other hand stochastic approach allows for statistical noise.

The stochastic frontier model was independently developed by Aigner, Lovell and Schmidt, and Meeusen and Van den Brock in 1977. The key feature of the stochastic frontier model is that the error in the model has two components. One is symmetric and captures statistical noise and exogenous shocks and the other is one sided that captures inefficiency such as mistakes related to management.

As regards application of these methodologies in case of rice crop, many studies have been conducted using data from various countries. These studies include: Belbase and Grabowski (1985) used Nepal's data; Kalirjan (1991), Kalirajan and Shand (1985) utilized Indian data; Kalirajan and Flinn(1983), Kalirajan (1984 and 1990), Dawson, Lingard and Woodford (1991) were based on the Philippines data; Ekanayake (1987) and Ekanayake and Jayasuryia (1986) analyzed data from Sri

Lanka. The study that used Pakistani Basmati rice data is that of Ali and Flinn (1987). The later study was based on stochastic profit function approach using cross-sectional data for the crop season 1981-82 and computed economic efficiencies. Consequently, the present study would be an interesting comparison.

II. DATA AND EMPIRICAL MODEL

The data used in this study were collected for the crop season o 1996-97 from the district of Sheikhpura. For the collection of data, a stratified random sampling technique was adopted to select villages namely Ratti Ribbi, Tahirabad and Amarkot from Ahmadabad Tehsil, which represent almost the average condition of Skeikhupura district. The farmers of Ratti Tibbi, Tahirabad and Amarkot were above 15 Kms, 8-5 Kms and 0-8Kms away from the main grain market, respectively. About 30 farmers from each village were selected for the purpose of analysis. Thus, the total sample size comprised of 90 farmers. A detailed questionnaire was designed and pre-tested for local conditions to collect the needed information from the respondents.

A stochastic production frontier technique was used to achieve desired objective of the study. The Cobb Douglas functional form was preferred because of its well known advantages. The empirical model is written as

$$\ln(Y_i) = \beta_o + \beta_1 \ln(NC) + \beta_2 \ln(LPC) + \beta_3 \ln(FC) + \beta_4 \ln(IC) + \beta_5 \ln(CC)$$
$$+ \beta_6 D_z + \beta_7 DV_2 + \beta_8 DV_3 + \beta_9 ADV_1 + \beta_{10} ADV_2 + \beta_{11} ADV_3$$
$$+ \beta_{12} \text{Timsow} + v_i - \mu_i \quad (1)$$

where:

- i refers to ith farm;
- In denotes the natural log to the base e;
- Y is the total output of Basmati 385 in maunds per farm;
- NC is the nursery cost for all sown acreage under Basmati;
- LPC is land preparation cost for basmati rice;
- FC is fertilizer cost incurred per farm;
- IC is the irrigation cost incurred per farm;
- CC represents the chemical cost including pesticide spray and weedicide used;
- DZ represents the dummy variable showing the value of 1 if zinc was used on the farm, otherwise zero;

DV_2 and DV_3 are dummy variables for villages for village Tahirabad and Amarkot;

ADV_1, ADV_2 and ADV_3 represent area under Bamati 385 in Ratti Tibbi, Tahirabad and Amarkot;

Timsow is dummy variable if the crop was relatively sown early showing the value of 1, otherwise zero;

β_s are unknown parameters to be estimated;

V is usual random error term identically independently normally distributed with mean zero and variance $\sigma^2 v_i$ and

μ is non-negative unobserable random rariable associated with the technical inefficiency of production . It assumes half normal distribution with mean zero and variance $\sigma^2\mu_i$.

Data on 84 sample farms of three villages in Sheikhup[ura district have been used to estimate the parameter estimates of the production frontier. Other six observations were dropped due to incomplete information.

Technical efficiency (TE) of rice farmers was calculated by taking the exponent of the predicted non negative unobseravable random variable that can be expressed as $TEi = EXP(-\mu_i)$. In order to determine the effect of various farm specific variables on the technical efficiency of rice farkers, technical efficiency was regressed on farm and farmer specific variables using ordinary least square technique. The model is expressed as

$$TEi = \alpha_1 + \alpha_2 AGE_i + \alpha_3 EXT_i + \alpha_4 CRED + \alpha_5 OWNRAT + \alpha_6 DV_2 + \alpha_7 DV_3 + \alpha_1 + E_i \quad (2)$$

Where AGE is the age of the farmer; EXT represents the number of visits by the extension agent on the farm or the farmers' visit to the extension office; CRED is a dummy variable showing whether the credit was obtained or not; and OWNRAT is the ratio of farm area owned to total farm size.

III. THE RESULTS

The stochastic Cobb Douglas production frontier was estimated using LIMDEP version 7 (Green, 1995). The maximum likelihood estimates (MLE) of the stochastic Cobb Douglas production frontier as well as the OLS estimates are presented in Table 1.The R^2 value for this model is 0.96, which indicates that 96 percent of the variation in rice output is explained by the variable included in the production function. Given the cross-sectional nature of the data, the value of this statistic is high showing good fit of the model to the data at hand. The stochastic frontier model provides two additional parameter estimates, i.e., λ and σ which are significant at five percent critical level or better. Out of other 13 parameter estimates, 8 are statistically significant at five percent level of significance or better. Moreover, all the parameter estimates have expected signs.

The ratio of the standard error of μ_i and v_i, i.e., λ, is 1.9. This magnitude of λ shows that the one-sided error term μ_i dominates the sources of random variation in the model implying that the discrepancies between the observed output and the frontier output are due primarily to technical inefficiency in the sampled area.

The index of technical efficiency for the rice farmers is calculated by taking exponent of the one-sided error term. The results show a wide variation in the level of technical efficiencies across farms. For example, the minimum and maximum technical efficiencies in the sample are 57 percent and 96 percent, respectively. Out of the sample of 84 farms, 26 percent have technical efficiency of 80 percent or below, 46 percent are technically efficient from 81 to 90 percent, while the remaining 28 percent have technical efficiency of higher than 90 percent. The average technical efficiency for the entire sample of farms is 85 percent. This shows that there is considerable scope for increasing the technical efficiency and thus the productivity as well as the overall rice output.

Table 1: Parameter Estimates of Cobb-Douglas Production Frontier

Variable	Ordinary Least Squares		Stochastic Frontier	
	Estimates	St. Error	Estimates	St. Error
Constant	0.0069	0.5377	0.4804	0.5418
Nursery Cost (NC)	0.1463***	0.0489	0.1207**	0.0517
Land Prep. Cost (LPC)	0.0772	0.0494	0.0596	0.0490
Fertilizer Cost (FC)	0.1645**	0.0651	0.1702**	0.0701
Irrigation Cost (IC)	0.0815**	0.0336	0.0760***	0.0281
Chemical Cost (CC)	0.0055	0.0106	0.0056	0.0103
Zinc (DZ)	0.0787	0.0488	0.0735	0.0563
Village 2 (DV_2)	0.4237***	0.1462	0.4243***	0.1419
Village 3 (DV_3)	0.3745**	0.1846	0.2764	0.1845
Basmati Area (ADV_1)	0.7398***	0.0808	0.7729***	0.0733
Basmati Area (ADV_2)	0.6075***	0.0808	0.6360***	0.0992
Basmati Area (ADV_3)	0.7154***	0.0873	0.7616***	0.0875
Time Sowing	0.1906***	0.0510	0.2359***	0.0584
$\lambda = \sigma_\mu / \sigma_v$	-	-	1.9044**	0.9943
$\sigma = \sqrt{\sigma^2_\mu + \sigma^2_v}$			0.2359***	0.0411
R^2	0.96			

***, ** and * : Significant at the one, five and 10 percent levels, respectively.

Comparison of these measures with that of the other studies who used the rice data of various countries shows that the average technical efficiency of the sampled farms fall very well in the range, i.e., 50 percent to 100 percent. Comparison of average technical efficiency (i.e.,85 percent) with that of Ali and Flinn (1987) who, though, computed economic efficiency (i.e., 69 percent) indicates significant improvement overtime.

To assess the determinants of production efficiency, the index of technical efficiency was regressed on various factors using Equation 2. The results are reported in Table 2. The results indicate that the number of years of education of the farmers have positive impact on the technical efficiency. However, the effect is statistically non-significant. The age of the farmers has also positive association with the technical efficiency indicating that the aged farmers who have more experience in farming are technically more efficient; however, the impact is statistically non-significant.

Agricultural extension services play crucial role in increasing agricultural productivity by transferring new technology and information at the farm level. The coefficient of extension variable is positive in sign and is also statistically significant, implying that the close contact of the farmers with the extension agents of the department of agriculture increases the production potential.

Table 2: Factors Affecting Technical Efficiency of Sample Farms

Variable	Coefficients	Standard Error
Constant	0.8573***	0.0314
Education (Educ)	0.0006	0.0013
Age	0.0002	0.0004
Extension (Ext)	0.0089**	0.0042
Credit (Cred)	0.0288**	0.0114
Ratio of Own Land Total Farm Size (OWNRAT)	-0.0256	0.0187
Village 2 (DV2)	0.0244*	0.0144
Village3 (DV3)	0.0140	0.0144
R	0.12	

***, ** and * : Significant at the one, five and 10 percent levels, respectively.

The adoption of new agriculture technologies requires investment that could be financed either from the savings of the farmers or borrowing from other sources. The results of this study show that the access and availability of agricultural credit statistically significantly increase efficiency of rice farms. Another important rather surprising result is that the farmers who had rented-in more land are technically more efficient than the farmers who cultivate their own land. It may be due to the fact that the farmers who cultivate rented in land they do have to pay rent or share to the land owners. From the rest over they have to meet the cost of production and save something for other needs. Therefore, due to this economic pressure they put more effort and try to achieve the higher output potential.

The coefficients of village dummies show that the farmers of village 2 (i.e. Tahirabad) are statistically significant more efficient that those of the village 1 (i.e. Ratti Tibbi). The farmers of village 3 were also more technically efficient than those of village 1: however, the difference appears to be non-significant.

IV. CONCLUSION

This study use stochastic Cobb-Douglas production frontier to estimate farm level technical efficiency using input and output data from 84 farms from Ahmadabad tehsil of district Sheikhupura. The results show that the average technical efficiency of sampled rice farmers is about 84 percent with a minimum of 57 percent and a maximum of 96 percent. Since technical efficiency represents the degree of ability to produce the maximum achievable (Frontier) output from a given bundle of inputs, it is possible to increase average output by about 15 percent from the existing bundle of inputs. Although the comparison of average technical efficiency with that of the mean economic efficiency of previously done Ali and Flinn (1987) study based on 1981-82 data from Gurjranwala district of Punjàb is difficult, it does suggest significant improvement in managerial skills over the last one and a half decade. One of the main reasons for this trend could be that the rice region faces almost the static technology setup. Thus an average rice farmer has moved closer to the output frontier over the years.

Second step analysis, where measures of technical efficiencies were regressed on different farm and farmer specific characteristics, shows that agricultural extension services and availability of agricultural credit play positive and statistically significant role in achieving frontier output. Age and education also have positive effect on technical efficiency; however, the effect is statistically non-significant. The ratio of own land to total farm size for the sampled farms shows that higher the ratio the lower is the technical efficiency. This indicates that the farmers who plough more rented in area are more efficient than that of the farmers cultivating land. This result is very surprising and requires careful interpretation.

REFERENCES

Aigner, D.J., C.K. Lovell, and P. Schmidt (1977) "Formulation and Estimation of Stochastic Frontier Production Function Models". Journal of Econometrics, 6.21-37.

Ali, M., and J.C. Flinn (1987) "Profit Efficiency Among Basmati Rice Producers in Pakistan Punjab". American Journal of Agricultural Economics, 71: 303-10.

Banker, R.D., A. Charnes and W.W. Cooper (1984) :Some Models for Estimating Technical and Scale inefficiencies in Data Envelopment Analysis". Management Science, 30: 1078-92.

Belbase, K., and R. Grawbowski (1985) "Technical Efficiency in Nepalese Agriculture". Journal of Developing Areas, 19: 515-25.

Charnes, A., W.W. Cooper and E. Rhodes (1981) "Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through". Management Science, 27: 668-97.

Ekaynake, S.A.B. (1987) "Location Specirficity, Settler Type and Productive Efficiency: A Study of the Mahaweli Project in Sri Lanka". Journal of Development Studies, 23:509-21.

Ekanayake, S.A.B. and S.K. Jayasuriya (1986) "Measurement Firm Specific Technical Efficiency: A Comparison of Model". Journal of Agricultural Economics, 38: 115-22.

Fare, R.,S. Grosskopf and C.A.K. Lovell (1985) The Measurement of Efficiency of Production. Boston: Kluwer-Nijhoff Publishing.

Farrel, M. (1957) "The Measurement of productivity Efficiency". Journal of the Royal Statistical Society A, 120:253-90.

Pakistan, Government of (1997) Economic Survey, 1996-97. Islamabad: Ministry of Finance. Adviser's Wing.

Pakistan, Government of (1988) Report of the National Commission on Agriculture. Islamabad: Ministry of Food and Agriculture.

Green, W.H. (1995) LIMDEP Version 7: User's Manual. New York: Econometric Software, Inc.

Kalirajan, K. (1981) "An Econometric Analysis of Yield Variability in Paddy Production". Canadian Journal of Agricultural Economics, 29: 283-94.

Kalirajan, K. (1984) "Farm Specific Technical Efficiencies and Development Policies". Journal of Economics Studies, 11:3-13.

Kalirajan, K. (1990) "On Measuring Economic Efficiency". Journal of Applied Econometrics, 5:75-85.

Kalirajan, K. (1991) "The importance of Efficient use in the Adoption of Technology: A Micro Panel Data Analysis". Journal of Productivity Analysis, 2:113-26.

Kalirajan, K., and J.C. Flinn (1983) "The Measurement of Farm Specific Technical Efficiency". Pakistan Journal of Applied Economics, II: 167-80.

Kalirajan, K., and R.T. Shand (1985) "Types of Education and Agricultural Productivity: A Quantitative Analysis of Tamil nadu Rice Farming". The Journal of Development Studies, 21:232-43.

Meeusen, W., and Vanden Broeck (1977) "Efficiency Estimation from Cobb-Douglas Production Function with Composed Error". International Economic Review, 18:435-44.