Determining the technical efficiency level of oily sunflower production by Stochastic Frontier Analysis (SFA) Method: the case of Thrace Region, Turkey.

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Abstract

This research aims to measure the efficiency in agricultural enterprises producing sunflower oil in Thrace Region and also to determine the causes of inefficiency. The data of the study have been obtained from 571 agricultural enterprises, which have been determined by using the Stratified Sampling Method, producing sunflower on an area of approximately 5400 hectares. Stochastic Frontier Analysis method has been used to measure the technical efficiency scores of the enterprises examined in the study. Data regarding five inputs is used in the function for Stochastic Frontier Analysis. Also five variables have been included in the technical inefficiency model. According to the results of the analysis, the efficiency scores of the examined enterprises ranged between 0.29 and 0.96, while the average efficiency score has been obtained as 0.80. According to these findings, an average enterprise predicts that sunflower yield can be increased by 17% without making a change in the amount of input it uses. However, it has been calculated that the enterprises operating at a minimum level can increase the sunflower yield by 70%. In the recent study, it has been determined that the sunflower yield per unit area is positively related to the use of seeds, labor and fuel, whereas it is negatively related to the use of fertilizers and pesticides. Findings, which have been obtained in the study, state that increasing the amount of seeds, labor and fuel will raise the amount of sunflower produced, while increasing the amount of fertilizer and pesticides used will cause a decrease in the amount of sunflower obtained. In the study, according to the γ parameter calculated for the inefficiency model in oil sunflower production, it has been concluded that 91% of the variation in sunflower yield is caused by technical inefficiency. The coefficients of age, education and number of parcels in the inefficiency model are negative. This situation indicates that those enterprise owners who are older, have a higher education level, and have more parcels are more effective. However, the results of the research have revealed that the coefficient of the sunflower cultivation area variable has a positive sign and the inefficiency increases as the cultivation area raises in the examined enterprises.

Keywords: Sunflower Production. Efficiency. Stochastic Frontier Analysis. Thrace Region. Turkey.

1. Introduction

Vegetable oils have a significant place in the healthy diet of people. Depending on the increasing world population, the consumption of food products and vegetable oil is also increasing. Sunflower oil ranks fourth in world vegetable oil production after palm, soybean and canola (FAO, 2022). Since the linoleic acid percentage of sunflower oil is higher than all other oilseed crops, its quality is better than the others. On average, 90% of the fat content consists of unsaturated fatty acids and 10% consists of saturated fatty acids (Khan et al., 2015). Inasmuch, it is recommended to reduce the consumption of saturated fat for a healthy diet.

Since oilseed plants provide food, feed and raw materials,they are economically, socially and environmentally significant (Popescu, 2020). There is a worldwide increase in the production of oilseed crops (Soare and Chiurciu, 2018). Sunflower ranks third in world oilseed production. According to 2018 data, 9.52% of the world's raw vegetable oil production is met from sunflower. In Turkey, on the other hand, sunflower is the oil plant with the largest cultivation area and production amount, meeting more than 50% of Turkey's vegetable oil needs. Nearly 46% of raw vegetable oil production is met from sunflower (USDA, 2020; Semerci and Durmuş, 2021).

According to 2020 data, the sunflower production area in the world reached 27.8 million ha and the production amount hit the level of 50 million tons. Turkey, on the other hand, is among the top ten countries with 2.61% in world sunflower production areas and 4.12% in production amount (FAO, 2022). Thrace region of Turkey, which is located in the European continent of the country, meets approximately 40% of the total production area and production amount (TSI, 2022).

Determining the reason for the inability to produce effectively helps to take some precautions, reduce costs and maximize profits. First expressed by Farrell (1957), the concept of efficiency is generally defined as the ability to transform inputs into outputs. Farrell (1957), suggested that the efficiency of the enterprise should be examined in two groups as technical and economic efficiency. He defined technical efficiency as the production of the maximum possible output by making the most appropriate use of the available input combination.

Efficiency and productivity analyzes could be carried out in two categories, namely as parametric and non-parametric, within the framework of the method developed by Farrell (1957). These methods consist of production functions, programming techniques and efficiency boundary concepts. Stochastic Frontier Analysis (SFA) approach is the most significant of the parametric methods, and Data Envelopment Analysis (DEA) is the most used non-parametric method.

In order to increase the amount of production in agricultural production, it is necessary either to expand the production areas or increase the amount of yield obtained from the unit area or animal. In today's world, the increase in production areas could only be achieved at a very limited level. Thus, increasing the yield value obtained from per unit area in agricultural enterprises becomes the first priority. In this context, it is needed to measure the efficiency levels of enterprises.

One of the parametric methods used to measure efficiency scores in agricultural enterprises is Stochastic Frontier Analysis (SFA). A number of researchers have performed efficiency analysis in agricultural production using this method (Sharma et al., 1999; Chakraborty et al., 2002; Masterson, 2007; Odeck, 2007; Külekçi, 2010; Mpeta et al., 2018; Njiku and Nyamsogoro, 2018).

In the present study, it is aimed to measure the technical efficiency of oil sunflower by using one of the parametric methods (Stochastic Efficiency Limit Method) in agricultural enterprises in Thrace Region, which is the most important oilseeds production center of Turkey. Depending on the data obtained as a result of the analyzes made in this research, a number of suggestions have been made in order to increase the efficiency level of the enterprises.

2. Literature Review

Information about the technical efficiency analysis in sunflower production using the stochastic frontier analysis method is give in this section.

In their research, carried out in Russia, Skold and Popov (1992) calculated the average technical efficiency score in 87 sunflower production enterprises.

Grazhdaninova and Brock (2004) determined the technical efficiency score for the sunflower production enterprises they examined in their research. In the study, land, labor, seed, fuel, tractor variables are included in the stochastic frontier analysis equation. In the inefficiency model, however, variables such as the proximity of the business to the city center, positive profit and whether the business is new or not are included.

Okwir (2009) calculated the technical efficiency score as minimum, maximum and average score values in sunflower producing businesses in his research in Uganda. In the technical inefficiency analysis in the research; variables such as the education level of the owner, professional experience, contract farming and access to credit were used.

In his research in Iran, Bagherzadeh (2010) calculated the technical efficiency scores of the enterprises in addition to the technical analysis of the sunflower producing enterprises.

Dafallah (2010) calculated the γ value related to the inefficiency model as well as the technical efficiency score in sunflower production in his study in Sudan. As a result of the research, it has been concluded that the variables such as age group of the owner of the business, gender, education level, household size and communication with extension services are effective in the technical inefficiency of the enterprises.

In the research conducted by Külekçi (2010), however, the technical efficiency score of the sunflower producing enterprises was calculated as minimum, maximum and average values. Variables such as capital, labor and land are included in stochastic frontier analysis. In the inefficiency model, however, the variables of the producer's age, education level, professional experience, household size, credit utilization status, business size and the producer's information resources status are included. The findings obtained as a result of the research were compared with other research findings.

In the study carried out by Henningsen et al. (2015), the technical efficiency score was determined for contracted and non-contracted sunflower enterprises. Variables such as land, labor and seed are included in the stochastic frontier model.

On the other hand, Khatun et al. (2016), in their research on 100 sunflower producers in Bangladesh, included variables of human labor, seeds, land preparation cost, irrigation cost, organic fertilizer, and dummy variable for chemical fertilizer for the land in the stochastic frontier model. In the inefficiency function, however, variables such as producer's age, education level, household size and business size are included. In the study, the γ value was calculated for the inefficiency function. In addition to this, within the scope of the research, the average, minimum and maximum values of the technical efficiency score for enterprises were calculated.

In a study conducted with 400 sunflower producing enterprises in Tanzania, Mpeta et al. (2016) estimated the average, minimum and maximum scale technical efficiency score for the enterprise-wide in sunflower production.

In the research conducted by Parlakay (2016), the cost analysis of the sunflower producing enterprises was carried out and the minimum, maximum and average technical efficiency scores of the enterprises were calculated. In the study, variables of labor force, pesticide, nitrogen and phosphorus and machinery rental value were included in the stochastic frontier analysis.

In another research conducted with 113 sunflower farms the technical efficiency and pure technical efficiency scores for sunflower were calculated as 0.82 and 0.92, respectively (Karadaş and Külekçi, 2020). Oguz and Ogur (2022) calculated the technical efficiency value (TE) of sunflower as 0.874% in their study conducted with 51 agricultural enterprises.

3. Materials and Methods

3.1. Materials

In the recent research, the data on sunflower oil production were obtained from 571 agricultural enterprises located in the provinces of Edirne, Kırklareli and Tekirdağ, which form the Thrace part of Turkey, and the settlements on the European side of Çanakkale and Istanbul. Enterprises were determined by the Stratified Sampling Method.

The Ministry of Agriculture "Farmers' Registration System" has been referred to establish the sampling frame in the research. In the determination process of the enterprises to be surveyed, assistance has been received from the technical staff of the Ministry of Agriculture, who have had sufficient experience in the region. In the mean time, within the scope of the study, theses, project reports and various publications related to research conducted in different countries on sunflower have been benefitted. In the literature review, it has been observed that there are very few studies on technical efficiency analysis in sunflower production using the stochastic frontier analysis method.

3.2. Methods

3.2.1. Stochastic Frontier Analysis Method

In the analysis of the data, the Stochastic Frontier Analysis method, which is one of the analysis methods used to measure the efficiency levels of the enterprises, has been applied. In the stochastic frontier approach, two error terms are added to the model while examining the effects of random factors that are not under the control of the enterprise. One of them is a symmetrical error term, which is consisted of coincidence and chance-related factors that are not under the control of the enterprise, and the other one is an error term that takes values between zero and greater than zero and represents deviations arising from inefficiency. Stochastic Frontier Analysis parameters are calculated with the highest likelihood method.

Aigner et al., (1977), Meusen and Broeck (1977) and Battese and Corra (1977) developed the Stochastic Efficiency Frontier (SEF) approach for estimating efficiency in production using the production function.

$$Yi = Xi\beta + \varepsilon i \qquad \textbf{(1)}$$

SEF approaches remain the most significant parametric method used in estimating production efficiency. Aigner et al., (1977) and Meusen and Broeck (1977) formulated the production function as follows by stating that the error term (i) of the production function consists of two independent components.

$$Yi = Xi\beta + vi - ui \qquad \textbf{(2)}$$

$$vi - ui = \varepsilon i \qquad \textbf{(3)}$$

Y*i* : *i.* the production function of the enterprise (the output of the ith decision unit),

X_i: *i.* shows the firm's input vector [(K+1) dimensioned input line vector],

β: shows the coefficient [(Kx1) dimensioned input vector's parameters],

v_i: is the variable that the enterprise owner cannot control (such as temperature, humidity and natural disaster) and that is random variable independent from *N (0, σ2 v)*.

u_i : is the variable that is not negative and reflects the technical inefficiency by using enterprise specific characteristics. Also it shows half normal, discrete normal or exponential distribution depending on the function used ui. The anti-logarithm of (U) gives the technical efficiency of the ith decision unit. K is the number of inputs, X and Y values are inputs and outputs expressed in logarithmic form.

In this study, the Ineffectiveness Factors (TE Effects) Model has been used in order to determine the effects of external factors on efficiency. In this model, efficiency scores and external variables that may cause inefficiency are included in the model together. And the production limit and the effects of external factors that may cause inefficiency are examined in a single step.

$$ui = zi\,\delta \qquad \textbf{(4)}$$

In the formula,

z_i : represents the explanatory variables such as education, age, which reflect the specific characteristics of the enterprise that affect the technical efficiency of the enterprise,

δ : shows the coefficients of the variables in the vector.

With the stochastic efficiency frontier approach, the efficiency of a firm is determined as the ratio of the observed output to the estimated output using equation 1 (Coelli et al., 2005). Accordingly, the technical efficiency is formulated as follows.

$$TE = \frac{e^{xi\beta+vi-ui}}{e^{xi\beta+vi}} \quad \textbf{(5)}$$

$$= e^{-ui} \quad \textbf{(6)}$$

Here, if =0, it indicates full efficiency. Coelli (1995) stated that the maximum likelihood method is more suitable than the least squares method in estimating production functions. In this study, the Cobb-Douglas type function with discrete normal distribution, which has been developed by Battese and Coellli (1995 maximum likelihood method has been estimated by using maximum likelihood method. It has been revealed that mostly Cobb-Douglas and Translog type production functions are used in the efficiency analysis using the Stochastic Efficiency Limit (Wadud and White, 2000; Okoye and Onyenweaku, 2007).

Summary statistics of the variables used in the study are given in Table 1. In technical efficiency analysis, sunflower production amount as output (kg da^{-1}), seed amount as input (kg da^{-1}), fertilizer costs (USD da^{-1}), pesticide costs (TL da^{-1}), labor (hour da^{-1}) and fuel oil amount (lt da^{-1}) have been determined. Frontier 4.1 program has been used in the analysis.

Table 1: Summary statistics of variables used in sunflower production

Variables	Minimum	Maximum	Average	Standard deviation
Output				
Sunflower production amount (kg da^{-1})	0.63	10800.00	183.83	654.10
Inputs				
Yield (kg da^{-1})	0.00	24.00	0.40	1.49
Fertilizer (USD da^{-1})	0.00	936.24	12.60	58.01
Medicine (USD da^{-1})	0.00	69.80	1.86	6.03
Labor force (hr da^{-1})	0.04	380.95	5.20	20.69
Fuel (lt da^{-1})	0.05	720,00	9.87	38.24

Moreover, as the factors affecting technical efficiency, factors such as the age of the operator, education level, sunflower cultivation area, number of parcels have been included in the inefficiency factors model.

3.2.2. Sampling Method

Within the scope of the study, in the determination of sample volume, statistical formula proposed by Neyman, which is one of the Stratified Sampling Methods, has been used (Yamane, 1967).

$$n = \frac{[\Sigma(Nh * Sh)]^2}{N^2 * D^2 + [\Sigma(Nh * Sh)]^2} \quad \textbf{(6)}$$

$$D^2 = \left(\frac{d}{t}\right)^2 \quad \textbf{(7)}$$

In the equation;

N: Sample size,

N_h: Number of enterprises in the sampling frame of layer h,

S_h: Standard deviation of data in layer h,

S_h^2: Variance of data in layer h,

t: Table value for a certain confidence interval,

N: The total number of enterprises in the sampling framework,

d: A certain % deviation from the mean.

Within the scope of the research, primarily the settlements to be surveyed have been selected. For this purpose, 53 villages have been determined (with 95% confidence interval and 4% deviation from the mean) considering the sunflower cultivation areas of the settlements throughout the Thrace Region. The distribution of the number of surveys applied within the scope of the research by provinces and settlements is given in Table 2.

Table 2: Number of surveys conducted in the research area and distribution by provinces

Province Name	Number of Settlements Surveyed in the Province (item)	Number of Surveys Applied (item)	Share of Province (%)
Tekirdağ	21	233	40.81
Edirne	16	175	30.65
Kirklareli	11	116	20.32
Istanbul	3	26	4.55
Canakkale	2	21	3.68
Research Area (Total)	53	571	100,00

In the further stage, 571 farms have been determined (with 95% confidence interval and 1% deviation from the mean) considering the sunflower cultivation areas and the number of farms in the selected villages. The data used in the research have been obtained by face-to-face survey application from sunflower production enterprises located in Edirne, Kırklareli, Tekirdağ, Istanbul and Çanakkale provinces in order to cover the whole of Thrace Region, which is located in the European part of Turkey.

4. Research Findings

Oil sunflower has a significant place in world oil seed production. Examining the 2010-2020 period, it is seen that the world oil sunflower production areas have increased by 20.97%, the production amount increased by 59.91% and the yield value increased by 32.11% (Table 3).

Table 3: Sunflower cultivation area, production and yield in the world

Years	Production Area (ha)	Production Amount (tons)	Yield (kg da^{-1})
2010	23024300	31411300	136.43
2015	24527800	42300000	172.46
2020	27874300	50229600	180.20

Source: FAO, 2021.

In Turkey, sunflower oil is in the first place in terms of vegetable oil source and oil consumption. In the 2010-2020 period, it is seen that the oil sunflower production areas of the country increased by 13.57%, the production amount increased by 56.59% and the yield value increased by 37.43% (Table 4).

Table 4: Sunflower cultivation area, production and yield in Turkey

Years	Production Area (ha)	Production Amount (tons)	Yield (kg da^{-1})
2010	641300	1320000	205.82
2015	685200	1680700	245.30
2020	728400	2067000	283.79

Source: FAO, 2021.

Considering the year 2020 data, Turkey constitutes 2.61% of the world sunflower production areas and 4.12% of the production amount. These data show that Turkey has a significant position in world oil sunflower production.

In 2021, 2,415,000 tons of sunflower was produced in a total area of 901153 ha in Turkey. Oil sunflowers constituted 91.72% of the country's sunflower production amount and 90.03% of the production areas (TSI, 2022). The distribution of sunflower production by provinces in Turkey is given in Table 5.

Table 5: Distribution of sunflower production by provinces in Turkey

Provinces	Production Area (ha)	Share (%)	Production Amount (ton)	Share (%)
Tekirdağ	166300.7	18.45	399531	16.54
Konya	93373.8	10.36	324790	13.45
Edirne	107350.8	11.91	285286	11.81
Kırklareli	91161.9	10.12	226163	9.36
Adana	65173.3	7.23	201366	8.34
Others	377792.6	41.92	977864	40.49
Total	901153.1	100.00	2415000	100.00

Source: TSI, 2022.

Thrace is a region with a highly rich history, which includes the lands of southern Bulgaria, northeastern Greece and Turkey in the European continent located in Southeast Europe. This region, which has an area of 23764 km^2 within the borders of Turkey, has borders with the Black Sea, the Marmara Sea and the Aegean Sea. In Turkey, 40.48% of the sunflower production areas and 37.71% of the production amount are met by the Thrace sector. The general feature of Thrace, which has been determined as the research area, is that all sunflowers produced are oil type sunflowers.

In Stochastic Frontier analysis, technical efficiency scores are calculated for the output. The purpose of output-oriented measurements is to determine how much the output amount can be increased proportionally without making any changes in the amount of inputs used. Considering this situation for sunflower production in this study; it is the determination of the increase that can be made in the amount of sunflower obtained without changing the amount of seeds used, the cost of fertilizers, the cost of agricultural pesticides, labor and fuel oil.

It is commonly known that the scores obtained as a result of the efficiency analysis vary between 0 and 1. The closer the score is to 1, the more effectively the company uses its resources. In the analyzes using the stochastic frontier method, the effective limit is determined according to the obtained production function. Therefore, the highest score is not 1 in the SFA method. The results of the SFA model used in the research are given in Table 6. According to the results of the analysis, the efficiency scores of the examined enterprises ranged between 0.29 and 0.96, while the average efficiency score has been obtained as 0.80. According to these findings, an average farm shows that sunflower yield can be increased by 17% (1-80/96) without making a change in the amount of input it uses. Besides, enterprises operating effectively at a minimum level can increase sunflower yield by 70% (1-29/96).

While examining the relationship between socio-economic variables and the obtained technical efficiencies, Ordinary Least Squares and Highest Likelihood methods have been treated in estimating the coefficients of the model, and the method with a higher Log likelihood result (-71.15) (Highest Likelihood) has been chosen. The Highest Likelihood results of SFA are given in Table 6.

Table 6: Highest likelihood estimates of coefficients in the technical inefficiency model

Variables	Parameter	Coefficient	Standard Error	t-ratio
Stochastic Frontier Analysis				
Constant	$_0$	5,802***	0.160	36.370
Ln (Seed)	$_1$	0.804	0.052	15.547
Ln (Fertilizer)	$_2$	0.007	0.002	-3.256
Ln (Agricultural Pesticide)	$_3$	0.007	0.003	-2.209
Ln (Labor)	$_4$	0.057	0.021	2.780
Ln (Fuel)	$_5$	0.123	0.047	2.624
Technical Inefficiency Model				
Constant	$_0$	-0.776	1,024	-0.757
Age	$_1$	-0.004	0.007	-0.550
Training	$_2$	0.032	0.027	-1.187
Number of Parcels	$_3$	-0.014	0.019	-0.720
Sunflower field	$_4$	0.001**	0.001	2.087
Variance Parameters				
	γ	0.907***	0.054	16.842
	^{2}	0.351*	0.211	1.660
Log. possibility func.		-71.15		
LR test		47.52		
Average Technical Efficiency Score		0.80		
Minimum Technical Efficiency		0.29		
Maximum Technical Efficiency		0.96		

*Significant at ; *0.1; **0.05; *** 0.01 significance level.*

It has been determined that sunflower yield per unit area is positively correlated with the use of seeds, labor and fuel, and negatively correlated with the use of fertilizers and pesticides, and the relationship between the variables has been found to be statistically significant.

According to the obtained findings, increasing the amount of seeds, labor and fuel will also increase the amount of sunflower produced, while increasing the amount of fertilizer and pesticides used will cause a decrease in the amount of sunflower obtained. The γ parameter of the Technical Inefficiency Model has been calculated as 0.91 and is statistically significant. This value indicates that 91% of the variation in sunflower yield is due to technical inefficiency.

Table 6 shows the hypothesis tests of the technical efficiency coefficients. The first null hypothesis has been rejected. In other words, it could be said that the production function, which is the inefficiency model, has sufficient representative ability for the analyzed data. The LR value has been found as 47.52 in the null test of the analysis performed with the production function that does not include ineffectiveness variables. This value is statistically significant at the 5% level according to the chi-square table.

Among the socio-economic variables, coefficients of age, education and number of parcels negatively signed. Being with a negative sign amounts to that from the enterprise owners, the ones who are older, have a higher education level, and have more parcels are more effective. However, among these variables, only education is statistically significant. The coefficient of the sunflower cultivation area variable has a positive sign and is statistically significant at a level of 5%. In other words, as the cultivation area increases, inefficiency increases as well (Table 7).

Table 7: Hypothesis tests of technical efficiency coefficients

Variables	Zero Hypothesis	Log Likelihood	t-statistic(λ)	Critical value	Decision
Constant: $_0$	H_0: γ :δ_0 =...=δ_7= 0	-71.15	47.52	12,59[a]	H_o: Rejection
Age : $_1$	H_1:δ_1 = 0	-71.29	0.29	3,84[b]	H_1: Acceptance
Education : $_2$	H_2:δ_2= 0	-71.56	0.82	3,84[b]	H_2: Acceptance
Number of parcels: $_3$	H_3:δ_3= 0	-71.64	0.98	3,84[b]	H_3: Acceptance
Sunflower area: $_4$	H_4:δ_4= 0	-74.01	5,72	3,84[b]	H_4: Rejection

a) Degree of freedom: 6; b) Degree of freedom: 1; (at 0.05 significance level)

In a study conducted in Russia, the average technical efficiency score has been determined as 64.1% in 87 sunflower production enterprises (Skold and Popov, 1992). In another study, the technical efficiency coefficient has been determined as 65% in sunflower producing enterprises. Land, labor, seed, fuel, tractor variables in the stochastic frontier analysis equation have been found to be statistically significant at a level of 5%. Among the variables in the inefficiency model, the proximity of the business to the province center, positive profit and whether the business is new or not have been statistically significant at a level of 5%. In the study, the γ parameter of the technical inefficiency model has been calculated as 0.99. This value indicates that 99% of the variation in sunflower yield is due to technical inefficiency.

In a study conducted in 196 agricultural enterprises in Uganda (Grazhdaninova and Brock, 2004), the technical efficiency score was determined as minimum 16.76%, maximum 96.20%, and average score 81.20% in sunflower producing enterprises. In the recent study, however, it has been determined that the education level of the business owner, professional experience, contract farming and access to credit variables have a statistically significant effect on technical inefficiency in the technical inefficiency analysis.

In a study conducted in Iran, Okwir (2009) calculated that the technical efficiency score of sunflower producing enterprises was as 53%.

Bagherzadeh (2010), on the other hand, found in a study on sunflower producing businesses that the average technical efficiency score was 64% for businesses in general. The calculated value has been determined as 73% for larger enterprise groups and 58% for small-scale enterprises. The variables in the stochastic frontier analysis were found to be statistically significant at the level of 1% for the capital, 5% for the land and 10% for the labor force. As for variables in the inefficiency model such as age and education have been found statistically significant at a level of 10%, household size at 5%, firm size and producer's experience variables at a level of 1%. The analysis revels that the difference between business size groups has been statistically significant at the 1% level. In the study, the γ parameter of the technical inefficiency model has been calculated as 0.78. This value indicates that 78% of the variation in sunflower yield is due to technical inefficiency. These values indicate that large-scale enterprises work more effectively than small-scale enterprises. The value calculated for the whole enterprise shows that the same production level could be reached even with a 56% decrease in the use of inputs (Külekçi, 2010).

In other study, the technical efficiency score of sunflower production has been determined as 83.9% in enterprises producing without a contract, and 51.6% in contracted enterprises. In the stochastic frontier model, variables of land, labor and seed have been found to be statistically significant at the 5% level (Henningsen et al., 2015).

In another study on the same issue, the technical efficiency score has been determined as 87%. In the examined enterprises, the minimum technical efficiency coefficient has been found as 48% and the maximum technical efficiency coefficient as 98%. In the study, pesticide, nitrogen and phosphorus variables have been found to be statistically significant at the 10% level in the variables included in the stochastic frontier analysis. In the study, the γ parameter of the technical inefficiency model has been calculated as 0.93. This value indicates that 93% of the variation in sunflower yield is due to technical inefficiency. The study has revealed that an 11% increase in the production amount could be achieved without changing the current usage amount and production technologies of the inputs in the examined enterprises (Parlakay, 2016).

In the stochastic frontier model of the research conducted on 100 sunflower producers in Bangladesh, dummy variables such as human labor, seeds, land preparation cost, irrigation cost, organic fertilizer, chemical fertilizer and land have been found. Except for the cost of land preparation and chemical fertilizer variables, other variables have been found to be statistically significant. In the inefficiency function, however, variables such as the age of the producer, his/her education level, household size and business size have been included, and among these variables, education and household size have been found to be statistically significant. The γ value of the inefficiency function is 28.4% and is significant at the 1% level. The average technical efficiency score of enterprises has been measured as 86%, minimum as 72%, and maximum as 97%. In the recent research, it has been determined that 46 of the 100 sunflower production enterprises have a technical efficiency score of 70%-79%, 37 of them are in the range of 80%-89%, and 17 enterprises are in the range of 90% and above. It has been concluded that sunflower production could be increased by 26% in enterprises with minimum value and 11% in enterprises with average value (Khatun, et al., 2016).

In a study conducted with 400 sunflower producing enterprises in Tanzania, the average technical efficiency score for the enterprises in sunflower production was determined as 66%. In the study, the technical efficiency score as been calculated as a minimum of 4% and a maximum of 99% (Mpeta et al., 2016).

In the recent study, the calculated the technical efficiency score (80%) has been has been found higher than the values in the studies conducted by Skold and Popov (1992), Grazhdaninova and Brock (2004), Bagherzadeh (2010), (Dafallah, 2010), Külekçi (2010) and Mpeta et al. (2016 whereas it has been found lower than the values found by Okwir (2009), Henningsen et al. (2015), Khatun et al. (2016) and Parlakay (2016). In the study, the γ parameter (91%) of the inefficiency function is smaller than the values calculated by Grazhdaninova and Brock (2004) and Parlakay (2016), while it has been found to be higher than the value determined by Külekçi (2010) and Khatun et al. (2016).

Variables in stochastic frontier analysis and inefficiency function and research findings related to these variables may differ from province to province, region to region and country to country. Naturally, the results of these studies could also affect the level of research findings. In general, it could be said that the technical efficiency score and the γ parameter value of the inefficiency function obtained in this study seem to be in line with the findings obtained in other studies.

5. Conclusion and Recommendations

Among the oilseed plants in the world, sunflower is a significant plant both in the world and in Turkey in terms of its economic value. Turkey is one of the countries where the sunflower supply cannot meet the demand and the resulting deficit is met through imports. The country's imports for oilseeds and their derivatives are on average 3.5 billion USD per year. Sunflower ranks first in Turkey's vegetable oil consumption. The country's self-sufficiency rate in this product is around 65%, and there are as much annual sunflower production as the imports or imports of sunflower oil.

This study has been carried out in the Thrace Region, which constitutes approximately 40% of Turkey's sunflower cultivation areas and production amount. The research has included 571 agricultural enterprises located in 5 provinces, 25 districts and 53 settlements. The sunflower production activity, which is carried out on an area of approximately 5400 ha in the examined enterprises, is 43% in the vegetative production pattern and the income obtained from sunflower constitutes approximately 20% of the total agricultural income of the enterprises.

In the Thrace Region, where the research was carried out, sunflower is the most important crop in alternation with wheat. Thus, analyzing the efficiency level of input use in sunflower production activity has significant results for producers in practice. Because rational use of inputs does not only ensure that the inputs used in sunflower production are given at the desired level and time by the plants, but also makes it possible that significant savings are achieved in both labor and input costs. This situation allows agricultural enterprises to produce on an economic scale. Thus, businesses can have higher competitiveness both on a national and global scale compared to other agricultural businesses that make the same production.

Stochastic Frontier Analysis (SFA) method is used to determine the efficiency level of agricultural enterprises in agricultural production. In this research, the technical efficiency analysis of sunflower production in Edirne, Kırklareli and Tekirdağ provinces located in Thrace, which constitute the European continent of Turkey, and in the provinces of Istanbul and Çanakkale in the Thrace part, has been carried out using the Stochastic Frontier Analysis (SFA) method.

The average technical efficiency score of the enterprises examined in the study has been determined as 80%. This value varies between 29% and 96% in enterprises. When compared with other research findings on the same issue, it seems that it is generally a higher value. However, the fact that the lower limit range is around 30% indicates that the use of inputs in these enterprises is not still effective. Research findings show that the productivity level in sunflower production in enterprises could be increased by 17%-70% without increasing the amount of input used per unit area.

The results of the research reveal that as the use of fertilizers and pesticides in sunflower production increases, there is a decrease in production. This situation reveals that an intensive training program should be applied on the use of fertilizers and pesticides on sunflower producing enterprises. Likewise, unconscious use of fertilizers and pesticides in sunflower production also negatively affects the production cost. In the analysis made in the research, it has been revealed that approximately 90% of the changes in efficiency are due to technical inefficiency.

It is understood that among the enterprise owners examined within the scope of the research, the older ones and those with a higher education level work more effectively. The research findings show that priority should be given to enterprises with owners of higher education level as well as professional experience and age in the projects and support practices to be made for businesses producing sunflowers.

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