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Estimation of Technical Efficiency of Walnut Orchardists: A Case Study of Kohgilouyeh and Boyerahmad of Iran

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Abstract: Walnut is one of the most valuable and highly used hardwoods for several purposes. Due to particular climate condition, Kohgilouye and Boyerahmad (KB) of Iran has the ideal climate and soil conditions for production of high quality walnut. The aim of this study is to estimate walnut production function and to measure the technical efficiency of walnut orchardists in KB of Iran. Despite the importance of such a research work, the present work is the first one has been conducted in this area in Iran so far and little or no research exists in the literature which has estimated the technical efficiency of walnut orchardists somewhere in the world. To estimate the technical efficiency, the stochastic frontier production function has been estimated using Frontier 4.1 software package provided and developed by Coelli. The Required primary data were gathered in the form of cross sectional survey (120 out of 600 walnut orchardists) in 2008 by questionnaire and interview. Several functional forms including Cobb-Douglas and transcendental production functions were estimated by maximum likelihood method using EViews econometric software. The findings of the research showed that the results of theoretically and empirically examination of several models strongly suggest the Cobb-Douglas form. The production elasticity with respect to fozalon pesticide, iron fertilizer, labor, irrigation water, machinery and planted area are 0.81, 0.212, 0.169, 0.158, 0.097 and 0.093, respectively. The return to scale was increasing. The technical efficiency for walnut production of the province on average is 94 percent ranging from a minimum of 89 to maximum of 99 percent reflecting a high level of technical efficiency. However, some social-economic factors such as the level of experience and the educational level of walnut orchardists, as well as the distance among the walnut trees caused technical inefficiency. It can be concluded that the efficiency is relatively high. However, in order to increase the efficiency there is need for changes in social and economic factors and to focus on the optimal use of inputs particularly on fozalon pesticide, iron fertilizer and labor in the first outset and then to irrigation water, machinery and planted area.

JEL Classification: Q12, C21
Key words: Production function · Frontier · Walnut · Efficiency

INTRODUCTION

Walnut is one of the best known, largest and most valuable hardwoods and highly used for culinary and medicinal purposes. Due to particular climate condition, Kohgilouye and Boyerahmad (hereafter KB) province has the ideal climate and soil conditions for production of high quality walnut. The aim of this study is to estimate the walnut production function in order to assess walnut production elasticity with respect to inputs and the amount of walnut orchardists' technical efficiency in Iran (KB province) in 2008.

A review of related studies shows that Anania and Aiello [1] studied the nut sector in Italy as one of the major world producers and exporters of edible. The results showed that the small size of the walnut farms has caused most of the problems faced by the production of nuts in Italy. The other obstacle is the inadequate quality of a large share of production in the face of increasingly market demands.

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Adem *et al*. [2] conducted a walnut project. The aims of the project were to raise the yield of quality walnuts, decrease the time to reach commercial yields and facilitate the expansion of the walnut industry. The findings of the research suggested a new management system for walnuts using soil modification and improved irrigation technology.

Commission of the European Communities [3] studied the nut sector in European Countries. The results showed that in spite of the positive effects of marketing and quality improvement plans, nut production in the EU has remained noncompetitive.

Russo *et al*. [4] estimated the supply and demand elasticity of walnut in California. The findings showed that walnut production is own-price demand inelastic and the income elasticity is less than one.

Banaeian [5] studied energy use efficiency for walnut producers using data envelopment analysis in Hamadan, Iran. The results showed that 13 walnut producers were producing at an efficient scale, whereas 24 producers were inefficient.

MATERIAL AND METHODS

Two types of data are needed in this study. The secondary data was obtained from statistics published by the Ministry of Agriculture, Management and Programming Organization and Agriculture Research Center. The primary data was gathered by face to face interview and questionnaire completed by 120 out of 600 walnut orchardists in KB province selected randomly.

The commonly used functional forms include the Cobb-Douglas, translog, transcendental, ... would be examined using EViews econometric software. To measure the technical efficiency, estimation of production frontier functions is required [6].

To estimate the technical efficiency the stochastic frontier production function [7] is applied:

$$Y_{it} = f(X_{it}, B)exp(E_{it});\ i = 1, \ldots, n;\ t = 1, \ldots, T$$

where Y_{it} indicates the level of production of i^{th} firm in the year t, X_{it} a k×1 vector of marginal quantity of i^{th} firm in the year t, B is a k×1 vector of parameters and E_{it} is the error term which consists of two components of U_{it} and V_{it}. All specifications of U_{it} and V_{it} fit here as well. The average of V_{it} in the above equation is considered to be equal to U_i. The relation between U_i and V_{it} is as below.

$$Uit = \{ui \exp(-\eta(t-T))\};uit \approx N(\mu, \delta_v^2)$$

The technical efficiency can be obtained from the following equation.

$$TE = \exp[-E(U_i \mid E_i)]$$

Given the constraint of n=0, the above model changes to model in which the amount of technical efficiency assumed to be constant [7, 8, 9]. If the constraint of U=0 is considered, the model changes to Pitt and Lee [10] model. If another constraint as T=1 holds, the above model varies to the main model which was presented by Aigner *et al*. [11]. In the same way, if the constraint U_i=0 is satisfied, Stevenson [12] model is obtained. All of the above models can be estimated using Frontier 4.1 software package provided and developed by Coelli [13, 14, 15].

To estimate parameters of each one of the stochastic frontier production functions, different assumptions regarding distribution of U_i and V_i in the form of below models should be considered.

Model 1: no constraint
Model 2: $\mu = 0$
Model 3: $\mu = \eta = 0$

RESULTS AND DISCUSSION

To estimate the walnut production function, several econometrics models have been examined using EViews. The results of theoretically and empirically examination of several models strongly suggest the Cobb-Douglas form. The logarithmic form of Cobb-Douglas model was estimated and the estimation results of this model are as follows.

$LnY = 4.856 + 0.810Lnx_1 + 0.169Lnx_2 + 0.097Lnx_3 + 0.212 Lnx_4 + 0.158\ Lnx_5 + 0.093\ Lnx_6$
t: 11.37 15.50 2.19 2.06 2.60 2.20 2.50
prb: (0.00) (0.00) (0.03) (0.04) (0.01) (0.02) (0.01)
$R^2 = 0.81$ $\bar{R}^2 = 0.80$ F=53.31 (0.000) DW=2.04
n=100 AIC=□0.040 SC=0.141 SEE = 0.223

Y indicates the quantity of production at kilogram, X_1 fazolun pesticide at liter, X_2 labor at man-day, X_3 machinery at hour, X_4 iron fertilizer at kilogram, X_5 irrigation water at hour and X_6 the planted surface at hectare. All diagnostic tests were satisfactory.

As it seen, the highest elasticity is 0.81for fazolun pesticide; in the sense that a one percent increase in fazolun leads to 0.81 percent increase in output (walnut); followed by iron fertilizer (0.212), labor (0.169), irrigation water (0.158), planted surface (0.93) and machinery (0.097). The return to scale is 1.539, *i.e.* increasing return to scale (or economies of scale) prevails.

Having estimated the walnut production function, attention now should be turned to estimation of technical efficiency of walnut orchardists. The overall results of the estimation of the technical efficiency have been summarized in the following table.

Given the calculated maximum likelihood statistics (ML), we now evaluate the maximum likelihood ratio (λ) to test the two hypotheses of μ=0 and μ=γ=0 regarding model selection.

λ = -2 {Log likelihood (H_0) – Log likelihood (H_1)}
λ =-2 [-12.157 – (-9.025)] = 6.264
λ =-2 [-10.125 – (-9.025)] = 2.2

Rejection of μ=γ=0 and acceptance of μ=0 suggested the maximum likelihood method for estimation of stochastic frontier production function. Therefore, a part of existing difference in production of walnut is due to managerial effect. The significant socio-economic variables were included in the model and some tests performed for model selection.

In the following table, β_1 to β_6 are the coefficients of explanatory variables, δ_1 indicates experience, δ_2 educational level and δ_3 the distance among the walnut trees (socio-economic variables), β_0 represents the intercept of the stochastic frontier production function and δ_0 the intercept of the function of the factors affecting the technical inefficiency.

Since all four hypotheses are rejected, the experience, educational level and the distance among the walnut trees significantly affect the technical efficiency.

The estimation results of the final regression model present in Table 5.

To sum up, based on the result of estimation of the stochastic Cobb-Douglas frontier production function, planted surface, labor, irrigation water, machinery, pesticide and fertilizer significantly affected the walnut production. All input elasticities are less than one referring to the fact that KB walnut orchardists behaved rationally. The highest elasticity is 0.81for fazolun and the lowest 0.097 for machinery. The technical efficiency on average was high (94 percent) ranging from a minimum of

Table 1: Estimation results of stochastic frontier

Model I		Model II		Model III		
Value	SE*	Value	SE	Value	SE	Coef.
4.863	0.467	4.857	0.578	4.856	0.427	β_0
0.810	0.051	0.810	0.050	0.810	0.052	β_1
0.169	0.073	0.169	0.078	0.169	0.077	β_2
0.097	0.046	0.097	0.045	0.097	0.047	β_3
0.212	0.086	0.212	0.077	0.212	0.081	β_4
0.158	0.071	0.158	0.067	0.158	0.071	β_5
0.093	0.036	0.093	0.034	0.0930	0.037	β_6
0.049	0.014	0.048	0.007	0.052	-	δ^2
0.007	0.303	0.00002	0.017	0.050	-	γ
-0.039	0.350	-	-	-	-	μ
-	-9.025	-10.125	-	-12.157	-	ML

*Standard Error

Table 2: Model selection

Result	Tab.* χ^2	df**	Cal.***	H_0****
Rejected	5.99	2	6.264	μ=γ=0
Accepted	3.84	1	2.2	μ=0

*Chi squared obtained from the Table
**Degree of freedom
***Calculated Chi squared
****The null hypothesis

Table 3: Results of frontier production function and factors affecting technical inefficiency

H_0*					
δ_1= δ_2= δ_3=0	δ_2= δ_3=0	δ_3=0	δ=0	MLE**	Coef.***
4.857	5.087	4.94	4.89	4.713	β_0
0.810	0.786	0.805	0.805	0.802	β_1
0.169	0.159	0.196	0.175	0.205	β_2
0.097	0.504	0.092	0.116	0.103	β_3
0.212	0.136	0.198	0.201	0.220	β_4
0.158	0.139	0.135	0.148	0.169	β_5
0.093	0.086	0.096	0.096	0.098	β_6
-0.049	-0.220	0.321	-	-0.003	δ_0
-	0.491	-0.124	0.0007	-0.055	δ_1
-	-	0.185	-0.158	-0.169	δ_2
-	-	-	0.033	-0.079	δ_3
0.0007	0.791	0.010	0.014	0.012	γ
0.048	0.050	0.043	0.051	0.050	δ^2
6.197	7.13	7.118	8.65	11.057	ML

* The null hypothesis
**Maximum Likelihood
***Coefficient

Table 4: Mximum likelihood ratio test

Result	Tab.χ^2	df	Cal.χ^2	H_0
Rejected	3.84	1	4.8	δ_1 = 0
Rejected	5.99	2	7.88	δ_3 = 0
Rejected	7.81	3	7.84	δ_2 = δ_3 = 0
Accepted	9.49	4	9.72	δ_1 = δ_2 = δ_3 = 0

*Chi squared obtained from the Table
**Degree of freedom
***Calculated Chi squared
****The null hypothesis

Table 5: Estimation results of the final model

Coefficient	Variable	Value	SE*
β_0	Intercept	4.713	0.239
β_1	Fazolun pesticide	0.802	0.052
β_2	Workforce	0.205	0.042
β_3	Machinery	0.103	0.079
β_4	Ferric fertilizer	0.220	0.067
β_5	Irrigation water	0.169	0.099
β_6	Planted surface	0.098	0.030
δ_0	Intercept	-0.003	0.868
δ_1	Experience level	-0.055	0.159
δ_2	Education level	-0.169	0.202
δ_3	Distance of the trees	-0.079	0.381
	γ	0.012	0.012
	δ^2	0.050	0.050
	Log likelihood	11.057	-

*Standard Error

89 to a maximum of 99 percent indicating that walnut orchardists can increase output by 6 percent under existing inputs and levels of technology through socio-economic factors. A part of existing difference in production of walnut is due to managerial effect. The significant socio-economic variables were included in the model and some tests performed for model selection.

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