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Estimation of Technical Efficiency of Barely Farms: A Case Study in Kurdistan Province, Iran

[1]Hamed Ghaderzadeh and [2]Mrs. Khadijeh Mahmoudi

[1]Department of Agricultural Economics, College of Agriculture, University of Kurdistan, Iran
[2]Department of Statistics, Payam Noor University, Kurdistan, Iran

Abstract: The present study was conducted in the Saqqez city of Kurdistan province, Iran, in order to study technical efficiency of Barely farmers. The data were collected from both rainfed and irrigated farms in three different areas (mountain, semi-plain and plain), based on two stage cluster random sampling, for agricultural year 2003-2004. In total 210 farmers were interviewed. With respect to the coefficient of multiple determinations (R^2) of estimated transcendental production function for rainfed farms, the variables included in this model are able to explain 99.7% of variation in the average production of rainfed barely per hectare. The variables such as farmyard manure, negatively, machinery and phosphate, positively, were significant. The estimated transcendental production function model for irrigated farms showed that the variables included in this model were able to explain 80.6 of variation in the average production of irrigated barely per hectare. The significant variables in the estimated model were phosphate, nitrogen, seed, human labor and machinery. The average of technical efficiency for rainfed farms in the mountain, semi-plain and plain areas was 0.758, 0.790 and 0.787, respectively. The average technical efficiency for the entire rainfed farms area was 0.782. In irrigated farms, the average of technical efficiency in mountain, semi-plain and plain areas was 0.772, 0.740 and 0.754, respectively and for the entire area was 0.758. This showed that rainfed and irrigated barely farmers were almost technically less efficient.

Key words: Production function · Technical efficiency · Barely farms · Kurdistan · Iran

INTRODUCTION

The Province of Kurdistan has been the cradle of agriculture and animal husbandry in Iran and production of various horticultural and agricultural products. In 2005, the total cultivated area of province was 940609 ha, of which 21247 ha (2.26%) was under horticultural trees and rest was under agricultural crops. Barely is one of the major crops of the province. Barely in case of area is third crop inside the province and 19th in country but according to the yield per hectare its rank in the country is 8th among 31 provinces and it shows that there is advantage to cultivate this crops in the Kurdistan province. The major reason that the area under this crop (4.53% of total area under agricultural crops) is compare to wheat (74.68%) is goes to the agricultural policy which has been taken by the government for the past two decades. While the province has about 3 million livestock and barely crop as a key food to feed them did not take much attention by the farmers due to the on going on policy and it needs more attention. According to the annual statistical report in agricultural year 2005-2006, by Iran's statistical center, total area under barely crop was 32292 ha (i.e. irrigated area 4905 and rainfed area 27387 ha) with total output 48525.67 tons. According to total numbers of farmers engaged with wheat and other agricultural crops were about 87527.

The study of efficiency, which focuses on the possibility of increasing output while conserving resource use, is very important especially in developing agricultural economies, where resources are meager and opportunities for developing and adopting better technologies have of lately started dwindling [1]. Efficiency can be defined in terms of producing the maximum amount of output, given a set of inputs; or producing a given level of output using a minimum level of inputs; or a mixture of both. Efficient

Corresponding Author: H. Ghaderzadeh, Department of Agricultural Economics, College of Agriculture, University of Kurdistan, Iran, Cell: +98-9183760861, E-mail: hamedar2002@uok.ac.ir.

farms either use less input than others to produce a given quantity of output, or for a given set of inputs they generate a greater output [2]. A frontier production function represents the maximum possible output for any given set of inputs setting a limit or frontier on the observed values of dependent variable, in the sense that no observed value of output is expected to lie above the production function. Any deviation of a farm from the frontier indicates the farm's inability to produce the maximum output from its given sets of inputs and hence represents the degree of technical inefficiency [3,4]. Much of the literature on efficiency is based 'directly or indirectly' on the seminal work of Farrell [5] who argued that efficiency could only meaningfully be gauged in a relative sense, as a deviation from the best practice of a representative peer group of producers. Who introduced the distinction between technical efficiency and allocative efficiency. From that time so far, the measurement of efficiency constituted a large portion of agricultural economic studies. For example, Dileep *et al.* [6]. examined resource use efficiency of contract farms and non-contract farms in tomato of Haryana State, India. Singh *et al.* [7] estimated technical, allocative and cost efficiencies of individual farmers and computed inter-farm and inter-regional variability in the efficiency measures to Haryana State, India by using the Data Envelope Analysis (DEA) approach. Mashayekhi [8] studied barley production and farm efficiency in Tehran province of Iran using Translog frontier production function. Who found the average TE for barley farms, to be 0.82 and included that about 52 percent of the differences between actual and frontier output had been due to technical inefficiency.

MATERIALS AND METHODS

We apply a parametric approach to estimate efficiency. The parametric approach is subdivided into two main classes of approaches namely deterministic and stochastic models. The main difference between these two broad categories is that deterministic models envelope all the observations, identifying the distance between the observed production and the maximum feasible production given the quantity of input used and identifying this distance as technical inefficiency. Stochastic models instead permit one to distinguish between technical inefficiency and statistical noise [8]. The stochastic frontier production function was selected for this study. A stochastic production frontier in general has the form [9]:

$$Q_i = Q\,(X_{ki}, \beta)\, e^{\varepsilon}\,,\ i = 1, 2 \ldots n\,;\ k = 1,2 \ldots n \qquad (1)$$

Where:
Q_i = Output of the i^{th} farm
X_{ki} = Vector of K inputs of the i^{th} farm
β = Vector of parameters
ε = Farm-specific error term

This stochastic frontier is also called a 'composed error' model because the error term is composed of two independent elements:

$$\varepsilon = V_i - U_i \qquad (2)$$

Where:
U_i = Non-negative term representing technical inefficiency
V_i = Symmetric component of the error term

The symmetric component, V_i, permits random variation in output due to factors outside the control of the farm such as weather and disease. It is assumed to be independently and identically distributed as N $(0, \sigma_v^2)$. A one-sided component ($Ui \geq 0$) reflects technical inefficiency relative to the stochastic frontier, thus $U_i = 0$ for any farm's output lying below the frontier, representing the amount by which the frontier exceeds the actual output of farm i. It is also assumed to be independently and identically distributed as N $(0, \sigma_u^2)$. That is half-normal distribution [10].

Let σ^2_u and σ^2_v be the variances of technical inefficiency parameter 'U' and statistical noise 'V' respectively then:

$$\sigma^2 = \sigma^2_v + \sigma^2_u \qquad (3)$$

The variance ratio γ, explaining the total variation in output from the frontier level of output attributed to technical inefficiencies, can be computed as:

$$\gamma = \sigma^2_u/\sigma^2 \qquad (4)$$

Where:

$$0 \leq \gamma \leq 1$$

Aigner *et al.* [1] defined λ as the ratio of standard errors in stochastic to symmetric disturbances as follows:

$$\lambda = \sigma_u/\sigma_v \qquad (5)$$

Estimation of stochastic frontier production function by maximum likelihood method gives the value of σ^2 and γ. The value of λ can be manually calculated by using the equations (3) and (4). From the equation (4), σ^2_u can be calculated as follows:

$$\sigma^2_u = \gamma \times \sigma^2 \quad (6)$$

By substituting the value of σ^2_u in equation the value of σ^2_v is computed by:

$$\sigma^2_v = \sigma^2 - \sigma^2_u \quad (7)$$

Then the square root of σ^2_u and σ^2_v are substituted in equation (5) to obtain the value of λ. In maximum likelihood technique, the estimates of λ and σ indicate the goodness of fit.

Individual firm measures of technical efficiency could be calculated from the error terms (ε_i) as follows:

$$E[u_i/\varepsilon_i] = \frac{\sigma_u \sigma_v}{\sigma} \frac{f(\varepsilon_i \lambda/\sigma)}{1-F(\varepsilon_i \lambda/\sigma)} - \frac{\varepsilon_i \lambda}{\sigma} \quad (8)$$

Where:

ε_i = The MLE residuals
$f(\varepsilon_i\ \lambda/\sigma)$ = Standard normal density function
$F(\varepsilon_i\ \lambda/\sigma)$ = Standard normal distribution function

The technical efficiency (TE_i) can be calculated as:

$$Te_i = Exp\,(-E\,[u_i/\varepsilon_i])\ ;\ i = 1, \ldots, n \quad (9)$$

So that $0 \le TE_i \le 1$.

The specific model estimated in this study, based on above theoretical frame work, is as following:

$$LnY = Lna_0 + \sum_{i=1}^{9}\left(\alpha_i LnX_i + \sum_{i=1}^{9} b_i X_i + e_i\right) \quad (10)$$

Where:

Y = Output (Kg/farm)
X_1 = Labor (man-days/farm)
X_2 = Machinery (working hours/farm)
X_3 = Nitrogen Fertilizer (Kg/farm)
X_4 = Phosphate Fertilizer (Kg\farm)
X_5 = Plant protection chemicals (Litter/farm)
X_6 = Seed (Kg/farm)
X_7 = Manure (Kg/farm)
X_8 = Number of Irrigation
X_9 = Area situation
bi = Linear coefficient of independent variables
a_i = Logarithmic coefficient of independent variables
α_0 = Intercept (constant term)
e = Residual term

Meeusen and Van Den Broeck [12] independently presented the Maximum Likelihood Estimates (MLE) to estimate a stochastic frontier production function. Data: The present study was conducted in the Saqqez city of Kurdistan province. The study tried to calculate technical efficiency of barely farmers both irrigated and rainfed farms.

The sampling technique was based on two stage cluster random sampling. In the first stage, 10 major villages from each area (mountain, semi-plain and plain areas) were selected followed by random selection of sample farmers based on population of each village. The numbers of samples in each area is 70 and in total 210 farmers were interviewed. The data were collected for agricultural year 2003-2004 by personally interviewing the selected respondents. The Limdep software used to analyze frontier production function and calculate Technical efficiency.

RESULTS AND DISCUSSION

Dry land and irrigated land formed 78.04 and 21.96% of total cultivated area, respectively. The cropping pattern followed rainfed wheat, chick-pea, irrigated wheat, rainfed barley, Alfa-Alfa, rainfed sunflower and irrigated barley (Table 1).

Rainfed and Irrigated Barely: The production function of rainfed barely estimated for Semi-Plain, Mountain areas and entire study areas are presented in Table 2, 3 and 4. The same only has been done in study area for irrigated farms due to less number of farmers who were cultivating irrigated barely and presented in Table 5.

Semi-plain Area: The estimated Transcendental production function model for rainfed barley of semi area showed that the Coefficient of multiple determination (R^2) was 0.423 indicating that the variables included in the model were able to explain 42.3% of variation in the average production of rainfed barley per hectare. The F-value was 16.161 and significant at 1% level, which indicates goodness of fit. The only significant variable in the estimated model was seed and it was negatively related at level of 1% (Table 2).

Mountain Area: The estimated Transcendental production function model for rainfed barley of Mountain area showed that the coefficient of multiple determination (R^2) was 0.846 indicating that the variables included in the model were able to explain 84.6% of variation in the average production of rainfed barley per hectare. The F-value was 93.144 and significant at 1% level of significance, which indicates goodness of fit. The only significant variable in the estimated model was human labor and it was positively related at level of 1% (Table 3).

Table 1: Cropping pattern in the Study Area

Crop	Particular	Kharif	Rabi	Total
Rainfed Wheat	Aggregate area (ha)	903.62		903.62
	Percentage	61.01		43.77
	Average area (ha)	4.61		4.61
	No of farm (%)	196 (93.33)		196 (93.33)
Rainfed Barley	Aggregate area (ha)	124.81		124.81
	Percentage	8.43		6.05
	Average area (ha)	1.41		1.41
	No of farm (%)	93(44.28)		93(44.28)
Rainfed	Aggregate area (ha)		514.74	514.74
Chick- Pea	Percentage		88.26	24.93
	Average area (ha)		3.26	3.26
	No of farm (%)		158(75.24)	158(75.24)
Rainfed Sunflower	Aggregate area (ha)		68.48	68.48
	Percentage		11.74	3.32
	Average area (ha)		3.28	3.28
	No of farm (%)		31(14.76)	31(14.76)
Irrigated Wheat	Aggregate area (ha)	274.62		274.62
	Percentage	18.54		13.30
	Average area (ha)	2.64		2.64
	No of farm (%)	104(49.52)		104(49.52)
Irrigated Barley	Aggregate area (ha)	64.01		64.01
	Percentage	4.32		3.10
	Average area (ha)	1.29		1.29
	No of farm (%)	48(22.86)		48(22.86)
Irrigated	Aggregate area (ha)	114.00		114.00
Alfa-Alfa	Percentage	7.70		5.52
	Average area (ha)	1.16		1.16
	No of farm (%)	97(46.19)		97(46.19)
	Total	1481.06 (100)	583.22(100)	2064.3(100)

Percent figure in parentheses are percentages to respective sample size

Table 2: Estimated transcendental production function of rainfed Barely in Semi- Plain area

Particular	Coefficient	Standard error	t- value
Variable			
Intercept	4.733**	0.389	12.161
Seed (Seed)	-0.018**	0.004	4.02
Model summary			
R^2	0.423		
$\bar{R}^2$	0.397		
F –statistic	16.161 **		
N	31		

*Significance at 5% level and ** Significance at 1% level

Table 3: Estimated transcendental production function of rainfed Barely in Mountain area

Particular	Coefficient	Standard error	t- value
Variable			
Intercept	5.678**	0.205	27.646
Human Labor	0.323**	0.033	9.656
Model summary			
$\bar{R}^2$	0.846		
R^2	0.837		
F-statistic	93.144 **		
N	43.00		

* Significance at 5% level and ** Significance at 1% level

Study Area: The estimated Transcendental production function model for rainfed barley of study area showed that the coefficient of multiple determination (R^2) was 0.997 indicating that the variables included in the model were able to explain 99.7% of variation in the average production of rainfed barley per hectare. The F-value was 222.15 and significant at 1% level of significance, which indicates goodness of fit. The variables such as farmyard manure, phosphate fertilizer and machinery were significant in the estimated model. The farmyard manure was negatively related while others positively (Table 4).

Irrigated Barley: The estimated Transcendental production function model for irrigated barley of study area showed that the Coefficient of multiple determination (R^2) was 0.806 indicating that the variables included in the model were able to explain 80.6% of variation in the average production of irrigated barley per hectare. The F-value was 16.161 and significant at 1% level of significance, which indicates goodness of fit. The significant variables in the estimated model were phosphate nitrogen, nitrogen fertilizer, seed, human labor and machinery (Table 5).

Technical Efficiency on Sample Farmers: To assess the level of technical efficiency obtained by individual farmers for major crops, the outputs obtained and inputs used were compared with the corresponding values derived from the frontier production function. The crop and area-wise frequency distribution of technical efficiency ratings for all three areas as well as study area are presented in the following sections.

Rainfed Barely: The technical efficiency for rainfed barely farms is presented in Table 6. The results showed that in the Plain area most of the farmers belonged to high and medium categories (36.8% each) followed by low and poor categories (5.3 and 21.1%, respectively). There was no farmer in very high category. In the Semi-Plain area most of the farmers belonged to high category (53.5%) followed by medium and low categories (39.5 and 7%) and there

Table 4: Estimated transcendental production function of rainfed Barely in Study area

Particular	Coefficient	Standard error	t- value
Variable			
Intercept	3.249**	0.216	15.010
X_7 (Farmyard Manure)	-0.568**	0.007	-8.449
Ln X_4 (Log Phosphate)	0.586**	0.071	8.204
Ln X_2 (Log Machinery)	1.021**	0.104	9.819
Model summary			
R^2	0.997		
$\bar{R}^2$	0.993		
F –statistic	222.15 **		
N	93.00		

* Significance at 5% level and ** Significance at 1% level

Table 5: Estimated transcendental production function of rainfed Barely for study area

Particular	Coefficient	Standard error	t- value
Variable			
Intercept	8.916**	1.101	8.099
X4 (Phosphate Fertilizer)	0.005**	0.001	3.541
X3 (Nitrogen Fertilizer)	0.002**	0.001	1.924
X6 (Seed)	0.004*	0.001	4.397
X1(Human Labor)	0.344**	0.127	2.703
X2 (Machinery)	-0.066*	0.016	-4.211
LnX1 (Log Human Labor)	-2.844**	1.032	-2.756
LnX2 (Log Machinery)	0.346*	0.196	1.768
Model summary			
R^2	0.806		
$\bar{R}^2$	0.744		
F –statistic	13.069 **		
N	48.00		

* Significance at 5% level and ** Significance at 1% level

Table 6: Frequency distribution of technical efficiency ratings for Rainfed Barely (Number)

Efficiency rating		Plain area		Semi-Plain area		Mountain area		Overall	
(Class interval %)	Classification	N	%	N	%	N	%	N	%
0-60	Poor	1	5.3	-	-	-	-	1	1.1
61-70	Low	4	21.1	3	7	-	-	7	7.5
71-80	Medium	7	36.8	17	39.5	20	64.5	44	47.3
81-90	High	7	36.8	23	53.5	11	35.5	41	44.1
More than 90	Very High	-	-	-	-	-	-	-	-
	Total	66	19	43	100	31	100	103	100
	Mean Efficiency	0.758		0.790		0.787		0.782	

Table 7: Frequency distribution of technical efficiency ratings for irrigated Barely (Number)

Efficiency rating		Plain area		Semi-Plain area		Mountain area		Overall	
(Class interval %)	Classification	N	%	N	%	N	%	N	%
0-60	Poor	-	-	-		1	5.6	1	2.1
61-70	Low	3	15.8	3	27.3	2	11.1	8	16.7
71-80	Medium	9	47.4	7	63.6	10	55.8	26	54.2
81-90	High	7	36.8	1	9.1	5	27.8	13	27.1
More than 90	Very High	-	-	-	-	-	-	-	-
	Total	19	100	11	100	18	100	48	100
	Mean Efficiency	0.772		0.740		0.754		0.758	

were no farmers in very high or poor categories in Semi-Plain area.

In the Mountain area most of farmers were belonged to medium efficiency category (64.5%) followed by high category (35.5%).

At the aggregate, most of the farmers belonged to medium efficiency category (47.3%) followed by high, low and poor categories (44.1, 7.5 and 1.1%, respectively).

The average of technical efficiency in all the three areas was 0.758, 0.790 and 0.787 in that order. The same for the entire area was 0.782. This showed that rainfed barley in all areas were technically medium efficient.

Irrigated Barley: The technical efficiency for irrigated barley farms the study area is presented in Table 7. The results showed that in Plain area most of the farmers were belonged to medium efficiency category (47.4%) followed by high and low categories (36.8 and 15.8%, respectively) and there was no farmer in very high and poor categories.

In the Semi-Plain area most of the farmers belonged to medium efficiency category (63.6%) followed by low and high efficiency categories (27.3 and 9.1%) and there were no farmers in very high or poor categories in Semi-Plain area. In Mountain area most of farmers were belonged to medium efficiency category (55.8%) followed by high, low and poor categories (27.8, 11.1 and 5.6%, respectively). At the aggregate, most of the farmers belonged to medium efficiency category (54.2%) followed by high, low and poor categories (27.1, 16.7 and 2.1%, respectively).

The averages of technical efficiency in all the three areas were 0.772, 0.740 and 0.754 in that order. The same for the entire area was 0.758. The showed that irrigated barley in all areas were technically medium efficient.

CONCLUSION

As the results shows, there are different variables which effect on barely production both irrigated and rainfed and type of variables differ from one area to another. Therefore, we can say that the behavior of the farmers respect to one crops significantly differ from one to another area. Again results show that, most of the farmers who selected barely as a crop in their annual cropping program either Rainfed or irrigated one as well as are technically less efficient.

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