Technical efficiency of almond farming in Muğla Province, Turkey: An application of Stochastic Frontier Analysis

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Abstract

The study aims to investigate the technical efficiency and determine the factors affecting inefficiency in almond farms in Muğla province, Turkey. For this aim, the stochastic frontier analysis approach is employed. The data were collected through surveys conducted by face-to-face interviews with 93 almond farmers in Muğla province, Turkey. It was determined that the average technical efficiency score is 94% for almond farmers in the sampled area. This result indicates that the average almond producer is highly efficient and can increase his output by another 6% by developing the use of his existing inputs without additional inputs. Furthermore, it was determined that the total number of almond trees owned by the farm and the average age of almond trees have a positive effect. However, the variable costs and almond area of the farm have a negative effect. According to Stochastic Frontier Analysis results, the farmers' age, education level, agricultural experience, experience in almond production and the number of the person in the family explain the inefficiency of the farmer in almond production. The farmers' age and the number of the person in the family have a negative effect while education level has a positive effect on efficiency. Also, according to the results, it is understood that the well-educated farmer will execute better and more advanced production systems than the less educated one. At the same time, higher experience in agricultural and/or almond production will result in higher efficiency. The results could be helpful to provide some beneficial suggestions for the policymakers and the producers. Furthermore, the study may conduce to project future research on a large scale.

Keywords: Almond. Stochastic Frontier Analysis. Technical Efficiency. Turkey

1. Introduction

The homeland of the almond fruit is the mountainous regions of Central and Western Asia. From here, the almond spread and settled completely in China, India, Northern Iran, Syria, and Mediterranean countries. Today, the most almond-growing region in the world is the Mediterranean region. Its cultivation in this region reaches 600 to 1000 meters. At higher latitudes and altitudes, it is difficult to grow economically because the fruits are damaged and the total temperature is insufficient for the ripening of the fruits due to late spring frosts (TOB, 2020). Despite this situation, the current gene potential of Turkey has been enriched with the import of standard varieties in recent years and there is a wide gene potential. Thus, research on late-flowering almond varieties has started to attract attention in Turkey as well as all over the world (Demircan et al., 2019 cited in Ozsu, 2003).

Almond cultivation in Turkey, which was initially limited to only the Aegean, Mediterranean, and Eastern Anatolian Regions, has been expanding in recent years with the establishment of new orchards in other regions. The high ability to adapt to difficult conditions and the high demand in the market make almond cultivation attractive. There has been an increase in the new almond orchards, especially in the Southeast Anatolian Region. Aegean and Mediterranean Regions supply 61% of the total almond production while these four regions supply 78% of it (TOB, 2020).

World almond production is 3.2 million tons on an area of 2.1 million hectares in 2018, and Spain is the country with the highest production area. Spain is followed by the USA, Tunisia, Morocco and Iran. Regarding Turkey, she is in 10th place. The USA ranks first in the world in almond production with 1.9 million tons. She is followed by Spain, Iran, Morocco and Turkey. Although the production area of Spain is 50% more than the USA, her production amount is 18% of the USA due to the USA's possible higher productivity (FAO, 2021). Almond production in Turkey is 150 thousand tons in 2019. Consumption per capita is 1.4 kg, and annual consumption is 114 thousand tons for the same year. Also, the adequacy ratio in fulfilling the almond need is 75.7%. The province of Muğla, where the research was conducted, ranks 3rd after Mersin (%15) and Adıyaman (10%) with a share of approximately 7% in production (9 955 tons) (TOB, 2020).

The world almond export value was approximately 1.5 billion dollars in 2017. The USA, which ranks first in production, is the country that exports the most almonds. She is followed by China, Australia and Benin (FAO, 2021). Turkey's almond export amount was 7 977 tons, and the export value was 77.7 million dollars in 2019 (TUIK, 2021). India takes first place in imports with 136 112 tons, followed by China, Turkey and the United Arab Emirates (FAO, 2021).

Kuden (2016) emphasized that the yield and quality will increase further with the availability of cold-resistant and late-flowering types and varieties of almond, which has a very high economic value. Although it is one of the oldest fruit species in Anatolia, they were not given due importance in the past and were generally grown as a border tree on the edges of the fields. Since the almond needs of the increasing population could not be met, larger and better quality almond fruits were imported and sold at high prices. That's why the Republic of Turkey Ministry of Forestry and Water Affairs (currently Republic of Turkey Ministry of Agriculture and Forestry) initiated the 'Almond Action Plan' in 2013 to increase the amount of almond production, diversify the economic activities in the rural, increase the income levels of the rural dwellers, and increase the employment opportunities in the rural by afforestation in Turkey (Kuden, 2016). Furthermore, almond contains a good source of vitamins and minerals (E, magnesium, copper, riboflavin (B2), phosphorus, iron and calcium), a small amount of protein, and high-fat which protects from the effects of ageing and many diseases. It is widely consumed as a snack and in the confectionery, chocolate and pastry industries. Also, it has an important place in the oil, cosmetics, and pharmaceutical industries. These situations make the almond quite important to determine its' efficiency (TOB, 2021). Therefore, increasing productivity mostly cognate with greater earnings will be a significant effort for farmers in particular and the national economy in general.

The research aims to obtain a statistical evaluation of the profit efficiency for almond farmers in Muğla, Turkey, via a stochastic profit frontier approach. This analysis provides useful information in evaluating the technical efficiency of each farmer and correlating their scores with the socioeconomic variables. In addition, the study explores the factors affecting efficiency. Investigating and understanding these factors are essential to project the policies and to make the necessary interventions in the sector. The article is structured in four sections. The second section provides an overview of previous literature. Then the research method is presented in Section 3. Finally, the results are presented and discussed in Section 4.

2. Literature Review

There are various studies in the form of both cultivations (Lena et al. 2018; Parker and Abatzoglou, 2018) and economic (Sottile, Massaglia and Peano, 2020; Exposito and Berbel, 2020) analysis on almond fruits. Efficiency studies within the scope of economic analysis are also quite extensive in the world (Bravo-Ureta and Riger, 1991; Alemdar and Oren, 2006; Nadolnyak, Fletcher and Hartarska, 2006; Masterson, 2007; Cakmak, Dudu and Ocal, 2008; Parlakay and Alemdar, 2011; Wijayanti, Darwanto and Suryantini, 2020). Furthermore, these researches are becoming widespread in Turkey day by day. However, as far as is known, there were not enough studies to determine the technical efficiency and the factors causing inefficiency for almond farmers, and only two studies could be found (Yazdani, Eshraghi and Poursaeed, 2006 and Moradi, 2011).

Yazdani et al. (2006) try to examine the comparative advantage and estimate the technical efficiency of almond production employing the Stochastic Frontier Analysis (SFA) method in Iran. They found the average technical efficiency was 0.81 which was a potency for increasing almond yield. Moradi (2011) analysed the technical, allocative and economic efficiency of almond farms in Sirjan city, Iran, and used the Stochastic Frontier Production and Cost Function methods for this aim. They claimed that the technical, allocative and economic efficiency of sampled 41 almond farms are 69%, 64% and 44%, respectively.

Some studies on this subject have been done on products, such as cotton (Gunden, 1999), wheat (Alemdar and Oren, 2006), corn (Kacira, 2007), and tobacco (Oren and Alemdar, 2006) in plant production, and dairy and beef cattle breeding (Koyubende and Candemir, 2006; Binici, Demircan and Zulauf, 2006) in animal husbandry in the agricultural sector in Turkey.

For example, Bravo-Ureta and Rieger (1991) examined the technical, economic and allocation efficiency of New England dairy farms in the USA in the study using the Stochastic Frontier model. According to the results, the economic, technical and allocative efficiencies are 70%, 83% and 84.6%, respectively. Furthermore, the relationship was examined between efficiency and the socioeconomic variables, such as farm size, extension, education, and experience in the research. They also determined that these variables did not affect the activity levels much.

Kibaara (2005) calculated the technical efficiency of maize production in Kenya applying the SFA method and found the average technical efficiency as 49%. The technical efficiency of the farms, growing only maize, was higher than the farms growing other crops with maize. It was determined that using hybrid seeds would increase technical efficiency by 36%, and using tractors in soil preparation increased it by 26%. The results showed that it was enough to have a 5-year primary education degree for a maize producer to be technically efficient.

Alemdar and Oren (2006) estimated the technical efficiency of wheat growing farms in the Southeastern Anatolia region in Turkey using parametric and non-parametric methods. According to the results of the Data Envelopment Analysis (DEA) model, the efficiency scores of the wheat-growing farms were calculated as 0.72 and 0.79, respectively. The technical efficiency scores estimated by the SFA method ranged between 0.34 (Constant Return to Scale-CRS) and 0.93 (Variable Return to Scale-VRS), with a mean of 0.73. From the results obtained, a strong correlation was determined between the output-oriented CRS-DEA and the SFA model. It has been concluded that wheat growers can increase their output by 21-27% using their resources better.

Nadolnyak et al. (2006) examined the peanut production efficiency in their study in the Southeastern region of the United States to determine the effects of the agricultural reform conducted in 2002 on agricultural farms using the SFA. It has been determined that features such as farm size, education and age of the farmer have significant effects on efficiency.

Oren and Alemdar (2006) estimated the technical efficiency of tobacco-growing farms in the South-eastern Anatolia region in Turkey using parametric and non-parametric methods. According to the results of the DEA model, the mean efficiency was determined as 0.45 and 0.56 under the assumptions of CRS and VRS, respectively. The mean efficiency value for the SFA was 0.54. Accordingly, there is a strong correlation between the DEA model, which assumes variable returns to the product-oriented scale, and the results obtained from the SFA model. These results show that tobacco-growing farms can increase their technical efficiency by 45% using the resources better under the current technology.

Kacira (2007) measured the technical, allocation and economic efficiency levels of farms engaged in second-crop maize farming in Şanlıurfa, Turkey. As a result of the DEA, the technical, allocative, and economic efficiency were 81%, 87%, and 77%, respectively. Regarding the SFA, the results were 84%, 78% and 64%. The values determined by the applied methods showed that the examined farms were inefficient. In addition, it was revealed that the number of irrigation and the irrigation interval, which were socio-economic factors, had a statistically significant effect on the farms' efficiency.

Masterson (2007) examined the relationship between farm size and productivity in Paraguay using both DEA and SFA methods for efficiency measures. The author determined that small farms had higher net farm income per hectare and were technically more efficient than large farms.

Cakmak et al. (2008) found the mean efficiency for farmers in Turkey as 33% in 2002 and 45% in 2004 using the SFA method. They stated that although the loss of efficiency decreases over time, it is one of the most important problems of agricultural production.

Parlakay and Alemdar (2011) aimed to analyse the technical, economic and allocative efficiencies of 90 peanut farms in Adana and Osmaniye in Turkey. DEA and SFA methods were conducted to derive the efficiency measures. As a result of the analysis, the technical efficiency ranged from 0.80 to 0.86, while economic and allocative efficiencies were 0.60 and 0.74. Therefore, a positive correlation was found between efficiencies and education level, growing area and nitrogen usage at the recommended level. However, it was seen that the only statistically significant correlation was between the growing area, the family labour force, and nitrogen usage.

Rahmati et al. (2016) investigated the production function and technical efficiency of Darreh Shahr wheat farmers. The Cobb-Douglas production function and SFA model were employed to analyse. The results presented that land, fertiliser, seeds, and dummy irrigation systems significantly affected wheat production.

The study of Wijayanti et al. (2020) was conducted SFA to calculate the technical efficiency of strawberry farming and the factors affecting inefficiencies with selected 100 farmers in Karangreja Subdistrict, Purbalingga Regency, Central Java Province. Technical efficiency values were between 26.50 and 99.40%, and a mean efficiency was 77.80%. In addition, the education level and the number of household members significantly affected the technical efficiency. Therefore, the results showed that it was important to improve the knowledge and skills of farmers through counselling, assistance, and training to obtain a more efficient strawberry production.

The present study aimed to accomplish two certain research tasks: First, to investigate the technical efficiency in almond orchards and second, to ascertain the factors influencing efficiency. The Stochastic Frontier Analysis method is employed to attain the conceived goal in the study. Thus, the research aims to fill a significant gap by applying a statistical procedure. The results may provide some suggestions for the policymakers and the producers. Furthermore, the study may conduce to project future research on a large scale.

3. Materials and Methods

The section is intended to introduce the empirical study by describing the data collected and explaining the method conducted.

3.1. Data

The primary data of the study was collected via survey method from almond orchards in Muğla province, Turkey. It was carried out based on a sample of 93 almond producers in the districts of Datça, Marmaris, Fethiye and Seydikemer along with 22 villages in the 2015 production season. The districts selected as the research area constitute approximately 72% of the total almond production in Muğla (TUIK, 2016). Therefore, it can be said that the research area has the necessary features to represent the almond farmers in Muğla province. Neyman Method was applied from the stratified sampling methods to define the number of samples (Yamane, 2001).

Input-output relations and some socio-economic characteristics of the farms were revealed in the interview. A cross-section of farm-level data was employed, and these include gross profit (TL/da), labour costs (TL/da), variable costs (TL/da), almond area of the farm (da/farm), the average age of almond trees (year), the total number of almond trees owned by the farm (unit/farm), the farmers' age (year), the education level (year), agricultural experience (year), experience in almond production (year), off-farm income (TL), cooperative membership (1-yes/0-no) and population (person/family). These variables have been implicated in much former research on technical efficiency (Alam, Khan and Hug, 2012; Tiedemann and Latacz-Lohmann, 2013; Bojnec and Ferto, 2013; Cillero et al., 2018). In Table 1, descriptive statistics of the variables used in the analyses are presented.

Table 1: Descriptive Statistics of the Variables

Variable	Minimum	Maximum	Mean	Standard deviation
Output				
Gross profit (TL/da)	-1 069.13	20 330.12	3 809.11	3060.11
Inputs				
Labour cost (TL/da)	228.62	2 809.13	1189.02	544.92
Variable cost (TL/da)	553.69	2 534.73	1512.54	371.15
Almond area of the farm (da/farm)	1.00	120.00	17.03	19.72
The average age of almond trees (year)	10.00	90.00	30.92	14.52
Total number of almond trees (unit/farm)	15	1525	284.15	318.56
Farmer's age (year)	30	90	57.70	12.89
Education level (year)	5	15	6.98	2.87
Agricultural experience (year)	5	75	39.35	14.15
Experience in almond production (year)	3	70	37.63	14.10
Off-farm income (TL)	0	1	0.75	0.43
Cooperative membership (1-yes/0-no)	0	1	0.45	0.50
Population (person/family)	1	7	3.42	1.31

1 USD = 9.68 TL (Turkish Liras)

3.2. Stochastic Frontier Analysis Method

Farrell (1957) divided cost efficiency or economic efficiency into technical efficiency and allocation efficiency. Since allocation efficiency is for the optimum use of available resources, it can be used as an economic efficiency by being close to the general definition of the economy. On the other hand, the more computational nature of technical efficiency and its ability to yield clear results make it a significant and widely used position in terms of performance measurements (Tutulmaz, 2012). The concept of technical efficiency, which is suitable to be a performance criterion, can be defined through parametric and non-parametric functions. Mathematical programming is employed as non-parametric functions, and econometric estimation methods are employed as parametric functions during the analyses. It is mentioned that the function establishes the relationship between the inputs of production and the outputs when the production activity is represented by the production function. When efficiency analysis is applied to the production function, the theory of technical efficiency emerges. Farrell (1957) proposed the first theoretical approach of production technical efficiency. The conventional methodology for assessing farm-level production efficiency is to estimate a production frontier covering all available input/output data for the analysis. The technical efficiency of a farm is estimated according to the input/output performance and compared with all other farms' in the sample. The farms that place on the production frontier are counted as efficient. The farms are counted as inefficient due to producing less output with available given inputs if they place under the production frontier (Binici, Demircan and Zulauf, 2006). Coelli et al. (2003) stated that it would be more relevant to apply the SFA for the efficiency analysis in the agricultural productivities of developing countries. It is because many risks and ambiguities exist in agricultural production in developing countries. Various functions such as linear, Cobb Douglas, translog or nonlinear functions can be used to represent production activities. Among the functions, the Cobb Douglas is generally used to estimate the stochastic production frontier due to its various advantages. It makes it easier to reach the ratio representing inefficiency with the help of linearized error terms. It also has microeconomic interpretation advantages (Tutulmaz, 2012).

When the Cobb Douglas production function is linearly expressed;

$$\ln y = XB + u \tag{1}$$

u: non-negative random variable

y: output(s)

X: input vector

B: parameter vector

The error term "u" includes measurement errors and other deviations such as chance, weather, shocks, as well as inefficiency. If a "v" error term is added to represent these random deviations, the "u" error term, it will be measured, will now only measure inefficiency (Aigner, Lovell and Schmidt, 1977). Therefore, the new equation is as follows:

$$Y = XB + v - u \tag{2}$$

or

$$y = exp(XB + v - u) \tag{3}$$

v: i.i.d. $(0, v^2)$, independent and homogeneously distributed random variable

u: semi-normal or exponential distribution

The necessary composite error distribution for the maximum likelihood estimation can be obtained by distinguishing the distribution of error terms. Also, the error terms can be separated with the help of a parameter defined using the variances of the error terms (Aigner, Lovell and Schmidt, 1977).

The technical efficiency of the i*th* farm is calculated according to Coelli and Perelman (1996);

$$TE_i = E[exp(-u_i)|\varepsilon_i] = E[exp(-\delta_0 - \sum_m^M \delta_m Z_{mi})|\varepsilon_i] \tag{4}$$

$$\varepsilon_i = v_i - u_i$$

where E is the expectation operator, Z_{mi} is explanatory variables considered to be the reason for inefficiency, δ_0 and δ_m are unknown coefficients to be estimated. The technical inefficiency of the i*th* farm depends on the observed value ε estimated from the SFA model. The parameters of the two functions (unknown parameters of the Cobb Douglas stochastic frontier and the inefficiency measurements) are estimated concurrently by the maximum likelihood. The fit of the models is examined by σ^2 and γ. The σ^2 designate the presence of inefficiency, and γ designates the level of inefficiency. The γ scales from zero to one, and zero means that the deviation from efficiency is all due to other causes (noise). One shows that the deviation is due entirely to the inefficiency (Battese and Coelli, 1995).

The critical point of the SFA method is that it provides the structure to predict inefficiency and boundary with a single econometric test. It can be suggested as the most important feature of the method that it introduces technical efficiency detection to econometric estimation methods with these features of the stochastic boundary method due to the importance of performance measurements (Tutulmaz, 2012). Therefore, the research was intended to examine the technical efficiency and determine the factors influencing efficiency in almond orchards in Muğla province, Turkey. For this aim, the questionnaire data were analysed using package software Microsoft Excel. Also, the model for SFA was developed and empirically tested via the Frontier 4.1 software program (Coelli, 1996).

4. Results and Discussion

4.1. Technical Efficiency

The estimated production efficiency scores are presented in Table 2. The average technical efficiency (TE) score for almond farmers in Muğla province is 94%. It indicates that the average almond producer is highly efficient and can increase his output by another 6% by developing the use of his existing inputs without additional inputs. Fifty-seven per cent of the sampled 93 farmers obtain technical efficiency scores over 95%. It means that the farms function at 95% or more of their potential efficiency. While only 2.2% of the almond farms operate between 85% and 80% efficiency, 40.8% of the farms operate between 95% and 85% efficiency. Also, variations in technical efficiency levels among farms in the study area are negligible. The efficiency level varies from a minimum of 0.82 to a maximum of 1.00. The frequency distribution reveals that all producers have technical efficiency scores above 0.80. Finally, there is only one farm operating fully efficient among the sampled farms. These results show that the sample of almond farmers in Muğla province operates close to the production frontier, according to the SFA.

Table 2: Technical Efficiency Scores of Almond Farms in Muğla Province, Turkey

Efficiency Scores (%)	Number of Farms (#)	Ratio (%)
TE ≥ 95	53	57.00
95 < TE ≥ 90	31	33.30
90 < TE ≥ 85	7	7.50

85 < TE ≥ 80	2	2.20
80 < TE	0	0.00
Total	93	100.00
Mean	0.94	
Minimum	0.82	
Maximum	1.00	

As stated before, a comprehensive literature review was made and only two researches have been found on the technical efficiency of the almond fruit. However, it is possible to make comparisons with also some other studies on crop plants for a better understanding. Yazdani et al. (2006) found that the average technical efficiency of almond farms in Chaharmahal Bakhtiary province, Iran was 0.81 while Moradi (2011) revealed that it is 69% for Kerman province in Iran. Regarding other crop studies; for example, Parlakay and Alemdar (2011) found that the technical efficiency of peanut production in Adana and Osmaniye ranged from 0.80 to 0.86. Theriault and Serra (2014) have found the average technical efficiency score is 80% for cotton in West Africa and it varies from 15% to 98%. The comparisons simply show that almond farmers in Muğla operate closer to their production frontier than farmers in other countries.

4.2. Factors affecting the inefficiency

Inefficiency may ensue owing to the failure to practice the relevant input combination in agro-farms. Farmers think that they gain more output by expanding the amount of input and ignore the optimal production with the most appropriate input combination. The one-sided likelihood ratio (LR test: 1.14) presents if there is a technical inefficiency in the data set (see Table 3). The null hypothesis for no inefficiency is rejected, and therefore it is suitable to examine the data with an SFA method. While a coefficient with a negative sign for inefficiency effects means a positive effect on the efficiency, a positive sign means a negative effect on it. The variance parameter, γ, which takes a value between zero and one, designates that the technical efficiency is stochastic and is relevant to procurement a sufficient representation of the data. Therefore, the γ equals 0.01 and it means that the variance of the inefficiency effect is an important part of the variance of the total error term. Thus, deviations from the optimal performance are essentially due to other (random) factors.

Table 3: Coefficients of the Stochastic Frontier Analysis Model

Variables	Coefficient	Standard-error	t-ratio
Stochastic Frontier Analysis			
Constant	4912.95	1.00	4906.24
Labour cost	-0.25	0.48	-0.52
Variable cost	-0.06	0.49	-2.18**
Almond area of the farm	-46.59	1.06	-43.86***
The average age of almond trees	19.36	2.22	8.72***
Total number of almond trees	3.71	0.95	3.91***
Technical Inefficiency Model			
Constant	-0.01	1.00	-0.01
Farmer's age	15.60	6.57	2.38**
Education level	-13.49	5.72	-2.24**
Agricultural experience	-9.67	4.17	-2.32**
Experience in almond production	-6.26	2.80	-2.23**
Off-farm income	-0.40	1.01	-0.39
Cooperative membership	-0.12	1.00	-0.12
Population	-0.17	1.23	1.39*
Variance Parameters			
γ	0.01		
Log-Likelihood	-874.67		
LR statistic	1.14		

Statistically significant at the level of $p < 0.01$ (***), $p < 0.05$ (**), and $p < 0.10$ (*), respectively.

Table 3 shows the elasticity coefficients of variable costs (TL/da), almond area of the farm (da/farm), the average age of almond trees (year) and the total number of almond trees owned by the farm (unit/farm) are statistically significant at least at the 95% level of statistical confidence. The total number of almond trees owned by the farm and the average age of almond trees have a positive effect, implying that the production augments by higher endowments of such factors. However, the variable costs and almond area of the farm have a negative effect. Although the labour cost is statistically insignificant, it has also a negative effect on the amount of almond production as expected.

As seen in Table 3, the farmers' age, education level, agricultural experience and experience in almond production are statistically significant at 5% level. The number of the person in the family is significant at the level of 10%. On the other hand, off-farm income and cooperative membership does not have a statistically significant effect on inefficiency in almond production. The farmers' age and the number of the person in the family have a negative effect while education level has a positive effect on efficiency. Unlike young farmers, the elders are less willing to embrace new technologies. This situation may cause the production of the elders to be less efficient. Findings related to farmers' ages from former observational research are diverse. For instance, Coelli et al. (2002) found younger farmers were more efficient than the elders. Also, Abdulai and Huffman (1998) found that getting old to be efficiency reducing. Binici et al. (2006) could not find any statistically significant correlation between age and efficiency. The results reveal that the efficiency decreases as the population in the family increases. This outcome is consistent with the previous prospects. Ajibefun (2002) and Gelaw and Emana (2008) also found a similar relationship in their studies.

Increasing the level of education affected the inefficiency negatively. The result shows that every 1% increase in the level of education will cause an approximately 13.5% increase in technical efficiency. According to the result obtained, it is understood that the well-educated farmer will execute better and more advanced production systems than the less educated one. With training, farmers gain new production and entrepreneurial skills to operate inputs for maximum efficiency. Similar results were reported by Binici et al. (2006), Keil et al. (2007) and Gebremedhin et al. (2009).

Furthermore, increases in agricultural experience and experience in almond production lead to an increase in technical efficiency. A 1% additional farmers' agricultural experience will cause a 9.7% increase in the technical efficiency of the farms. Regarding the experience in almond production, an increase of 1% of experience will create an increase of 6.3% in farm efficiency. These results indicate that higher experience in agricultural and/or almond production will result in higher efficiency because more experienced farmers will use and allocate resources more efficiently. Similar to our finding, Gul et al. (2009) also determined that the farmers' experience in cotton farming affects efficiency positively. However, Theriault and Serra (2014) could not find that the experience had a positive effect on productivity.

As expected, the relationship between cooperative membership and efficiency is positive. It indicates that an increase in being membership to a producer's cooperative will increase technical efficiency. Although the size of the relationship is small and statistically insignificant, this result is important. Regarding the final variable, off-farm income, the result shows that a 1% increase in off-farm income leads to an increase by 0.12% the efficiency. It is an indicator that off-farm incomes are used in agricultural production. This shows that the farmers' off-farm income enables the farm to perform more efficiently.

5. Conclusions

The research explores how socio-demographic variables affect the farmers' technical efficiency in Muğla, which is a major almond producer province in Turkey. For this purpose, a Stochastic Frontier Analysis method was used in the analysis of 93 farms in the region. At the same time, this study contributes to the evaluation of the technical efficiency of each farmer.

Our findings imply that the mean TE score for almond farmers in Muğla province, Turkey, is 94%. This result shows that the average almond farmer is highly efficient and can enhance his output by an extra 6% without new inputs. Also, it was observed that the efficiency level ranges from 0.82 to 1.00. Performing at high efficiency is an influential factor in staying competitive, and therefore, in the market over time.

The field research also confirms that four main factors- variable costs, almond area of the farm, the average age of almond trees and the total number of almond trees owned by the farm- have a significant impact on almond output. While the total number of almond trees owned by the farm and the average age of almond trees have a positive effect, the variable costs and almond area of the farm have a negative effect.

According to the SFA results, the almond farmers in Muğla province operate close to the production frontier, which means that they can use their resources almost completely efficiently. Therefore, in the light of the obtained results, it is seen that there is little inefficiency in almond production in the observed area. However, even this small inefficiency can be remedied by ascertaining the factors affecting the level of inefficiency. The analysed SFA model presented that the farmers' age, education level, agricultural experience, experience in almond production and the number of the person in the family explain the inefficiency of the farmer in almond production. It is necessary to make national campaigns to raise awareness of the importance of education and experience in increasing the efficiency of almond farms. At the same time, it would be beneficial to establish a program to increase the theoretical and practical experience of the farmers. Also, to keep young people in rural areas, making and implementing encouraging policies will be instrumental in ensuring a better efficiency level. The results and their inferences may be a source of recommendations for policymakers to raise the efficiency of almond farms. Reforms in line with these facts should be implemented to increase efficiency in almond production and revive the sector, ensure economic growth and reduce poverty. Moreover, these results can contribute to the large-scale design of future research.

Ultimately, this research intended to highlight the requirements for a clearer comprehension of almond farmers' regional facts. Also, it contributes to the agricultural production efficiency literature by enriching traditional production efficiency models with significant factors affecting the almond sector.

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