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Measuring the Technical Efficiency of Canola Farmers and Determining the Effective Factors in Tabriz County, Iran

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Abstract

The purpose of this study was to measure the technical efficiency of canola farmers and determine the underpinning factors. Required data were collected using stratified random sampling method and questionnaire survey. In this context, 157 canola farmers from Tabriz County, Iran, were asked to fill out the questionnaire in 2012-2013 growing season. The technical efficiency was evaluated using stochastic frontier approach. The results of inputs production elasticity indicated that all inputs were consumed in economic area. In addition, the highest (0.504) and lowest (0.095) elasticity rate was related to water consumption and education level, respectively. The estimated technical efficiency demonstrated that the highest and lowest technical efficiencies were 25 and 95% with an average of 80%. It should be noted that the highest efficiency was observed in the farms with the area covering 3-4 hectares. Furthermore, the estimated inefficiency model indicated that education level, training course number, and cultivated area negatively affected the inefficiency. By contrast, age of farmer had a positive effect on inefficiency. As the results show, educating and training farmers for the optimum use of inputs as well as improving their knowledge as to promote agricultural products should be taken into account.

Keywords:
Canola, Stochastic Frontier Function, Tabriz County, technical efficiency

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INTRODUCTION

Self-sufficiency in agricultural products is one of the most important concerns in each country. Since food security is closely associated with the country's political stability, increase in production might be a good solution. It is clear that crop production can be increased in two ways: by increasing the cultivated area or by improving the efficiency. It is obvious that although increasing the cultivated area is the easiest way, there are some limitations; for instance, increasing the cultivated area of a certain crop means stopping the cultivation of other crops. Furthermore, due to water scarcity, especially during the recent years, increasing cultivated area is not a good solution. Therefore, the most logical solution is to increase the efficiency. Generally, increasing efficiency and also identifying its effective factors can be considered as suitable supplement for the established policies that encourage and conserve domestic production (Dashti et al., 2011). Identifying effective factors, implementing proper policies and making careful plans play a crucial role in increasing production through improving efficiency of canola growers in Tabriz County. Consequently, improving efficiency is inevitable.

As oilseeds have high energy, they play an important role in supplying energy in developing countries. Amongst oil seeds, canola contains approximately 40-45% oil, which is extracted for use as a premium edible vegetable oil. The remaining canola meal is widely used as protein source (38-43%) in animal feeds (Ahmadi & Javidfar, 1998). Canola cultivation in rotation with wheat reduces pest and disease as well as weed population. Canola cultivation in East Azerbaijan dates back to 1993. It has been estimated that 810 hectares are allocated to canola production in Tabriz County that produces 70% of province total production (East Azerbaijan Jihad-Agriculture Organization, 2014). Accordingly, the aim of this study was to measure the technical efficiency of canola growers and determine its affecting factors.

Several studies have been carried out on agricultural units' efficiency in Iran and different parts of the world. Rafaty et al. (2011) studied the technical, locative and economic efficiencies of cotton growers using stochastic frontier approach. The average technical, allocative and economic efficiencies were85, 90 and 77%, respectively. The results indicated that the cultivated area, machinery, work force, chemical fertilizer amount and irrigation schedule hadpositive and significant effect on efficiency. Similar results were found by Dashti et al. (2011) who studied technical efficiency of broiler farmers in Songhor and Kolyaee County. They used stochastic frontier approach for estimating technical efficiency. Average technical efficiency was found to be 82.17. In addition, the results showed that day-old-chick-numbers, level of equipment and training courses per year hadsignificant and positive impact on technical efficiency. Pishbahar and Nasiri (2012) measured technical efficiency in strawberry farms using stochastic frontier approach in Kurdistan County. Average technical efficiency was found to be 83%. Inefficiency model indicated that education level, sponsorship, experience and weeding number had negative effect on inefficiency. By contrast, plot number, plant age and plant distance had positive effect on inefficiency. Doorandish et al. (2013) studied technical efficiency in dairy farms using Cobb-Douglas function. Average technical efficiency was 93%. Their results showed that experience, farmer's main job and subsidy management hadpositive and significant effect on technical efficiency. Esfandyari et al. (2013) examined technical efficiency of rice production using stochastic frontier approach and indicated that average technical efficiency was about 83% and that the factors affecting inefficiency were age, education level, farmer's experience, land size, land ownership, and membership in the cooperative production.

Otieno et al. (2012) focused on technical efficiency in beef cattle production in Kenya. The average technical efficiency was found to be 69%, suggesting that there is considerable scope to improve beef production in Kenya. Effective institutional support is also necessary in order to improve efficiency, including improved access to market contracts, better farm management skills and off-farm income opportunities. Agom et al. (2012) measured technical efficiency of cocoa farms in Nigeria using stochastic frontier approach.The average technical efficiency was found to be 69%. There were some variables affecting inefficiency negatively such as farmer age, farm size, education level, farmer gender and history of land use. Karthic et al. (2013) investigated technical efficiency in turmeric reduction using stochastic frontier approach. The results indicated that the average technical efficiency was more than 80% and that the education level and farmers experience negatively affected inefficiency. In addition, variables such as nitrogen and potassium amount, irrigation frequency and machinery showed positive and significant effect on turmeric yield. Adenuga et al. (2013) studied technical and economic efficiency in potato production using stochastic frontier approach and found the average efficiency as to be about 80%. The results showed that farmers' age, their training and credit accessibility hadnegative effect on inefficiency. Trujillo and Iglesias (2014) assessed technical efficiency of pineapple farms using stochastic frontier approach and revealed that education level, farmers' experience and credit accessibility had negative influence on inefficiency. Mohammad and Saghaian (2014) measured technical efficiency in rice farms located in eight different provinces in South Korea from 1993 to 2012 using stochastic frontier approach. Average technical efficiency was 77% and there was no significant difference in technical efficiency between provinces. In addition, family labor was suggested to be replaced by wage labor. Based on the reviewed literature, there are afew studies on the efficiency facets of canola productionwhereas efficiency improvement is the best approach to develop canola cultivation. Thus, the aim of this study is to measure the technical efficiency of canola farmers and determine its affecting factors.

MATERIALS AND METHODS

Efficiency is the ratio of the output to the input value; in fact, efficiency is an inclusive concept consisting of three different areas: engineering, management, and economy. In economy, efficiency means optimal allocation of resources (Mehrgan, 2004). Efficiency is optimum use of resources to produce a specific outcome with a minimum amount or quantity of waste expense, or unnecessary effort. Finally, the unit or units which have the highest output in a certain degree of technology with proper management would have the highest efficiency (Zeranejad & Hajiabad, 2009). Farrell (1957) divided the general concept of efficiency into three parts: technical efficiency, allocative (price) efficiency, and economic efficiency. Technical efficiency is a measure of a farmer's success in producing maximum output from a given set of input. Allocative efficiency is the extent to which a farmer equates the marginal value product of a factor of production to its price. Economic efficiency is calculated by multiplying technical and allocative efficiency. In order to measure efficiency in a certain unit, two common approaches are used: (1) Stochastic Frontier Production Function (parametric), and (2) Data Envelopment Analysis Approach (nonparametric). Since the agricultural production process is a random process, stochastic frontier production function is more common in agricultural studies. Stochastic frontier analysis (SFA) is a method of economic modeling. It has its starting point in the stochastic production frontier models introduced by Aigner et al. (1977). Unlike data envelopment analysis, stochastic frontier production function acknowledges the fact that factors outside the control of the farmer can considerably affect unit's efficiency. The production frontier model proposed by Battese) 1991 (can be expressed as:

$$Yi=f\,(X_i,\,)\;exp\;(V_i-U_i)\quad i=1,\,2\ldots\ldots,\,N. \qquad (1)$$

where, Y_i represents the possible output level of *ith* farm, *fis* an appropriate production function (e.g., Cobb-Douglas or translog), *Xi* is a (1×k) vector of production inputs and, β is a (k×1) vector of parameters to be estimated. The term V_i is a two-sided ($-\infty< V_i<+\infty$) normally distributed random error $V\sim N[0,\ \delta_v^2]$ that represents the systematic error which accounts for random variation in output due to factors beyond the control of farmers. The term U_i is a one-sided ($U_i \geq 0$) efficiency component that captures the inefficiency in production relative to the stochastic frontier. The two components V_i and U_i are assumed to be independent of each other.

The technical efficiency of an individual producing unit is defined in terms of the ratio of the observed output to the maximum production of the corresponding frontier output, given the best available technology (Onyenweaku & Effiong, 2006). Thus, the technical efficiency of ithunit in the context of the stochastic frontier production function is given in the form of equation 2.

$$TEi = Y_i / Y_i^* = F(x_i;\beta)exp(V_i - U_i)/F(x_i;\beta)exp(V_i) = exp(-U_i) \quad (2)$$

where, Y_i is an observed output and Y_i^* is the frontier output. Yi achieves its maximum value of $F(x_i;\beta)$ exp (V_i) if TE_i is 1. Otherwise, a value of TEi less than 1 provides a measure of the shortfall of the observed output from maximum feasible output in an environment characterized by stochastic elements that vary across producers.

The technical inefficiency effect model, U_i, proposed by Batteseand Coelli (1995) is described by

$$U_i = \delta_0 + \delta_1 Z_i + \varepsilon_i \quad (3)$$

where, U_i is non-negative random variable representing inefficiency in production relative to the stochastic frontier in the *ith* form, Z_i is vector of explanatory variables associated with the technical inefficiency effects in the *ith* form, δ is vector of unknown parameters to be estimated, and ε_i is error term. $U_i=0$ means thatthe production is on the frontier and is technical while $U_i > 0$ means that production is inefficient since it will lie below the frontier.

Empirical Model

In this study, the Translog and Cobb-Douglas production functions of frontier model specification for the data were carried out for testing the functional form, inefficiency effect, determinants of coefficients and model best fit to the data. After comparing two functional forms, the results showed that the Cobb-Douglas model fitted the data and the Translog model was rejected. Therefore, the production technology of canola farmers in the studied area was assumed to have been specified by the Cobb-Douglas frontier production function. The Cobb-Douglas functional form is preferable to other forms if there are three or more independent variables in the model (Hanley & Spash, 1993). Thus, the Cobb-Douglas functional form has been widely used in farm efficiency analysis for both developing and developed countries.

The experimental model for investigating stochastic frontier production function is

$$LnTC_i = \beta_0 + \beta_1 LnSa_i + \beta_2 LnLL_i + \beta_3 LnWi i + \beta_4 LnKA_i + \beta_5 LnSeed_i + V_i - U_i \quad (4)$$

where, *Sa* is the pesticide cost (herbicide and insecticide) based on *IRR*[1], *LL* is the work force number (person/day), *W* is the irrigation frequency, *KA* is the amount of consumed fertilizer (kg), Seed is the amount of consumed seed (kg), *Ln* is the natural logarithm, β_i are regression parameters to be estimated while V_i and U_i are as defined earlier.

In order to study the factors influencing technical inefficiency, stochastic frontier production function and the factors affecting technical inefficiency are estimated simultaneously.

$$U_i = \delta_0 + \delta_1 Edu_i + \delta_2 AC_i + \delta_3 Se_i + \delta_4 Amozesh_i \quad (5)$$

where, U_i is the inefficiency term, δ_0 is the constant term, *Edu* is the canola growers education level, *AC* is the cultivated area, *Se* is the canola growers' age and *Amozesh* is the training course number.

Data Sources

Tabriz County is the most populated and historic city in the north west of Iran, and the present capital of East Azerbaijan Province. Agriculture is considered as one of the main pillars of the economy in this city. Tabriz has about 810 hectares (46% of total area) under canola cultivation, with total production of 1,710 tons (70% of total production in province). In this study, the required information and data were collected with a questionnaire filled out by canola growers in 2012-2013 growing season.The statistical population of the study included all canola growers in Tabriz city. According to data published by Ministry of Jihad-Agriculture, there were 198 canola growers

[1] *IRR: Iranian Currency ($1= 25000 IRR)*

in 2012-2013 growing season in Tabriz. In addition, there were reportedly four regions in Tabriz where growers were producing canola including Kojabad (75 farmers), Khosroshah (62 farmers), Mayan-Sofla (51 farmers) and Gharamlak and Khajedizak (10 farmers). Considering the four different regions of canola cultivation, sampling was performed using stratified sampling method. Cochran's formula was used to determine the sample size. The sample number for each region was found as follow: Kojabad 53 samples, Khosroshah 44 samples, Mayan-Sofla 36samples and Gharamlak and Khajedizakseven samples.

RESULTS AND DISCUSSION

According to Table 1, most canola growers (31%) are in the age range of 51-60 years. There is just 3% older than 71 years old. These results indicate that younger farmers are not interested in canola production. The education level results showed 45.2% were illiterate, 29.3% were lowly educated and 25.5% were moderately educated, suggesting that education level among the farmers is low. In case of canola cultivation experience, 14%of the farmers had 2 years or less experience of canola production. In addition, 26% of the farmers had 5-6 years of experience, 19% of the farmers had 7-8 years of experience and 2% of the farmers had 3-4 years of experience (most frequent). There were only 8% of the farmers with more than 8 years of experience. Therefore, we can conclude that there is short history in canola cultivation in the region. Regarding promotion courses, 5-9 sessions per course showed the highest frequency (23%).

Statistical properties of the consumed inputs and canola production in the farms are given in Table 2. The results indicated that average cultivated area was 2.3 hectares. However, the highest frequency (64%) was related to 1.5-3.5 hectares. Therefore, we can conclude that average cultivated area in the region was low. For instance, 20% of farmers were working on lands smaller than 1 ha and 16% were working on lands larger than 3.5 hectares.

Stochastic frontier model as Cobb-Douglas form with, inefficiency model was estimated and the results are shown in Table 3. The results indicated that λ value was significant at 0.01 probability level, suggesting that it is possible to estimate linear inefficiency model and stochastic frontier approach model at the same time. Likelihood ratio test was calculated for

Table 1
Summary Statistics of Qualitative and Quantitative Characteristics of Farmers

Variable	Class	Frequency	Percentage
Age (year)	≤ 30	3	1
	31-40	28	17
	41-50	47	29
	51-60	50	31
	61-70	23	14
	≥71	6	3
Family size(person)	≤ 2	10	6
	3-4	64	40
	5-6	59	37
	7-8	18	11
	≥ 8	6	3
Canola cultivation experience (year)	≤ 2	23	15
	3-4	47	29
	5-6	41	26
	7-8	31	19
	≥ 8	15	9
Number of passed training courses	≤ 1	4	2
	1-4	30	19
	5-9	37	23
	10-14	34	21
	15-19	22	14
	≥ 20	30	19

Table 2
Summary Statistics of the Quantitative Variables in Canola Production

Variable	Unit	Minimum	Maximum	Average	Standard
Irrigation before seed sowing	H	0	69	10.5	2.3
Irrigation during seed sowing	H	8	240	61.63	42.63
Irrigation during plant growth	H	25	765	154.29	129.43
Cattle manure	1000 kg	0	4	0.05	0.405
P fertilizers	Kg	0	600	157.8	105.10
N fertilizers	Kg	0	1000	212.4	155.93
Herbicides	liter	0	10	1.82	1.34
Herbicides cost	IRR	0	2700000	778152.8	5.32
Insecticide	liter	0	5	0.99	0.89
Insecticide cost	IRR	0	2500000	486178.3	4.36
Seed	Kg	6	120	25.8	15.4
Work force for fertilizing during seed sowing	Person/day	0.25	6	1.31	1.04
Work force for irrigation during crop growth	Person/day	3	75	8.5	7.5
Work force for pesticides and fertilizing	Person/day	0.5	8	2.9	1.16
Family work force during seed sowing	Person	0	2	0.96	0.308
Family work force during crop growth	Person/day	0.5	2	1.05	60.38
Seed cost	IRR	17000	17500	17445.8	155.86
Canola yield	1000 kg	0.4	28	5.9	4.63
Cultivated area	Ha	0.5	10	2.3	1.5

Notes: H: hour, Ha: hectare, IRR: Iranian Currency ($1= 25000 IRR) Source: Derived from field survey data 2013

zero tests based on independent variables of inefficiency model ($H_0 = \delta_1 = \delta_2 = \dots \delta_3 = 0$). In fact, technical inefficiency effects were assayed by

$$LR=-2ln\lambda=-2(logL_{UR}-10gL_R)=-2(-234.83-(-21.96)=425.74$$

$LR= 425.74$ $\quad x^2=0.351$ $\quad LR>x^2$

Since the calculated LR value was greater than the critical value (0.351) and it was significant at 5 % probability level, the null hypothesis is rejected suggesting that thewhole regression is significant. Therefore, it can be concluded that there are technical inefficiency effects among farmers so that some part of inefficiency is affected by inefficiency variables.

According to Table 3, in inefficiency model,

Table 3
The Results of Simultaneous Estimation of Stochastic Frontier Production Function, and Inefficiency Affects Models

Variable	Parameter	Coefficients	t-statistic
Stochastic frontier production:			
Intercept	β_0	-1.733	-1.56*
N fertilizer amount	β_{KA}	0.163	-1.72*
Work force number	β_{LL}	0.303	1.94*
Pesticide cost	β_{sa}	0.074	5.01***
Canola cultivated area	β_{AC}	0.15	0.38***
Inefficiency effects model:			
Intercept	δ_0	-1.760	-0.70***
Education level	δ_1	-0.866	-2.09**
Number of training courses	δ_2	-2.37	-2.74***
Farmer's age	δ_3	0.122	2.69***
Canola cultivated area	δ_4	-1.76	-3.58***
Variance parameters:			
Lambda	λ	1.35	22.46***
E(Sigma U)	$E(\delta_U)$	4.32	
E(Sigma V)	σ_v	0.27	
Log-Likelihood	*-234.83*		

Notes: *p<0.1, **p<0.05, ***p<0.01

Table 4
Technical Efficiency Frequency of Canola Growers in Tabriz County

Class (efficiency %)	Absolute frequency	Relative frequency
40	1	0.00636
40.01-50	8	0.05732
50.01-60	9	0.057
60.01-70	9	0.057
70.01-80	30	0.19108
80.01-90	75	0.47770
90.01-100	25	0.15923
	Average 80	
	Standard deviation 0.131	
	Minimum 25	
	Maximum 95	

Table 5
Technical Efficiency Frequency of Canola Growers in Tabriz County Based On Cultivated Area

Absolute frequency	Frequency	Relative frequency	Absolute frequency		
			Min	Average	Max
Less than 1	31	19.78	0.44	0.7786	0.93
1.1-2	68	43.58	0.25	0.7933	0.94
2.1-3	30	12.32	0.42	0.8319	0.95
3.1-4	11	4.51	0.73	0.8510	0.94
4.1-5	8	3.69	0.75	0.8244	0.90
Greater than 5	7	2.87	0.68	0.7770	0.84

there are some significant factors with negative coefficients such as education level. As expected, utilization increases with education level. Therefore, we can use advanced equipment and use inputs properly. Training course number had significant and negative coefficient. Therefore, it can be concluded that inefficiency effect decreases with increasing training courses. These results reveal the effect of educational programs held by Jihad-Agriculture Organization. Cultivated area had significant and negative effect on inefficiency, stating that increases in cultivated are increases canola grower's efficiency. In addition, farmers' age showed a significant and positive effect on inefficiency. The results indicated that older farmers are more conservative and do not prefer to use new technologies which results in lower efficiency.

As shown by Table 4, the average technical efficiency was 80%. On average, canola growers' efficiency is augmentable up to 20%. The lowest and highest technical efficiency of produces was found to be 25 and 95%, respectively. In other words, the difference between minimum and maximum efficiency is 70%. Based on results presented in Table 4, more than 82% of canola growers have technical efficiency of more than 70%.

As mentioned in Table 5, almost 48% of canola growers have efficiency of 80-90%. Therefore, it can be concluded that technical efficiency improvement is one of the efficient methods for increasing production. Technical efficiency frequency in relation to cultivated area is shown in Table 5. Average efficiency of 85.1% was related to cultivated area of 3-4 hectares, and then 2-3 hectares showed average efficiency of 83.19%. Furthermore, average efficiency of farmers working on 4-5 hectares lands was 82.44%. According to these results, average efficiency increases with cultivated area.Theseresults suggest that efficiency in larger units is more than small units. Finally, it can be concluded that with the current technology, management factors and optimum use of inputs can improve technical efficiency among farmers, especially in small scales.

CONCLUSIONS

The results indicated that the difference between the most efficient and inefficient canola growers is 70%. This clearly suggests that there is a considerable gap which can be removed by proper management. In fact, management factors are derived from socio-economic factors, affecting production directly or indirectly. Average technical efficiency of canola growers was 80%. Accordingly, it can be said that if canola growers use current technologies more efficiently, the canola production can increase up to 20%. The results demonstrated that education level, training course number and cultivated area have significant and negative effect on inefficiency, while farmers' age showed a significant and positive effect on inefficiency. Finally, based on the results the highest average efficiency was related to 3-4-halands with average efficiency of 85%. Considering the results, authors suggest that Jihad-Agriculture Organization should use educational and promotional programs to promote farmers' skills. In addition, farmers should be trained in order to choose the best sowing date, irrigation and fertilizing, weed management, harvest time and foliar application of nutrients such as zinc. Considering the gap between canola growers in the region, it is necessary to convey knowledge and information from efficient farmers to other farmers. Considering this fact that the highest technical efficiency was observed in 2-4-ha lands, it is recommended that canola growers use such lands to produce canola. In addition, they should enterprise to integrate small farms.

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