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A Study on Technical Efficiency of Wheat Cultivation in Haryana

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Abstract

The farm-specific technical efficiency of wheat cultivation in Haryana at the aggregate and disaggregate levels has been studied using stochastic frontier approach. A high degree of technical inefficiency in wheat farming has been reported, which is due to factors under farm's control. It has been argued that wheat-cultivating farms in the state can increase their production by 27 per cent without increasing the quantity of inputs, i.e. just by way of realizing efficiency. The estimates of technical efficiency have indicated that small-size farms are more efficient than medium- and large-size farms, negating thereby the myth that large-size farming is more profit/business-oriented.

Introduction

India has made substantial progress in the agricultural sector, achieving self-reliance in food grains production and exportable surplus status in some other crops. Despite this, productivity in India is low in comparison to not only developed countries but also some developing countries[1]. The agricultural sector in India, in spite of vast potential for growth, is showing a decline in terms of productivity due to irrational exploitation of resources, improper adoption of technology and anomalies in policy formulations. The situation is getting aggravated further due to the continuously-increasing cost of cultivation and attaining of saturation in the green revolution belts. At the same time, under new economic policies, the subsidies offered on various crucial inputs are being reduced so as to eliminate them eventually. It has all the more increased the pressure on this sector to enhance productivities and efficiencies.

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The increase in agricultural production depends not only upon land-use but also on productivity or efficiency. The productivity can be increased by either improvement in technology or enhancement in the efficiency of the resources used. Improvement in the efficiency of the resources being at the disposal of the farmer, assumes great concern. The study on technical efficiency is of significant importance for the policymakers/planners to frame suitable policies for increasing efficiency or reducing inefficiency. Recent studies have indicated the presence of technical inefficiency in agriculture. Under this background, the present paper has reported technical efficiency of wheat farming in the state of Haryana, with the following hypotheses:

- The technical efficiency of wheat cultivating farms in Haryana is invariant to farm-size; and
- Technical inefficiency is dominated by random factors beyond the control of farmers[2].

Methodology

The concept of technical efficiency was elaborated by Farrell in 1957. Later, Aigner *et al*. (1977) and Meeusen and Van Den Broeck (1977) suggested the stochastic frontier[3] model as a means for estimating the technical efficiency. Many researches, such as Taylor and Shonkwiller (1986); Ali and Flinn (1989); Kalirajan and Shand (1989); Kutala (1993), Banik (1994); Shannugam and Palanisami (1994); Sharma and Dutta (1997); and Reddy and Sen (2004); have estimated the technical efficiency using stochastic frontier model, based on the cross-sectional as well as time series data.

In the present study, the stochastic frontier production function approach was used to measure technical efficiency of wheat-cultivating farms. In analysing technical efficiency, it is not the average output, but the maximum possible output obtainable from a given bundle of inputs, is of importance. The frontier production function is defined as the maximum possible output that a farm can produce from a given level of inputs and technology. In stochastic frontier, the disturbance term is decomposed into two components: a symmetric component, which captures randomness outside the control of the farmer, such as droughts, floods, etc. and the statistical noise contained in every empirical relationship and the other one-sided component capturing randomness under the control of the farmer (i.e., inefficiency). Formally,

$$Y = f(x)\, e^{Ei} \qquad \ldots(1)$$

where,

$$E_i = v_i - u_i \quad i=(1,2\ldots,n), \qquad \ldots(2)$$

- *vi* is the symmetric component; and

u_i 0 is the one-sided component.

Since the frontier is stochastic in nature, permitting random variations of the production frontier across observations, the technical inefficiency, which is captured by the one-sided error component, i.e. $u_i \geq 0$ is relative to the stochastic frontier.

Model Specification

In the present study, stochastic frontier production function of Cobb-Douglas form was specified, which is defined in logarithmic form as:

$$\ln Y_i = b_0 + b_1 \ln X_{1i} + b_2 \ln X_{2i} + b_3 \ln X_{3i} + v_i - u_i$$

where,

Y_i = Output in Rs

X_1 = Agro-chemicals in Rs[4]

X_2 = Labour in human-days

X_3 = Land in acres

b's = Elasticity coefficients ; and

$v_i - u_i$ = Error-term, defined earlier.

The above model was estimated by the method of COLS using computer programme, LIMDEP.

The technical efficiency of individual farm lies between zero and one and is estimated as:

$$T.E. = \exp(-u_i) \quad \ldots(3)$$

The Data

The technical inefficiency of wheat cultivating farms in Haryana was estimated at the aggregate and three farm-size levels using production frontier approach. For this, farm-level cross-sectional data pertaining to *rabi* season of the year 1998-99 was used. The sample farms were selected by using two-stage stratified random sampling technique. In the first stage, two villages from each district of the state were selected randomly. All the farmers of the selected villages were grouped into three categories, based on their landholidings, i.e. small-size farms (up to 5 acres), medium-size farms (5-15 acres) and large-size farms (above 15 acres). At the second stage of sampling, proportionate random samples (10 per cent of each farm-size) were taken. In all, a sample comprising 315 farms was selected. The required data on input-output coefficients, input-output prices and related variables was also collected through questionnaire-cum-interview method.

Results and Discussion

A basic summary of the values of the key variables used in the stochastic frontier production function model has been presented in Appendix 1. The average size of farm holding has been found as 6.87 acres at the aggregate level. Interestingly, the average size of holding turned out to be less in medium-size than small-size farms[4]. The table reveals a positive association between output per acre and use of labour mandays per acre. There existed diminishing returns to scale to the labour input. Large-size farms were found using more agrochemicals and capital inputs than medium- and small-size farms. The small-size farms were found the least users of hired labour, followed by large- and medium-size farms.

The estimated coefficients of stochastic production frontier at aggregate and three farm-size levels are presented in Table 1. All the coefficients of independent variables considered in the model were found statistically significant and depicted the expected signs at the aggregate level and for small- and medium-size farms. In large-size farms, only land-input was found statistically significant, bearing positive sign. However, the agrochemicals-input attached with a positive sign was found insignificant. The coefficient of variation for agrochemicals-input was estimated to be

Table 1. COLS estimates of Cobb-Douglas production function

Farm-size groups	Parameter estimates				
	$\hat{b}_0$	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	R^2
Aggregate	6.036*	0.2390*	0.0967*	0.625*	0.89
	(0.3376)	(0.0517)	(0.0402)	(0.0606)	
Small-size	6.51*	0.2024*	0.0670*	0.6960*	0.89
	(0.5176)	(0.077)	(0.051)	(0.093)	
Medium-size	5.49*	0.2942*	0.1976*	0.4318*	0.92
	(0.5138)	(0.0758)	(0.0801)	(0.0960)	
Large-size	7.93*	0.02215	-0.0277	0.972*	0.86
	(1.069)	(0.1518)	(0.0967)	(0.1670)	

Note: Figures within the parentheses represent standard errors
*Significant at 5 per cent level.

relatively low which indicates that there was not much variability in the use of agrochemicals-input among the large farmers. The low variability may be the reason for non-significant coefficient of this input. On the other hand, the labour variable for large farms had negative sign but was statistically non-significant. It was due to the low variability in labour use among the large farmers (Appendix 1).

In Table 2, λ measures the degree of asymmetry in the distribution of the composite error-term, $E_i = v_i - u_i$. The value of λ was more than one at the aggregate as well as three farm-size levels, implying the dominance of one-sided component u_i in E_i and thus indicated high degree of technical inefficiency. In other words, inefficiency component was not dominated by the random factors, thereby refuting our null hypothesis that "random factors outside the control of farm dominate inefficiency". It was further confirmed by the ratio [Var (u)/], which was also greater than one at the aggregate and the three farm-size groups. It suggested that the variance of observed output beneath the stochastic frontier was 8.79, 9.93, 9.17 and 13.81 times the variance of frontier itself for aggregated, small, medium and large farm-size groups, respectively.

$\hat{E}^{2}_{u}(u)$

The mean of one-sided E (u) implied the percentage of output, on an average, below the frontier. It turned out to be 35 per cent for aggregated farms and 32 per cent, 33 per cent and 32 per cent for small-, medium- and large-size farms, respectively. The discrepancy parameter, q, explained that 97 per cent inefficiency in the case of aggregated farms and 94 per cent, 97

Table 2. COLS estimates of Cobb-Douglas stochastic frontier production function

Parameters estimates	Aggregated farms	Large-size farms	Medium-size farms	Small-size farms
$\hat{\ }^{2}_{u}$	0.1926	0.1604	0.1680	0.1605
$\hat{\ }^{2}_{v}$	0.0079	0.0042	0.0066	0.0059
$\hat{\ } = \sigma_u/\sigma_v$	4.92	6.36	5.02	5.22
	-0.3502	-0.3195	-0.3269	-0.3196
$V\hat{a}r(u)$	0.0699	0.058	0.0610	0.0583
$V\hat{a}r(u)/\hat{\ }^{2}_{v}$	8.79	13.81	9.17	9.93
$\hat{\ }$ $/\ \hat{\ }^{2}_{u} + \hat{\ }^{2}_{v}$	0.97	0.97	0.97	0.94
Mean technical efficiency[5]	0.73	0.74	0.73	0.75

per cent and 97 per cent inefficiency in small-, medium- and large-size farms, respectively was due to the factors which were under farmers' control.

The mean technical efficiency (Table 2) turned out to be 73 per cent at the aggregate level. The three groups of farms were more or less equally efficient, small-size farms, 75 per cent; large-size farms, 74 per cent; and medium-size farms, 73 per cent. Thus, the hypothesis that 'technical efficiency is invariant to farm-size' finds empirical support.

The estimates of technical efficiency indicated a high degree of inefficiency in the production of wheat in Haryana. The stochastic frontier estimates of technical inefficiency worked out to be 27 per cent at the aggregate level and 25 per cent, 27 per cent and 26 per cent for small-, medium- and large-size farms, respectively. In other words, wheat-cultivating farms in Haryana can increase the production of wheat by 25 - 27 per cent just by way of realizing efficiency, without necessarily increasing the quantity of inputs. The stochastic frontier analysis has further shown that 97 per cent of the observed inefficiency was due to farmers' inefficiency in decision-making and only 3 per cent of it was due to random factors outside their control at the aggregate, large and medium farms. For small-size farms, the corresponding values were 94 per cent and 6 per cent, respectively.

As is evident from the Table 2, about 64 per cent of the sample farms realized more than 60 per cent efficiency at the aggregate level while for large-, medium- and small-size farms, this figure was 63 per cent, 43 per cent and 45 per cent, respectively. On the other hand, 17 per cent farms at the aggregate level, 22 per cent small-size, 37 per cent medium-size and 38 per cent large-size farms realized less than 40 per cent efficiency level. Small-size farms were found realizing more efficiency at the top level, whereas large-size farms at the lower level. It may also be noted that in

Table 3. Frequency distribution of technical efficiency

Technical efficiency	Aggregated farms	Large-size farms	Medium-size farms	Small-size farms
Below 40%	55	24	53	24
	(17)	(38)	(37)	(22)
40-60%	59	11	28	27
	(19)	(17)	(20)	(25)
60-80%	91	21	39	45
	(29)	(34)	(33)	(41)
Above 80%	110	7	15	13
	(35)	(11)	(10)	(12)

Note: Figures within the parentheses represent percentage of farms each of the three farm-size groups, there was a concentration of farms realizing efficiency between 60 per cent and 80 per cent. The percentage of farms achieving efficiency more than 80 per cent was more or less uniform across the three farm-size groups.

The relatively higher technical efficiency of small-size farms may be attributed to their motivated family labour, which dominates the hired component of labour on these farms. Besides, the small-size farms are the beneficiaries of several policy programmes at the state and central levels. The large-size farms, equally efficient ones, have scale advantages of easy access to institutional credit and extension services to perform their operations efficiently. On the other hand, the medium-size farms, which neither have the benefits of family labour nor the kind of policy support enjoyed by large-size farms, require recognition at the level of policy formulation as well as its execution.

Conclusions and Policy Implications

The study has examined the technical efficiency of wheat crop in Haryana using stochastic production frontier at the aggregate and three farms-size levels, involving land, labour and agrochemicals. The study has indicated high degree of technical inefficiency in wheat farming in Haryana, which has been attributed to the low level of education of farmers, poor extension services, centuries old unbusiness-like attitude and gross distortion in the price of inputs like agrochemicals, and labour. The study has revealed that the perceived inefficiency is due to farmer's own decisions. So the focus of the policy should be on improving the decision-making process of the farmers in the state.

The technical efficiency has indicated that the three farm-size groups are more or less equally efficient, exploding the myth that large-size farming is more business/profit-oriented than the small-size farming. So the recent moves towards grouping of farmers under cooperative farming do not seem to be well-founded. The study has observed that Haryana agriculture has a long way to go to realize its full potential and in the transition, it needs patronage of the state. Therefore, a two-way strategy, one aiming at raising the technical efficiency of farmers by strengthening their resource-base and the other at providing the extension services and education to the farmers, would have a cumulative effect.

Notes

1) According to FAO report (2004), the wheat productivity in developing countries like Chile, Egypt and Zambia was 4299 kg, 6358 kg and 6667

kg per hectare, respectively, whereas in developed countries like Belgium, Germany and United Kingdom, it was 8981 kg, 8171 kg and 7889 kg, respectively, which is considerably more than India's average yield of wheat (2707 kg/ha).

2) Kutala's study of 110 randomly selected wheat farms (on reclaimed soils) in the Karnal district of Haryana has indicated the dominance of random factors.

3) The estimation of production frontiers has proceeded along two general paths: (1) deterministic frontier, which forces all observations to be on or below the production frontier so that all deviations from the frontier are attributed to inefficiency; and (2) stochastic frontier, where disturbance term is composed of two parts, one symmetric and the other, one-sided. Deterministic frontiers excluded the impact of random factors, which are outside the control of farmers.

4) The present study only pertains to wheat cultivation and the farmers have been categorized into small, medium and large farm-sizes according to their landholdings. In Appendix 1, the average farm-size reflects the area under wheat cultivation. By chance the average area under wheat cultivation of medium-size farms came out to be smaller than the average area of wheat cultivation under small-size farms.

5) The mean of the estimated technical efficiency was estimated as suggested by Lee and Tyler (1978), by $E(e^{u}) = 2e^{\hat{\sigma}_u^2/2}[1-F(\hat{\sigma}_u)]$.

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Appendix 1

Summary statistics for variables in the stochastic frontier model for farmers in Haryana

Variables	Aggregated farms	Large-size farms	Medium-size farms	Small-size farms
Average area under wheat crop (in acres)	6.84	16.86	4.20	4.52
	(114.21)	(69.54)	(74.03)	(51.87)
Output per acre (Rs)	8282	8004	8613	8233
	(20.04)	(16.97)	(21.34)	(20.33)
Labour (human-days per acre)	12.33	9.48	15.82	11.68
	(51.87)	(22.05)	(67.09)	(135.68)
Hired labour (human-days per acre)	6.03	6.54	6.7	4.81
	(136.22)	(50.78)	(68.22)	(87.09)
Output per labour (Rs)	672	844	545	704
	(48.87)	(61.56)	(53.92)	(16.59)
Agrochemicals (Rs/acre)	1216	1332	1245	1049
	(25.02)	(17.61)	(24.73)	(31.58)
Capital cost (Rs/acre)	826	979	708	784
	(123.48)	(84.68)	(153.94)	(98.70)
Average years of schooling	7.45	7.09	7.04	6.96
	(45.16)	(49.39)	(47.45)	(47.59)
Mean technical efficiency, %	73	74	73	75
	(33.05)	(31.38)	(38.50)	(28.76)

Note: Figures within the parentheses represent coefficients of variation.