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Cross Efficiency Comparison In Olive Oil Sector: A Case Study Of Aydın And Balıkesir Province

Zeytinyağı Sektöründe Çapraz Etkinlik Karşılaştırması: Aydın ve Balıkesir İlleri Örneği

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Cross Efficiency Evaluation In Olive Oil Sector: A Case Study Of Aydın And Balıkesir Province

Abstract

The aim of this study is to reveal whether there is a relationship between the production activities of olive oil mills in Aydın and Balıkesir provinces, where important olive oil producers of our country are located, and the province in which they are located, and what are the determining factors on their efficiency. The main material of the study consists of data obtained from face-to-face surveys covering the 2020-2021 and 2021-2022 production seasons in a total of 131 olive oil mills, 63 in Aydın province and 68 in Balıkesir province, determined by the stratified random sampling method. Data envelopment analysis was used to calculate the effectiveness scores, and a discrete and bootstrapped regression model with 1000 repetitions was used to determine the factors affecting the effectiveness. As a result of the analysis, it was found that the olive oil mills in Balıkesir province used production inputs more effectively compared to those in Aydın province, the number of fully effective mills in Balıkesir province was higher, the mills in Balıkesir province had lower ratios of improvement compared to the mills in Aydın, and the meta-technology ratios were always higher. It has been concluded that the two provinces are close to each other, 95% of the current output is met with the current technology, and there is a significant relationship between the activities of the olive oil mills in Aydın and Balıkesir provinces and the province they are located in. In addition, it is thought that newly established mills with support and incentives make existing mills ineffective and cause market contraction, and instead, it would be more appropriate to support and encourage the revision of existing mills.

Keywords: Olive Oil, Aydın, Balıkesir, Efficiency analysis, Data envelopment analysis

Zeytinyağı Sektöründe Çapraz Etkinlik Değerlendirilmesi: Aydın ve Balıkesir İlleri Örneği

Öz

Bu çalışmanın amacı ülkemizin önemli zeytinyağı üreticilerinin bulunduğu Aydın ve Balıkesir illerindeki zeytinyağı sıkım tesislerinin üretim etkinlikleri ile bulundukları il arasında bir ilişki olup olmadığının ve bununla birlikte etkinlikleri üzerinde belirleyici olan faktörlerin neler olduğunun ortaya konulmasıdır. Çalışmanın ana materyalini tabakalı tesadüfi örnekleme yöntemiyle belirlenen Aydın ilinde 63 adet, Balıkesir ilinde 68 adet olmak üzere toplamda 131 adet zeytinyağı sıkım tesisinde 2020-2021 ve 2021-2022 üretim sezonlarını kapsar nitelikte ve yüz yüze gerçekleştirilen anketlerde elde edilen veriler oluşturmaktadır. Etkinlik skorlarının hesaplanmasında veri zarflama analizinden, etkinlik üzerinde etkili faktörlerin belirlenmesinde 1000 tekrarlı kesikli ve ön yüklemeli regresyon modelinden yararlanılmıştır. Yapılan analizler neticesinde Balıkesir ilinde bulunan zeytin sıkım tesislerinin Aydın ilinde bulunanlara kıyasla üretim girdilerini daha etkin kullandıkları, Balıkesir ilinde tam etkin tesis sayısının daha fazla olduğu, iyileştirme oranlarında da Balıkesir ilindeki tesislerin Aydın'daki tesislere kıyasla daha düşük oranlara sahip oldukları, meta teknoloji oranlarının her iki il için birbirine yakın olduğu, mevcut teknoloji ile mevcut çıktının %95' inin karşılandığı, Aydın ve Balıkesir illerinde bulunan zeytinyağı sıkım tesislerinin etkinlikleri ile bulundukları il arasında anlamlı bir ilişki olduğu sonucuna ulaşılmıştır. Ayrıca destekleme ve teşvikler ile yeni kurulan tesislerin mevcut tesisleri etkinsizleştirdiği, pazar daralmasına neden olduğu, bunun yerine mevcut tesislerin revize edilmesinin desteklenip teşvik edilmesinin daha uygun olacağı düşünülmektedir.

Anahtar Kelimeler: Zeytinyağı, Aydın, Balıkesir, Etkinlik analizi, Veri zarflama analizi

1. INTRODUCTION

The agricultural sector is important in terms of ensuring sustainability in terms of meeting the physiological needs of human beings, as well as providing raw materials for the industrial production of developed and developing countries, and thus making a significant economic contribution. While the two main branches of agricultural production are plant and animal production, one of the oldest known fruits in the agricultural sector, whose roots date back to ancient gathering, is the olive.

The olive tree is a tall shrub or an evergreen tree that is specific to the Mediterranean climate type and is cultivated in all countries bordering the Mediterranean (Türkiye, Spain, Italy, Tunisia, Morocco, Algeria, Syria, Greece, etc.), and can find habitats all over the world from South Africa to South America, from China to Australia and New Zealand, whose fruit is edible and whose oil is extracted only by simple pressing (Turkish Language Association [TDK], 2022).

The fact that the olive, whose existence is as old as human history, has been the subject of religious, political, legal, mythological and legendary events throughout the process, as well as its economic dimension being important in international trade thanks to its place in world gastronomy, and that our country lags behind many countries in exports in the world market, draws attention to the issue of how effective olive oil mills are in terms of examining the situation in the provinces of Aydın and Balıkesir, where the most important olive and olive oil producers are located, revealing the differences and deficiencies, and strengthening the good aspects. It is aimed to reveal the current situation with the evaluations as a result of the analyses made and to guide the steps to be taken in this direction.

Demand pressure originating from population growth that threatens all sub-branches of the agricultural sector, continuous increase in production costs, decrease in input amounts in production and many similar factors direct researchers to conduct efficiency studies in every field.

Although the fact that there are very few similar studies conducted on the subject of the research and that there is no such study between the two provinces under study is interesting in terms of revealing the similarities and differences, it is important to reach conclusions about the production activities of the mills within the framework of the data on production inputs and outputs, as well as the methods of the olive oil mills in Aydın and Balıkesir provinces, which are constantly in competition in the real market for olive and olive oil products.

The main hypothesis of the research is that there is a statistically significant difference between the efficiency scores of olive oil mills operating in Aydın and Balıkesir provinces and the factors affecting these scores.

The primary aim of the study is to determine the efficiency levels of olive oil mills, to compare the efficiency scores of Aydın and Balıkesir provinces and to reveal the factors affecting efficiency. In this context, it will be clarified whether there is a relationship between the efficiency values of olive oil mills and location. The location concept mentioned in the study emphasizes that olive oil mills are located in Aydın or Balıkesir province.

2. MATERIAL AND METHODS

2.1. Material

Primary data, which constitute the main material of the research, were obtained from face-to-face surveys conducted in olive oil mills operating in Aydın and Balıkesir provinces. Secondary data were obtained from reports and documents of institutions such as FAO, Ministry of Agriculture and Forestry, Agricultural Economics and Policy Development Institute, Provincial Directorates of Agriculture and Forestry and Turkish Statistical Institute.

Due to the periodicity experienced in olives, a year in which the yield is high is considered a year of availability, while the other year is considered a year of absence and a low yield is obtained. In order for the study not to be affected positively or negatively by periodicity, data from two seasons,

2020/21 and 2021/22 production seasons, were evaluated.

2.2. Method

2.2.1. Method Followed in Data Collection

In light of the data obtained from the Provincial Directorates of Agriculture and Forestry of Aydın and Balıkesir provinces, there are 170 olive oil mills in Aydın and 230 olive oil mills in Balıkesir. The number of mills to be surveyed was determined by the stratified random sampling method. The formula proportional sample volume (95% confidence interval and 10% margin of error) was used to determine the sample volume (Newbold, 1995). Since the ratio of efficent and non-efficent olive oil mills are unknown, the p value was taken as 0.5 in order to calculate the probability distribution in a balanced way. The sample size was determined as 63 for Aydın province and 68 for Balıkesir province.

$$n = \frac{Np(1-p)}{(N-1)\sigma_{px}^2 + p(1-p)}$$

σ_p^2= Variance of the ratio

n = Sample volume

N = The population

p = Ratio of efficient mills (0.5)

q= Ratio of non-efficient mills (0.5)

2.2.2. Methods Used in Data Analysis

DEA-based meta-boundary analysis was used in estimating efficiency scores. In determining the factors affecting the efficiency scores of the mills, since the use of classical regression models has been criticized because these factors may be correlated with inputs and outputs, truncated regression with bootstrapping with 1000 repetitions was used (Kumbakhar and Lovell, 2000). DEAP (v. 2.1), IBM SPSS Statisticks, Stata (v. 11) package programs were used in the analyses. In order to understand the attitudes, opinions and behaviors of the participants regarding the sector, scaled questions created with Likert Scale were used and explained with descriptive statistical methods. The production results of the mills at the end of both production seasons were examined with an output focus and the issue of whether the technology used within the enterprise was sufficient between the current inputs and the output they obtained was revealed by calculating the meta-technology ratios (Özden and Palomares, 2016).

Data Envelopment Analysis; There are almost no production functions consisting of a single input and a single output during production. There is a structure with multiple inputs and multiple outputs in many production functions. When more than one producer following these stages is to be compared, successful or unsuccessful producers will change based on the selected input and output. In this case, it is necessary to use a method that can measure all variables simultaneously in the selection of successful or unsuccessful (Özden, 2008). The methods used in the measurement of efficiency scores are generally divided into two as parametric methods and non-parametric methods. The most frequently encountered non-parametric method in the literature is DEA. The main reasons for preferring this method include its positive features such as allowing the use of multiple outputs and the ability to use variables with different units together (Özden, 2010). In addition, the method is widely used in efficiency studies because it deals with special situations, produces only one value specific to the firm, can respond to alternatives with multiple inputs and outputs, does not impose any restrictions on the functional structure of the input-output relationship, does not require weights determined before the function is established for outputs and inputs, focuses on best practices, and provides information on the improvement percentages required for ineffective units to become effective (Madu and Kuei, 1998).

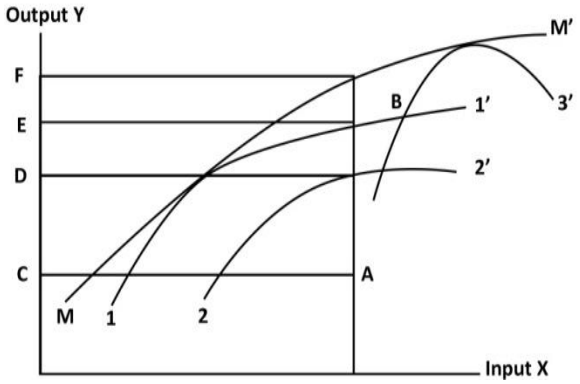
CCR Model; It was developed by Charnes, Cooper and Rhodes (1978), who set out by taking as reference the definition of technical efficiency in the study of Farrell in 1957 on DEA, in order to measure the relative efficiencies of decision or economic units that are similar to each other in terms of goods and services produced. BCC Model; CCR models are used in the calculation of

relative total efficiencies based on the assumption of constant returns to scale, in other words, on the assumption that all Decision Making Units (DMU) perform their activities at the optimum level. However, in real life, there are examples with variable returns to scale. In order to calculate the efficiencies of examples with variable returns to scale, Banker, Charnes and Cooper developed the BCC model in 1984.

For this purpose they added the $\sum_{j=1}^{n} \lambda_{jk} = 1$ constraint which is called the convexity constraint, to the dual of the CCR models. With this constraint, the types of returns to scale of DMUs can also be determined. Accordingly; if the sum of the λj (weights) calculated for a DMU is greater than one, the DMU operates according to decreasing returns to scale, if it is less than one, it operates according to increasing returns, and if it is equal to one, it operates according to constant returns. Since the relative total efficiency value is equal to the product of the relative technical efficiency value calculated with BBC and the relative scale efficiency, the scale efficiency value of a DMU is calculated with; Scale Efficiency (SCA) = CCR/BCC. Knowing the scale efficiency and technical efficiency values allows determining whether the inefficiency of a DMU that is inefficient in total is due to technical efficiency or scale efficiency or both. Since the efficiency frontier exhibits a characteristic of variable returns to scale, the relative technical efficiency values calculated with the input-oriented BCC model may differ from the relative technical efficiency values calculated with the output-oriented BCC model. Because under the assumption of variable returns to scale, the scale returns of any DMU may be increasing with respect to input, while it may be decreasing with respect to output.

For the meta-frontier, F and S are non-negative input and output vectors of size N x 1 and M x 1, respectively. In this case, the meta-technology set that takes into account all inputs to produce outputs is (O'Donnel et al., 2008).

Graphic 1. Production efficiencies and meta-technology ratios.



The following equation will be used in calculating meta-technology ratios (O'Donnel et al.; 2008; Özden and Palomares, 2015).

$$MTO^{n} = \frac{D\ (f,s)}{D^{n}\ (f,s)} = \frac{\text{Meta Efficiency}}{\text{Group Activity}}$$

In the study, the efficiency ratios of olive oil mills in Aydın and Balıkesir provinces were calculated for the province and among all olive oil mills. In these calculations, olive oil production (tonnes) was used as the only output, and the inputs were the amount of olives processed (tonnes), total labor force (hours), amount of water used in production (tonnes), electricity cost (₺), chemical cost (₺), fuel cost. (₺) and repair-maintenance cost (₺) were used. While the efficiency ratio approaches 1, it indicates the extent to which mills are technologically competent compared to the general population, while moving away from 1 means technological inadequacy compared to the general public.

The super efficiency model was introduced to science by Andersen and Petersen in 1993. In the model, each effective Decision Making Unit (DMU) is removed from the effective production limit in order and the DMU with the highest score among the super efficiency scores obtained as a result of the calculations is the most effective unit. The super efficiency values of the effective units are ranked from largest to smallest, and an efficiency ranking is also made among the effective units (Özden, 2008). The super efficiency model is equivalent to the dual CCR-

DEA model except for the feature of removing the DMU under evaluation from the reference set. The model is shown below (Andersen and Petersen, 1993). In this study, in order to reach more specific results between Aydın and Balıkesir provinces, the mills whose efficiency scores were calculated among the olive oil mills and whose result was found to be 1 were subjected to efficiency analysis again, the efficiency scores of the mills were calculated and the most efficient ones were determined with their mills numbers.

Regression Analysis; This analysis is performed to determine the relationship between two or more variables that have a cause-effect relationship between them and to make predictions about the subject in line with the determined relationship. Truncated regression models are used for data where all observations are missing. If some data is removed from the experiment in a planned manner in the research, the newly created model will be truncated. Truncated models include dependent and independent variables with limited observations at a certain time. There are limited or missing observations for both dependent and independent variables. Here, the efficiency score ranging from 0 to 1 will be taken as the dependent variable. The independent variables were determined as specially trained employees, number of partners, production manager experience, membership in marketing organizations, number of permanent employees, environmental index, quality index and location of the mills (Aydın, Balıkesir) (Simar and Wilson, 2007). Factors such as “membership in professional organizations”, which received a very high ratio of “yes” responses in the survey results, were not included in the model.

In this study, Likert-type questions were used to determine the attitudes of olive oil producing mills regarding environment and quality criteria. This method is a measurement tool that emerged with Rensis Likert's study titled "an attitude measurement technique" in 1932, and offers response options that can reflect the participant's views, attitudes and feelings on the subject by directing a series of statements to the participant (Yoshi et al., 2015). It is very useful in measuring structures that cannot be observed directly and it is accepted that participant expressions are graded at equal intervals (Chyung et al., 2017). Likert-type scales are based on the assumption that attitudes are on a linear structure with two ends, from positive to negative, with a neutral point that expresses neither a positive nor a negative attitude (Symeonaki et al., 2015). It is frequently used in research conducted in many disciplines, especially in social sciences. Although the scale generally consists of five response options as "strongly agree, agree, undecided, disagree, strongly disagree", there are also forms consisting of different answers according to the participant characteristics and the subject of the research.Although measurement tools developed in the Likert type have their drawbacks, it is an undeniable result that the ease of construction and adaptation, the statistical processing of data obtained from the scales, the convenience provided by Likert-type scales in data collection and the reliable results they provide have made these types of scales extremely popular data collection tools (Li, 2013).

In order to collect the research material, an ethics committee approval decision was taken by the Aydın Adnan Menderes University Social and Human Sciences Research Ethics Committee in accordance with the decision numbered 187 dated 27.10.2021.

3. RESEARCH FINDINGS

Descriptive statistics showing the production output and production inputs for the years 2020-2021 and 2021-2022 for Aydın province, Balıkesir province and the total of the two provinces are shown in Table 1. The averages of the amount of olives processed and the amount of olive oil produced are higher in Balıkesir province than in Aydın province for both production seasons. Again, when the average values are examined, it is observed that the average labor force (hour), the amount of water spent in production (tonnes), electricity cost (₺) and chemical expenses (₺), fuel expense (₺) and repair-maintenance expenses (₺) are also higher in Balıkesir province than in Aydın province.

Table 1. Descriptive statistics of output and inputs

Production Season	2020-2021			2021-2022		
Variables	Aydın (n=63)	Balıkesir (n=68)	Total (n=131)	Aydın (n=63)	Balıkesir (n=68)	Total (n=131)
Olive oil production (tonnes)	138.89 (157.46)	413.49 (548.24)	281.43 (430.93)	208.83 (152.81)	422.29 (618.77)	319.63 (468.97)
Amount of olives processed (tonnes)	729.43 (846.06)	2114.59 (2869.39)	1448.44 (2251.09)	1095.16 (833.27)	2157.21 (3307.73)	1646.45 (2500.75)
Total workforce (hours)	4101.59 (4637.24)	11271.94 (14175.05)	7823.60 (11258.18)	5742.86 (4741.04)	12173.21 (15206.63)	9080.75 (11844.83)
Amount of water used in production (tonnes)	180.79 (372.08)	720.38 (1131.46)	460.89 (893.91)	259.76 (433.71)	768.90 (1168.74)	524.05 (926.77)
Electricity cost used in production (₺)	36380.95 (16828.77)	93123.65 (127176.39)	65835.18 (96336.68)	89095.24 (40900.63)	154078.71 (207914.46)	122827.11 (155368.51)
Cost of chemicals used in production (₺)	3761.90 (2586.97)	8943.44 (14767.77)	6451.56 (11060.94)	6209.52 (4395.33)	12666.78 (16927.11)	9561.38 (12937.32)
Fuel cost used in production (₺)	23392.06 (24697.40)	32940.65 (59368.82)	28348.58 (46156.20)	54349.21 (51579.46)	71312.97 (129002.98)	63154.82 (99589.79)
Repair and maintenance cost (₺)	59682.54 (76863.27)	94862.76 (161546.57)	77944.03 (128759.95)	78825.40 (85837.72)	112257.22 (237628.08)	96179.32 (181376.58)

*Values in parentheses show standard deviation

The values of the discrete data are shown in Table 2. In terms of receiving special training related to the mills line, the answer yes was 6% in Aydın and 12% in Balıkesir to the question of whether they are Agricultural Engineers, Food Engineers and other professional groups related to the sector. To summarize the answers to the other questions, the answer yes was 13% in Aydın and 21% in Balıkesir to the question of whether the 2nd extraction, which can be defined as oil extraction from pomace, was performed; the answer yes was 57% in Aydın and 51% in Balıkesir to the question of whether the production facility is outside the residential area; the answer yes was 57% in Aydın and 51% in Balıkesir to the question of whether the production facility is outside the residential area; the answer yes was 16% in Aydın and 43% in Balıkesir to the question of whether they are members of marketing organizations; and finally, the answer yes was 17% in Aydın and 56% in Balıkesir to the question of whether the mills have websites. In the 2015 study examining the productivity of the olive oil sector in Aydın province with a meta-boundary analysis taking into account the ownership constraint (cooperative/private mills), it was determined that 39% of all mills had specially trained technicians, 86% were members of professional organizations, 5% were members of marketing organizations, 69% were online sales (through all online sales sites) and 76% were private mills in ownership structure (cooperative/private mills) (Özden and Dios Palomeras, 2015). In the study, it was thought that the decrease in the percentage of specially trained personnel compared to the findings of 2015 was due to increasing labor costs, however, it was observed that membership in professional organizations is now realized in almost all mills and membership in marketing organizations is increasing.

Table 2. Descriptive statistics for discrete data (%)

Yes-No	Yes (%)		
	Aydın	Balıkesir	All
Have you received special trainingin this line of work?	6	12	9
Is second extraction done?	13	21	18
Is the production mill outside the residential area?	57	51	55
Are you a member of professional organizations?	98	97	98
Are you a member of marketing organizations?	16	43	30
Do you have a website?	17	56	37

The efficiency scores of each province, both specifically and as a whole, for the 2020-2021 and 2021-2022 production seasons, obtained under the assumptions of output-oriented and constant returns to scale (CCR) and variable returns to scale (BCC) made with data obtained from olive oil mills in Aydın and Balıkesir provinces, are summarized in Table 3 and Table 4. Regarding the correlation values, which are important in terms of checking whether the efficiency scores are related to each other, a statistically significant result of 5% is seen in the correlation values of increasing returns to scale and constant returns to scale in the 2020-2021 production season, and it is seen that there is a significance of 10% in Aydın and 5% in Balıkesir between the increasing returns to scale and efficiency ratios. When the correlations of Aydın and Balıkesir provinces are examined in terms of the others, it is observed that the correlation of increasing returns to scale and constant returns to scale is significant at the 5% level, while the correlation of constant returns to scale and efficiency ratios is significant but negatively correlated at the 10% level in Aydın, and not significant in Balıkesir. It is seen that there is no relationship in the correlation of increasing returns to scale and efficiency ratios in Aydın and it is significant at the level of 5% in Balıkesir. When the correlation values of Aydın and Balıkesir provinces within themselves are

Table 3. Efficiency scores of olive oil mills in Aydın and Balıkesir provinces within themselves and as a whole

Production Season: 2021-2022		Aydın			Balıkesir	
Analysis Model	VRS	CRS	SCA	VRS	CRS	SCA
Average	0.88	0.86	0.98	0.94	0.89	0.95
Minimum	0.64	0.64	0.67	0.44	0.44	0.69
Maximum	1.00	1.00	1.00	1.00	1.00	1.00
Standard deviation	0.09	0.10	0.05	0.10	0.12	0.07
Fully active	12	9	14	41	22	23
Correlation VRS-CRS			0.89**			0.81**
Correlation VRS-SCA			-0.18			-0.02
Correlation CRS-SCA			0.28*			0.57**
Production Season: 2020-2021		Aydın***			Balıkesir****	
Analysis Model	VRS	CRS	SCA	VRS	CRS	SCA
Average	0.83	0.81	0.98	0.92	0.89	0.97
Minimum	0.60	0.60	0.61	0.44	0.44	0.74
Maximum	1.00	1.00	1.00	1.00	1.00	1.00
Standard deviation	0.11	0.11	0.05	0.12	0.12	0.06
Fully active	9	6	10	32	22	25
Correlation VRS-CRS			0.88**			0.89**
Correlation VRS-SCA			-0.27*			-0.09
Correlation CRS-SCA			0.23			0.38**

* Indicates significance at 0.05 significance level. ** Indicates significance at 0.01 significance level
***Shows the efficiency scores of mills belonging to Aydın province among all mills
**** Shows the efficiency scores of mills belonging to Balıkesir province among all mills

Table 4. Efficiency scores of olive oil mills in Aydın and Balıkesir provinces within themselves and as a whole

Production Season: 2021-2022		Aydın			Balıkesir	
Analysis Model	VRS	CRS	SCA	VRS	CRS	SCA
Average	0.90	0.84	0.93	0.95	0.89	0.94
Minimum	0.53	0.53	0.67	0.44	0.44	0.69
Maximum	1.00	1.00	1.00	1.00	1.00	1.00
Standard deviation	0.12	0.12	0.09	0.09	0.12	0.08
Fully active	29	11	16	40	23	25
Correlation VRS-CRS			0.76**			0.76**
Correlation VRS-SCA			-0.32*			-0.00
Correlation CRS-SCA			0.38**			0.64**
Production Season: 2021-2022		Aydın***			Balıkesir****	
Analysis Model	VRS	CRS	SCA	VRS	CRS	SCA
Average	0.87	0.80	0.93	0.93	0.87	0.93
Minimum	0.49	0.48	0.63	0.44	0.43	0.69
Maximum	1.00	1.00	1.00	1.00	1.00	1.00
Standard deviation	0.13	0.13	0.09	0.12	0.13	0.09
Fully active	21	9	11	35	18	20
Correlation VRS-CRS			0.75**			0.79**
Correlation VRS-SCA			-0.33**			-0.14
Correlation CRS-SCA			0.38**			0.49**

* Indicates significance at 0.05 significance level. ** Indicates significance at 0.01 significance level
***Shows the efficiency scores of mills belonging to Aydın province among all mills
**** Shows the efficiency scores of mills belonging to Balıkesir province among all mills

examined in the 2021-2022 production season, it is observed that the correlation of increasing returns to scale and constant returns to scale is significant at the level of 5% in both provinces, the correlation of constant returns to scale and efficiency ratios is significant at the level of 10% in Aydın and it is negatively correlated and it is not significant at any level in Balıkesir. It was concluded that there is no relationship in the correlation of increasing returns to scale and efficiency ratios in Aydın and it is significant at the level of 5% in Balıkesir. When the correlation values in general within the provinces of Aydın and Balıkesir are examined, it is observed that the correlation of increasing returns to scale and constant returns to scale is significant at the level of 5% in both provinces, the correlation of constant returns to scale and efficiency ratios is significant at the level of 5% in Aydın and it is negatively correlated and it is not significant at any level in Balıkesir. In the correlation between increasing returns to scale and efficiency ratios, it is seen that there is no relationship in Aydın, but it is significant at the 5% level in Balıkesir. When evaluated in terms of efficiency scores, it is seen that the efficiency values within Aydın and Balıkesir provinces have decreased among all mills, but this decrease is greater in mills in Aydın compared to mills in Balıkesir. In addition, it has been determined that the number of fully efficient mills is higher in Balıkesir than in Aydın for both production seasons.

After determining the efficiency scores of the mills, a total of 28 mills, 6 in Aydın and 22 in Balıkesir in the 2020-2021 production season, and a total of 27 mills, 9 in Aydın and 18 in Balıkesir in the 2021-2022 production season, were subjected to super efficiency analysis and their super efficiency scores were calculated (Table 5 and Table 6). When the factors affecting the efficiency of the five most efficient mills were examined, it was determined that mills numbered 10 in Aydın and 89 and 95 in Balıkesir were fully efficient in both production seasons and that these mills used water, chemicals, fuel and repair-maintenance factors more effectively in production.

Table 5. Super efficiency scores of olive oil mills in the 2020-2021 production season

Province	Mill number	Efficiency score
Balıkesir	88	1.90
Aydın	10	1.64
Balıkesir	95	1.48
Balıkesir	89	1.43
Balıkesir	96	1.42

Table 6. Super efficiency scores of olive oil mills in the 2021-2022 production season

Province	Mill number	Efficiency score
Balıkesir	90	1.35
Balıkesir	89	1.35
Aydın	10	1.31
Balıkesir	95	1.27
Balıkesir	120	1.27

When looking at the meta-technology ratios, it is observed that the values in Aydın and Balıkesir provinces are close to each other, and in the 2020-2021 season, it is calculated that 95% of the current output in Aydın and almost all of it in Balıkesir is met with the current technology, and in the 2021-2022 production season, 96% of the current output in Aydın and 97% in Balıkesir is

met with the current technology (Table 7). A 2015 study conducted in Aydın province revealed that 97% of the output in private mills is met with the current technology (Özden and Palomares, 2015). This means that the technology level has not changed, the current structure is well preserved, and maintenance and repair operations are carried out on time.

Table 7. Meta technology ratios

Production Season /Province		Aydın			Balıkesir		
	Analysis Model	VRS	CRS	SCA	VRS	CRS	SCA
2020-2021	Average	0.95	0.94	0.99	0.99	0.99	1.02
	Minimum	0.87	0.89	0.91	0.80	0.94	0.97
	Maximum	1.00	1.00	1.09	1.00	1.00	1.25
	Standard deviation	0.03	0.03	0.02	0.05	0.01	0.06
2021-2022	Average	0.96	0.95	0.99	0.97	0.96	0.99
	Minimum	0.83	0.85	0.88	0.51	0.63	0.77
	Maximum	1.00	1.00	1.16	1.00	1.00	1.24
	Standard deviation	0.05	0.04	0.05	0.07	0.06	0.06

The percentages of improvement tools are summarized in Table 8, and although there is no need for a significant reduction in the amount of olives processed in the 2020-2021 production season, it has been concluded that the same output will be achieved as a result of significant reductions in the inputs of repair and maintenance costs (41%) and electricity (36%), water (30%) and fuel costs (55%) used in production in Aydın province. In addition to the calculation that inputs are used more efficiently in Balıkesir province, it has been concluded that the same output will be achieved when the inputs of fuel used (21%), repair and maintenance costs (17%), electricity consumed (21%) and water consumed (17%) are reduced. Similarly, although it was concluded that inputs were used more efficiently in the 2021-2022 production season, reducing repair and maintenance costs (29%), fuel costs (20%) and total labor force (13%) in Aydın province, and reducing other inputs, especially repair and maintenance costs (21%) and total labor force (14%) in Balıkesir province, at the ratios specified in the table, will not cause any decrease in the amount of production.

In the 2015 study covering the province of Aydın regarding the percentages of improvements, it was calculated as olive oil production (12%), processed olive quantity (19%), number of qualified employees (10%), number of unqualified employees (13%), current assets (11%) and fixed capital (20%) and it was determined that the reduction in these ratios would not change the efficiency (Özden and Dios Palomeras, 2015). According to the findings of the study in 2015, while a significant decrease was observed in the improvement ratio of the processed olive quantity in Aydın province, similar results were found in the total workforce improvement ratio. It is thought that the drought experienced in recent years affected the production in the amount of processed olives.

The results of the regression analysis carried out with the 2021-2022 production season data of the mills located in Aydın province are shown in Table 9. In the increasing returns to scale indicator, the experience of the production manager is significant at the level of 10%. In the constant returns to scale indicator, the number of partners is significant at the level of 10%, but no significant result was reached at any level in the regression analysis of the efficiency ratios.

Table 8. Improvement percentages * (%)

Production season/Inputs		Amount of olives processed (tonnes)	Total personnel (hours)	Amount of water spent (tonnes)	Cost of electricity consumed (₺)	Cost of chemicals used (₺)	Cost of fuel used (₺)	Repair and maintenance costs (₺)
2020 2021	Aydın	0.00	11.74	30.32	36.22	17.97	55.24	41.10
	Balıkesir	0.19	14.72	17.60	21.25	9.61	21.12	17.63
	All	0.10	13.29	23.72	28.45	13.63	37.53	28.91
2021 2022	Aydın	0.03	13.33	7.03	10.62	8.74	19.88	28.63
	Balıkesir	0.02	14.27	9.91	11.94	10.66	11.62	20.63
	All	0.03	13.82	8.53	11.30	9.74	15.60	24.48

*Values in parentheses show standard deviation

The regression analysis values performed with the 2021-2022 production season data of the mills located in Balıkesir province are shown in Table 10. The environmental index is significant at the 10% level in the increasing returns to scale indicator. No statistically significant result was found in the constant returns to scale and scale efficiency ratio indicators.

Table 9. Factors affecting the efficiency of olive oil mills in Aydın province in the 2021-2022 production season

2021-2022	Coefficient	Standard error	P> |z|	Confidence interval (%95)	
CRS				Minimum	Maximum
Specially educated employees	0.02	0.07	0.79	-0.12	0.15
Number of partners	0.00	0.00	0.33	-0.00	0.02
Production manager experience	0.06	0.03	0.07*	-0.00	0.13
Membership in marketing organizations	0.05	0.06	0.38	-0.16	0.06
Environmental Index	0.00	0.14	0.92	-0.26	0.28
Quality Index	-0.07	0.10	0.50	-0.27	0.13
Number of experienced employees	-0.04	0.04	0.32	-0.10	0.03
VRS				Minimum	Maximum
Specially educated employees	-0.00	0.13	0.99	-0.25	0.25
Number of partners	0.02	0.00	0.09*	-0.00	0.04
Production manager experience	0.08	0.05	0.14	-0.02	0.18
Membership in marketing organizations	-0.06	0.10	0.55	-0.26	0.14
Environmental Index	-0.16	0.22	0.47	-0.58	0.27
Quality Index	-0.12	0.17	0.47	-0.44	0.20
Number of experienced employees	-0.02	0.05	0.64	-0.12	0.07
SCA				Minimum	Maximum
Specially educated employees	-0.15	1.23	0.90	-2.57	2.27
Number of partners	0.00	0.10	0.97	-0.19	0.20
Production manager experience	0.48	0.61	0.43	-0.72	1.67
Membership in marketing organizations	-0.76	0.92	0.41	2.56	1.04
Environmental Index	-0.83	1.73	0.63	-4.22	2.57
Quality Index	0.03	1.22	0.98	-2.37	2.43
Number of experienced employees	0.36	0.48	0.46	-0.58	1.29

Number of mills= 63, Regression analysis repetition count= 1000 *P<0.1, **P<0.05, ***P<0.001

Table 10. Factors affecting the efficiency of olive oil mills in Balıkesir province in the 2021-2022 production season

2021-2022	Coefficient	Standard error	P> |z|	Confidence interval (%95)	
CRS				Minimum	Maximum
Specially educated employees	0.03	0.10	0.75	-0.17	0.23
Number of partners	0.00	0.02	0.61	-0.03	0.05
Production manager experience	-0.02	0.02	0.57	-0.09	0.05
Membership in marketing organizations	-0.02	0.06	0.79	-0.14	0.11
Environmental Index	0.35	0.19	0.06*	-0.02	0.71
Quality Index	-0.02	0.15	0.90	-0.32	0.28
Number of experienced employees	-0.01	0.03	0.72	-0.08	0.05
VRS				Minimum	Maximum
Specially educated employees	0.11	0.54	0.85	-0.96	1.17
Number of partners	0.09	0.22	0.68	-0.34	0.52
Production manager experience	0.01	0.12	0.92	-0.23	0.25
Membership in marketing organizations	0.15	0.34	0.65	-0.51	0.81
Environmental Index	0.73	1.19	0.54	-1.60	3.05
Quality Index	-0.70	1.02	0.49	-2.70	1.30
Number of experienced employees	0.05	0.15	0.74	-0.25	0.35
SCA				Minimum	Maximum
Specially educated employees	0.11	0.36	0.77	-0.60	0.81
Number of partners	-0.01	0.06	0.81	-0.13	0.10
Production manager experience	-0.06	0.35	0.85	-0.75	0.62
Membership in marketing organizations	-0.12	0.43	0.78	-0.97	0.73
Environmental Index	0.29	0.89	0.74	-1.45	2.02
Quality Index	-0.27	0.57	0.63	-1.39	0.85
Number of experienced employees	0.04	0.33	0.92	-0.61	0.68

Number of mills= 68, Regression analysis repetition count= 1000 *P<0.1, **P<0.05, ***P<0.001

The results of the regression analysis conducted with the 2021-2022 production season data of all mills located in Aydın and Balıkesir provinces are shown in Table 11. In the increasing returns to scale indicator, it was concluded that the environmental index for mills was significant at the level of 10%, and the province where the mills were located was significant at the level of 5%. In the constant returns to scale indicator, the number of partners and the quality index were significant at the level of 10%, and the significance level of the province where the mills were located was significant at the level of 5%. No significant result was found at any level in the regression analysis indicator of the efficiency ratios.

4. CONCLUSION

Primary data obtained through face-to-face surveys from the production results of the 2020-2021 and 2021-2022 production seasons of olive oil mills located in Aydın and Balıkesir provinces and secondary data obtained from institutions and organizations were subjected to efficiency, super efficiency and regression analyzes using appropriate package programs. Accordingly, it was determined that the mills located in Balıkesir province were more efficient than the mills located in Aydın province, they used inputs more effectively, the number of fully efficient mills was higher, and their improvement ratios were lower than those in Aydın province.

Table 11. Factors affecting the efficiency of all olive oil mills in Aydın and Balıkesir provinces in the 2021-2022 production season

2021-2022	Coefficient	Standard error	P> |z|	Confidence interval (%95)	
CRS				Minimum	Maximum
Specially educated employees	0.29	0.06	0.61	-0.08	0.14
Number of partners	0.00	0.00	0.37	-0.00	0.02
Production manager experience	0.00	0.02	0.77	-0.03	0.05
Membership in marketing organizations	-0.03	0.04	0.50	-0.11	0.05
Environmental Index	0.24	0.12	0.05*	-0.00	0.48
Quality Index	-0.05	0.08	0.52	-0.21	0.11
Number of experienced employees	0.09	0.03	0.00**	-0.03	0.16
Specially educated employees	-0.02	0.02	0.44	-0.06	0.02
VRS				Minimum	Maximum
Specially educated employees	0.07	0.12	0.54	-0.16	0.31
Number of partners	0.02	0.01	0.07*	-0.00	0.05
Production manager experience	0.03	0.04	0.41	-0.04	0.11
Membership in marketing organizations	0.06	0.09	0.51	-0.12	0.24
Environmental Index	0.26	0.28	0.34	-0.28	0.81
Quality Index	-0.31	0.18	0.08*	-0.66	0.03
Number of experienced employees	0.18	0.07	0.00**	0.04	0.31
Specially educated employees	-0.01	0.04	0.77	-0.09	0.07
SCA				Minimum	Maximum
Specially educated employees	-0.32	1.22	0.79	-2.71	2.06
Number of partners	0.07	0.25	0.78	-0.42	0.57
Production manager experience	0.07	0.46	0.87	-0.82	0.97
Membership in marketing organizations	-0.78	1.60	0.63	-3.92	2.36
Environmental Index	0.50	2.68	0.85	-4.75	5.75
Quality Index	-1.70	2.32	0.46	-6.25	2.84
Number of experienced employees	-0.00	1.01	0.99	-1.98	1.98
Specially educated employees	0.42	0.61	0.48	-0.77	1.61

Number of mills= 131, Regression analysis repetition count= 1000 *P<0.1, **P<0.05, ***P<0.001

It has been determined that water, electricity, fuel and repair and maintenance cost inputs used in production in the 2020-2021 production season in Balıkesir province are not used effectively and that reducing input amounts in improvement ratios will increase efficiency. If the highest improvement ratios are taken into account, improving fuel usage and repair and maintenance costs in Aydın province and repair and maintenance costs in Balıkesir province in the calculated ratios in the 2020-2021 production season will increase efficiency in production. In the 2021-2022 production season between Aydın and Balıkesir province, it has been determined that electricity usage (₺), water consumption (₺), chemical usage (₺) and personnel (hours) inputs are close to each other in the improvement ratios of production input usage, but in Aydın province, it has been determined that the usage of fuels such as pomace, seed, wood and coal used in production (₺) and repair and maintenance costs (₺) are used more and that the mills in Aydın province are ineffective compared to Balıkesir province, and it has been concluded that they will be more effective by taking into account the improvement ratios.

It has been determined that the repair and maintenance expense (₺) inputs used in production

in the 2021-2022 production season in Balıkesir province were not used effectively and that reducing the input amounts at improvement ratios would increase the effectiveness.

As a result of all the evaluations made, it was concluded that there is a relationship between the efficiency values and locations of the olive oil mills in Aydın and Balıkesir provinces and that there is a relationship between the efficiency values and the environment and quality criteria.

In interviews with mills officials in the research areas; It has been stated by the operators that TKDK (Agriculture and Rural Development Support Institution) supports and other incentives finance the establishment of new olive oil mills, and that this situation causes a major market contraction in the sector and prevents the effective operation of existing mills. It is thought that it would be more appropriate in terms of both resource use and sensitivity to environmental pollution to provide public or foreign-sourced supports and incentives for the renewal of tools and equipment in existing mills, as well as for the renewal or repair maintenance of other physical structures and areas, and also to encourage cooperative-type mergers of olive oil mills located in the same region.

As observed in the provinces of Aydın and Balıkesir, it has been determined that national and international mills in the sector are pressing olives for very low unit prices (₺/kg) and this situation is putting small-scale local family mills in a difficult situation. It is thought that it would be appropriate to prevent monopolisation by not leaving olive pressing prices to the large shareholders of the sector and to determine the unit olive pressing price annually by the relevant official institutions and to announce it throughout the province.

It has been observed that in some mills, olives are kept in bags in the open for long periods during the product processing phase and that, although production is carried out with modern machines, the necessary care is not shown in terms of cleaning, hygiene and product health. In terms of the quality and health of the product produced, professional qualification training should be made mandatory and mills should be regularly inspected. In addition, many olive oil mills do not have areas where employees and customers can rest and opportunities to meet personal needs, and their physical environments are inadequate. It is thought that certain standards should be introduced with legal regulations on this issue and that mills should be encouraged to comply with these regulations.

It is a positive development that the transition to a two-phase system in production is mandatory, and apart from storing pomace in leak-proof pools and giving it only to licensed pomace mills, there is also a need to identify those suitable for use in agricultural irrigation and use them as a source of organic matter in the irrigation of agricultural lands. It is thought that the suitability of these waters for use should be determined by analyzing them with laboratories in the Agriculture and Forestry Directorates, DSI (Directorate General For State Hydraulic Works) Regional Directorates and Municipalities, and that public studies should be carried out to reuse those found to be suitable.

Considering the existing olive tree presence as well as the areas suitable for olive cultivation that can be established on top of the existing ones, our country is far behind the world countries in terms of olive and olive oil production and marketing. In olive cultivation, it is necessary to continuously increase the production amount with new mills and to develop production and marketing methods for export, thus ensuring that Türkiye rapidly moves up to the upper echelons among the countries that have a say in the market.

REFERENCES

Andersen, P., Petersen, N. C. (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Management Science 39*, 1261-1264.

Chyung, S. Y., Roberts, K., Swanson, I., Hankinson, A. (2017). Evidence-based survey design: The use of a midpoint on the Likert scale. Performance Improvement, *56*(10), 15-23.

FAO, (2022). Food and Agriculture Organization of the United Nations:

https://www.fao.org/faostat/en/#data/QCL. [Erişim Tarihi: 21/09/2022]

Kumbhakar C A, Lovell K. (2000). Stochastic Frontier Analysis. New York: Cambridge University Press.

Li, G., Feng, Z., You, L., Fan, L. (2013). Re-examining the inverse relationship between farm size and efficiency:The empirical evidence in China. *China Agricultural Economic Review 5(4)*, 473-488. doi: 10.1108/CAER-09-2011-0108.

Madu, C. N., Kuei, C. H. (1998). Application of data envelop analysis in benchmarking. *International Journal of Quality Science.*

Newbold, P. (1995). *Statistics for Mills and Economics*. Prentice Hall Int., USA, New Jersey.

O'Donnel, C. J., Elosua, R. (2008). Factores de riesgo cardiovascular. Perspectivas derivadas del Framingham Heart Study. Rev. esp. cardiol.(Ed. impr.), 299-310.

Özden, A., Armagan, G., (2005). Aydın İli Tarım İşletmelerinde Bitkisel Üretim Faaliyetlerinin Verimliliklerinin Belirlenmesi. Tarım Ekonomisi Dergisi 11(2), 111- 121.

Özden, A. (2010). Günümüzde Etkinlik Kavramı ve Ölçüm Metotları. Presented at the Türkiye IX. Tarım Ekonomisi Kongresi, Şanlıurfa.

Özden, A., Dios-Palomares, R., (2015). Environmental, quality and technical efficiency in olive oil industry. A metafrontier comparison between Türkiye and Spain. *Fresenius Environmental Bulletin 24(12)*: 4353-4363.

Özden, A. (2016). Gelir Gruplarına Göre Ülkelerin Tarımsal Üretim Etkinliklerinin Analizi Meta Sınır Yaklaşımı. Tekirdağ Ziraat Fakültesi Dergisi - JOTAF, 13(3), 121–128.

Özden, A. (2016). Measuring Environmental Efficiency in the EU Agricultural Sector Considering Desirable and Undesirable Outputs. Fresenius Environmental Bulletin, 25(1), 240–248.

Özden, A., Cankurt, M. (2016). İşletme Etkinliği Üzerine Etkili Faktörlerin Belirlenmesinde Yeni Bir Yaklaşım. Presented at the Türkiye XII. Tarım Ekonomisi Kongresi, Isparta.

Özden, A., Cankurt, M., Hurma, H. (2016). Firm Efficiency Measurement for Various Technology Groups. Presented at the International Balkan and Near Eastern Social Sciences Conference Series-IBANESS Conference Series, Plovdiv.

Özden, A., Öncü, E. (2016). Kiraz Üretim İşletmelerinde Etkinlik Analizleri Çanakkale İli Lapseki İlçesi Örneği. Ege Üniversitesi Ziraat Fakültesi Dergisi, 53(2), 213– 221.

Özden, A., Palomeras, R. D. (2016). Is the olive oil an Efficient sector A Meta Frontier Analysis Considering the Ownership Structure. New Medit, vol.15, 2-9 .

Simar L, Wilson P. (2007). Estimation and Inference in Two-Stage Semiparametric Models of Production Processes. Journal of Econometrics, 136: 31–64.

Symeonaki, M., Michalopoulou, C., Kazani, A. (2015). A fuzzy set theory solution to combining Likert items into a single overall scale (or subscales). Quality & Quantity, 49, 739-762.

Türk Dil Kurumu [TDK]. (2022). Zeytin, Türk Dil Kurumu Güncel Türkçe Sözlük. https://www.sozluk.gov.tr/ [E.T. 15/09/2022]