# Is the olive oil an efficient sector? A meta frontier analysis considering the ownership structure

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## Abstract

*The world's olive oil production is concentrated in the Mediterranean countries and a high percentage of olive oil is produced in Spain, Italy, Greece, Turkey, Tunisia and Syria, which together control 85 percent of the world output. This paper focuses on the impact of the ownership structure on the efficiency and sensitivities of the producers towards the quality and the environment of the olive oil sector. The efficiency of the olive oil sector was estimated by Data Envelopment Analysis. The Meta Frontier methodology was carried out in order to consider the ownership structures: cooperatives and private firms. The quality and the environmental compliance of firms were found to be of medium level. The firms analyzed showed a medium tohigh technical efficiency level. Results of bootstrapped truncated regression indicates that ownership structure (private firms), experienced production manager and extensive specialized training within the industry have together a positive effect. However, the number of partners, the number of permanent unskilled labour and environmental indice cause negative effects. In this paper, it is concluded that olive oil firms should solve their environmental and quality problems and reduce their fixed capital.*


***Key Words:*** *cooperatives, DEA, Delphi method, olive oil, truncated regression.*


## Résumé

La production d'huile d'olive dans le monde est concentrée dans les pays méditerranéens, avec une part importante en Espagne, Italie, Grèce, Turquie, Tunisie et Syrie, qui contribuent dans l'ensemble à 85% du total mondial. Dans cet article, nous allons parcourir l'effet de la structure de propriété sur la performance et la sensibilité des producteurs à l'égard de la qualité et de l'environnement du secteur oléicole. La performance du secteur de l'huile d'olive est calculée à l'aide de la méthode DEA (méthode d'analyse d'enveloppement des données). L'approche de la métafrontière est adoptée pour prendre en compte deux types de structure de propriété : les coopératives et les entreprises privées. Les entreprises montrent un niveau moyen de conformité à la qualité et à l'environnement et un niveau moyen à haut d'efficacité technique. Les résultats issus d'une régression tronquée et de la méthodologie du bootstrap indiquent que la structure de propriété (entreprises privées), des managers expérimentés et une formation spécialisée complète au niveau du secteur ont globalement un effet positif. En revanche, le nombre d'associés, le nombre de travailleurs permanents non-qualifiés et l'indice environnemental ont des effets négatifs. Nous allons en conclure que les entreprises d'huile d'olive doivent résoudre leurs problèmes d'environnement et de qualité et réduire leur capital fixe.


**Mots-clés:** coopératives, Analyse d'Enveloppement des Données, méthode Delphi, huile d'olive, régression tronquée.

## 1. Introduction

This paper presents the results of a research conducted to identify and evaluate the efficiency level of the olive oil production industry in Turkey. Besides, the impact of the ownership structure on the technical efficiency, quality and environmental respect of this industry was studied.

The world's olive oil production is concentrated in the Mediterranean countries (Turkekul *et al*., 2010). The top countries in virgin olive oil production account for 85% of the world output (FAO, 2014). These countries are Spain 39%, Italy 16%, Greece 11%, Turkey, Tunisia 7% and Syria 6%, respectively (FAO, 2014). The ranking for olive oil production also does not change much for olive production. On the other hand, olive oil consumption for the first four countries are as follows: Spain 150, Italy 550, Greece 180 and Turkey 150 thousand tonnes per year (IOOC, 2013). However, according to export figures, Turkey seems to be too far from the rank of olive oil production. A large part of Turkey's olive oil exports are carried to Italy, US and Canada. 70% of these are in bulk and 30% are packed (Yilmaz, 2013). The olive oil industry, which is a combination of agriculture and food sector, is facing difficulties. The most important of these for European Union Countries is the reduction of direct support given to olive oil production with regulations made under the EU Common Agricultural Policy (CAP) (Dios-Palomares *et al*., 2013). Nevertheless, the EU supports given to olive oil are rather high and more sustainable than in Turkey. The production aid for olive oil in the EU and Turkey is 1323 Euro per tonne and 175 Euro per tonne (European Commission, 2012; MFAL, 2012). Given the statistics of the olive oil sector, it is not wrong to state that, although Turkey has all the necessary production characteristics, it still has a lot to achieve.

Olive oil production is increasing thanks to new plantations, new technologies and management development. However, it also creates both quality and environmental troubles. Therefore, it is very interesting for the sector to know its actual efficiency level and the way to improve it. In addition, consumers' demand for safe and high quality food is increasing. These two factors, and the environmental respect are essential for the current olive oil market. For this reason, for the purpose of increasing the international competitiveness of Turkish Olive Oil Sector, besides increasing the technical efficiency, environmental da-

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mage must be reduced and the quality must be increased.

In addition to the evaluation of the technical efficiency, it is very important to detect the factors, that may improve the efficiency level. Quality and environmental management strategies may influence the efficiency levels of the firms in conjunction with other characteristics. Many studies have been carried out on the technical efficiency and on the factors affecting it within olive oil firms. In these studies, in general, olive oil price, ownership structure, farm type, adoption of new technologies, accumulation of skill and knowledge as well as stable input sourcing were generally indicated to improve the technical efficiency of the olive oil industry (Artukoglu *et al*., 2010; Gunden *et al*., 2010; Dios-Palomares and Martínez-Paz, 2011; Vidal *et al*., 2014; Ozden and Dios-Palomares, 2015).

Regarding the ownership structure, cooperative firms are very frequent in the olive oil sector. This because agricultural cooperatives offer services to small-scale firms , and play the double role of gathering small-scale firms and of connecting them to the market of inputs and outputs (Coulter *et al.*, 1999). The whole sector is composed of two different olive oil mill groups: cooperative firms and private firms. Managers of the cooperative and the private olive oil firms (mills) have different quality and environmental respect and compliance strategies. It is certain that the cooperatives work with the purpose of social benefits. However, it is also known that firms do not only work with the idea of social benefits, but they also care about the efficiency. On the basis of some literature on agricultural cooperatives, cooperative firms are expected to show lower efficiency levels when compared with private firms (Dios-Palomares and Martínez-Paz, 2011; Dios-Palomares *et al.*, 2013; Kanter *et al.*, 2013). In contrast, some researchers found that cooperative firms are more efficient than private firms or with a similar performance (Alonso de Magdaleno and Garcia-Garcia, 2009; Abate *et al.*, 2014). It can be established that both groups are working with different technologies, and therefore, their production frontiers are not the same. For this reason, the efficiency level should be evaluated by means of the meta frontier methodology.

On the basis of the aforementioned information, this research was conducted with the general purpose of estimating the technical efficiency of the olive oil sector in Turkey, considering the ownership structure (cooperative firms versus private firms) as an exogenous variable, by Meta frontier Data Envelopment Analysis (DEA) methodology. Also, this study estimates the quality and environmental respect levels of both groups of firms and the impacts of both factors in the technical efficiency even depending on the ownership structure.

## 2. Material and Methods

This study was carried out in Aydin province, which performs 13% of Turkey's total olive oil production (MFAL, 2012). The efficiency scores of olive oil firms in Aydin were estimated by DEA, and also Meta frontier model was carried out in order to compare different ownership structures (cooperative firms and private firms). Quality and environmental standards of the firms were estimated by quality and environmental indices (Dios-Palomares and Matinez-Paz, 2011; Ozden and Dios-Palomares, 2015).

It is also necessary to detect the factors which affect the efficiency of olive oil firms. For this reason, bootstrapped truncated regression model (efficiency scores, truncated 0-1), with the ownership structure and nine additional explanatory variables, was applied.

### 2.1. Data

Face to face survey method was conducted for collecting data for olive oil firms (mills) in Aydin, in 2013. Totally, 84 firms (20 cooperative firms and 64 private firms), which run every year and constitute 62% of the total, were selected to make a survey.

The olive oil produced (tonnes) was determined as the output and skilled labour (hours), unskilled labour (hours), the amount of processed olives (tonnes), floating capital (local currency) (1000 Turkish Lira ₺) (calculated by OECD, 2001 methodology), fixed capital (local currency) (1000₺) (calculated by OECD, 2001 methodology) were determined as the inputs.

### 2.2. Quality and Environmental Indices

Both indices were calculated for each firm, to estimate the quality and environmental respect of the firms, by the simple indexing procedure (Dios-Palomares and Matinez-Paz, 2011; Ozden and Dios-Palomares, 2015). Primarily, the qualifications of the olive oil firms, that will help determine the levels of the quality and environmental respect, were determined. Subsequently, these qualifications were measured as absence (0) and presence (1). In the next step, a weight was calculated for each qualification to determine its relative importance by the Delphi method (Rowe and Wright, 2011) using the opinion of 26 experts. The panel of experts were agricultural engineers (Ph.D. degree) (nine persons), managers of olive oil mills (eight persons) and environmental sciences graduates (nine persons) with known experience in the olive oil sector. Five point Likert scale, ranging between 1 (not at all) and 5 (very much), was applied to determine the importance of each qualification. Only two rounds were necessary to achieve the inter-round stability in all the questions because the ratings converged with stable median and interquartile range* (Dalkey and Helmer, 1963). Finally, a weighted mean was calculated for each firm as an indice score. Quality and environmental indices were both calculated by this procedure (Table 2).

### 2.3. Technical efficiency framework

The literature proposes two main formal approaches to measure agricultural efficiency: non-parametric and parametric. Non-parametric approaches involve the DEA, whi-

* The results obtained in the Delphi process are available upon request.

le parametric approaches comprise the index number and econometric methods (Dhehibi *et al.*, 2014). In a non-parametric focus, the DEA is the most frequently used method (Armagan et al., 2010; Ozden, 2010). Technical efficiency of olive oil mill firms in Aydin was calculated by a DEA Metafrontier framework. Technical efficiency of a group of firms which are using the same production technology can be estimated by means of the frontier function methodology. An envelopment is determined by including the totally efficient firms in the sample. Firms which are under the frontier (an envelopment) are inefficient. The radial distance from the inefficient firm to its target in the frontier determines its technical efficiency score. Nevertheless, if there are some groups of firms belonging to the same economic sector, but producing with different production technologies, DEA can not be applied to consider the data of all the groups together. In this case DEA Meta frontier methodology should be carried out.

DEA is based on a non-parametric model which was presented by Charnes *et al.* (1978), and developed by Färe *et al.* (1994) and Cooper *et al.* (2006). DEA estimates the efficiency score of each decision making unit (DMU) by using a group of outputs and inputs. The score of each DMU is identified as the ratio of the weighted sum of these groups.

DEA procedure is carried out by means of the resolution of a linear programming optimization problem for each DMU in the sample. The frontier is an enveloping composed by convex combinations of the efficient firms and the rest of them are classified as inefficient.

We can define the activation of the each firm with its outputs and inputs. Therefore, given a list of *m inputs*, ($x \in \Re_+^m$) and *s outputs* ($y \in \Re_+^s$) , of a firm or DMU, we described the activities *(x, y)* which characterize different firms through the *production set* of attainable points (Alcaide-Lopez-de-Pablo *et al.*, 2014). This production set is given in Equation 1.

$$\Psi = \left\{(x,y) \in \Re_+^{m+s} / x \text{canproduce} y\right\} \quad (1)$$

The so-called output *requirement set* for each input vector ($x \in \Re_+^m$) can be considered as the set of outputs that can be produced by such input, i.e.:

$$Y(x) = \left\{y \in \Re_+^s / (x,y) \in \Psi\right\} \quad (2)$$

When we want to analyze the technical efficiency of a firm ($DMU_o$), we can estimate the set of inputs and outputs with the sample of the observed values of *n* DMUs from the same economic sector. DEA is the frequently used non-parametric methodology to solve this equation. Therefore, we can define the production possibility set (1) as Equation 3.

$$P_{CCR} = \left\{(x,y) \in \Re_+^{m+s} / x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0\right\} \quad (3)$$

Where $\lambda \in \Re_+^n$ describes a semi positive vector in $\Re^n$, $X \in \Re_+^{mxr}$ and $Y \in \Re_+^{sxr}$ describes the matrix of inputs and the matrix of outputs, respectively. Each column *j* of these matrixes corresponds to $j^{th}$ firm of the sample data, with $j = 1, \ldots, n$.

The production facility set can be estimated by the original model of Charnes *et al.* (1978). Such output-oriented CCR model, formulated in the *envelopment form*, assumes constant returns in the production process and can be written as:

*Output-oriented CCR model:*

$$\max_{\theta, \lambda} \theta \quad (4)$$

$$\text{s.t.: } x_0 - X\lambda \geq 0 \quad (5)$$

$$X\lambda \geq \theta y_0 \quad (6)$$

$$\lambda \geq 0 \quad (7)$$

Where is a vector, $X = (x_1, \ldots, x_n) \in \Re^{mxn}$ is a *m x n* matrix of inputs (with $x_j \in \Re^m$ the data vector with the values at $DMU_j$), and $Y = (y_1, \ldots, y_n) \in \Re^{sxn}$ is a *s x n* matrix of outputs (with $y_j \in \Re^s$ the data vector of the output values at $DMU_j$).

The solution of the model (4) – (7) (θ, λ) will provide us with an output-oriented global technical *efficiency scores under* constant returns to scale (CCR).

Banker *et al.* (1984) presented the BCC model for estimating pure efficiency under variable returns to scale. This model is the same as CCR, but with the addition of the constraint $\sum\lambda = 1$. The scale efficiency (SCA) is calculated using the ratio between pure efficiency (BCC) and global efficiency (CCR).

Meta frontier model was developed by O'Donnel *et al.* (2008). Primarily, we assume that there are *f* groups of firms, producing with different production technologies. In the first step, the model estimates the partial frontiers for each different group and the technical efficiency score of the $j^{th}$ firm is defined as . The next step is the estimation of the meta frontier which envelops all partial frontiers. Meta frontier efficiency scores are calculated with pooled data and the efficiency score of the $j^{th}$ firm is defined as . Finally, Meta Technology Ratio, which measures the distance between the group *k* and the meta frontier, can be calculated as:

$$MTR_j = \frac{TE_j}{TE_j^f}$$

## 2.4. Outliers

Results of DEA are very sensitive to the presence of outliers, when the frontier is constructed from the observations in the sample, therefore it is necessary to check carefully the presence of contradictory and extreme observations (Latruffe *et al.*, 2012). Herewith, prior to the analysis of the technical efficiency, a statistical methodology for outlier detection, which was proposed especially for Data Envelopment Analysis by Wilson (1993), was applied.

## 2.5. Efficiency factors

When estimations of the technical efficiency scores have been made, it is also necessary to detect the possible effects of the factors in order to evaluate the behavior patterns among the full efficient firms. The factors should reflect the characteristics of the sector. If classic regression models are

used for the detection of these factors, they may be correlated with inputs and outputs (Dios-Palomares and Matinez-Paz, 2011). Therefore, bootstrapped truncated regression was applied to each efficiency score with the method which was proposed by Simar and Wilson (2007). Efficiency scores, which limited between 0-1, were determined as dependent variables. The factors (independent variables) were especially determined for the olive oil sector (Dios-Palomares and Matinez-Paz, 2011; Ozden and Dios-Palomares, 2015):

- Ownership Structure (only for Meta Frontier Analysis) ***(private firms=0, cooperatives=1)***
- The technician specially trained for the sector **(*No=0, Yes=1*)**,
- Membership to mills association **(*No=0, Yes=1*)**
- Membership to marketing association **(*No=0, Yes=1*)**
- Promotion on the internet **(*No=0, Yes=1*)**
- Quality indice (QI) (continuous variable between (***0-1***)
- Environmental indice (EI) (continuous variable between (***0-1***)
- Partners (number)
- Permanent unskilled workers (number)
- Experience of production manager (years)

## 3. Results and Discussion

Descriptive statistics of output, inputs and efficiency factors are given in Table 1. The remarkable differences which are demonstrated between the variables make it clear that, all different types of cooperative firms and private firms were represented in the sample of olive oil firms in Aydin. In both groups, it has been achieved that, in some firms only the skilled or unskilled labour was employed. The scores of the quality indices are lower than the scores of the environmental indices. The mean values of the indices are 51% and 63%, respectively. Also the mean values of both indice scores are approximately matched with the results of the study, which was carried out by Ozden and Dios-Palomares (2015). Likewise, it would not be incorrect to state that, in terms of environmental and quality criteria, firms are not at a high level. None of the cooperative or private firms had fallen to the minimum level *(min=0)* in both indices. However, none of the firms had reached the maximum level *(max=1)* in environmental indices and only three private firms were able to reach the maximum value in quality indice score. The environmental indice scores are generally higher than quality indice scores (Dios-Palomares and Martínez-Paz, 2011). Correlations among indices for both groups were not significant. Considering the surveys from both groups, the greatest problem in terms of both quality and the environmental respect is the lack of ISO standards. This result is similar with Arvanitoyannis (2008). However, in both groups, the experts thought that employing an experienced production manager will contribute to the quality. The other important issue to consider is owning a two-stage exhaust system is not significant for private firms. Private firm managers believe that, the two-phase system will contribute to the new financial and location adaptation problems. The results show that, a high percentage of the private firms in Turkey are using three stage exhaust system which generates high amounts of wastewater.

Table 2 shows the qualifications and the weights of the quality and the environmental indices, which were determined by the Delphi Analysis as mentioned afore. Opinions of the experts regarding the environmental and food safety of ISO standards, which determine the weight, were not so clear. Partial productivities (which are a ratio of output and a single input) are important to distinguish the differences between the two groups and in terms of the requirement of the meta frontier model. The partial productivities show that the partial productivity of skilled and unskilled labour are quite different for cooperatives and private firms. Partial productivities are respectively 0.575 and 1.217 for skilled labour and 0.083 and 1.263 for unskilled labour. The striking results show that the partial productivity of private firms was much higher than cooperatives according to skilled and unskilled labour. This result is contrary to Akridge and Hertel (1992). In this way, it is proven the requirement of the meta frontier model.

Table 1 - *Descriptive statistics of continuous and binary variables*[*].

| **Continuous Variables** | **Cooperatives (n=20)** | **Private Firms (n=64)** | **All Firms (n=84)** |
|---|---|---|---|
| Olive Oil Produced (tonnes) | 354.50 (185.06) | 627.34 (822.86) | 562.38 (732.03) |
| Amount of Processed Olives (tonnes) | 1731.00 (1085.98) | 3701.16 (7049.40) | 3232.07 (6222.25) |
| Skilled Labour (hours) | 1866.30 (2286.94) | 2329.72 (4415.22) | 2219.38 (4012.05) |
| Unskilled Labour (hours) | 6529.00 (5704.19) | 9819.41 (10552.25) | 9035.98 (9713.23) |
| Floating Capital ($1000_{£}^{*}$) | 47.04 (43.53) | 92.86 (180.98) | 81.95 (160.33) |
| Fixed Capital ($1000_{£}^{*}$) | 1172.60 (645.82) | 1415.94 (1367.64) | 1358.00 (1237.38) |
| Number of Partners | 396.60 (270.34) | 2.36 (1.85) | 90.91 (63.77) |
| Number of Permanent Unskilled Workers | 4.38 (3.07) | 4.04 (4.87) | 4.12 (4.02) |
| Experience of Production Manager (years) | 13.40 (10.41) | 16.45 (10.43) | 15.32 (10.42) |
| Quality Indice | 0.54 (0.21) | 0.49 (0.22) | 0.51 (0.22) |
| Environmental Indice | 0.67 (0.14) | 0.61 (0.16) | 0.63 (0.16) |
| **Binary Variables (yes %)** | | | |
| Specially Trained Technician | 40 | 39 | 39 |
| Membership of Mills Association | 85 | 86 | 86 |
| Membership of Marketing Association | 15 | 2 | 5 |
| Internet Promotion | 65 | 70 | 69 |
| Ownership Structure | 0 | 100 | 76 |

[*]*Values in the parenthesis are standard deviations.*

Estimates of the technical efficiency scores relevant with the meta frontier and the partial group frontiers were obtained under the assumption that the meta technology and partial group technologies all exhibited variable returns to scale (BCC), constant returns to scale (CCR) (O'Donnel *et al.*, 2008). Also the SCA, which is a simple ratio of BCC and CCR, was calculated for both different production technologies. Technical efficiency scores for two models (BCC and CCR) and their ratio (SCA) for partial group and the estimates of the meta frontier model are presented in Table 3, along with the pooled group estimates of the DEA model (Chen and Song, 2008). Correlations among the scores of the models were significant for all. In their own separated frontiers, relative efficiency values were determined by references within their own group. Thus, to make a comparison between the two separate groups would not be very accurate. Within their groups, in the analysis, it can be seen that most of the firms which are a cooperative member performed with full efficiency. When the groups were analyzed under a pooled frontier, the difference in scores was apparent. The means of scores for cooperatives [0.75 (BCC), 0.67 (CCR), 0.80 (SCA)] and private firms [0.84 (BCC), 0.72 (CCR), 0.87 (SCA)] showed that olive oil firms had a medium–high technical efficiency level. As seen in Table 3, private firms performed higher than the cooperative firms in the area, similar to the study of Cinemre *et al.* (2006).

The meta technology ratio (MTR) shows the relative proximity between the frontier of each partial group and the meta frontier. When a MTR of a firm is equal to one, it means that the frontiers of the partial group and the pooled group are exactly the same. But, if less than one means that, the partial group frontier could not reach the pooled frontier. Also a high MTR is evaulated, as there is not much technological difference between the partial and pooled frontier (O'Donnel, 2008; Beltrán-Esteve and Reig-Martínez, 2014).

The mean of MTR values implied that private firms achieved, on average, about 97% potential output given the technology available to the whole olive oil mills used for this study. Conversely, cooperative firms in the area, on average achieved about 79% of potential output given the technology available (Table 4). The maximum value of MTR for both groups and models, indicating that in each of the six combinations, the group frontiers were found to be tangent to the meta frontier. Means show that private firms are almost the same and cooperatives are inferior to the meta frontier.

Along with the estimation of the technical efficiency scores, improvements for the inputs and output was determined. Improvement for the output shows the percentage of the increase in olive oil production when improvements for inputs shows the percentages of the decreases for each input. Table 5 shows the means of the improvements for the output oriented production frontier. When the improvements for inputs were considered, it's seen that the skilled and unskilled labour should be highly reduced in cooperative firms (28%). Referable to the seasonal employment,

Table 2 - *Qualifications and weights of the quality and environmental ındices.*

| Qualifications | Weights* |
|---|---|
| **Environmental Indice** | |
| Environmentally friendly waste management | 0.180 |
| Two-phase extraction system | 0.167 |
| Leakproof pools for olive waste water | 0.169 |
| Environmentally friendly fuel use | 0.178 |
| Location (outside the urban areas) | 0.174 |
| ISO 14000 certificate | 0.132 |
| **Quality Indice** | |
| Classification of the olives in accordance with the variety and types (harvest and transport) | 0.134 |
| Controlling the cleanliness, timing and temperature in production | 0.179 |
| Critical control point check | 0.162 |
| Product traceability | 0.150 |
| Experienced expert in production | 0.172 |
| Checking the features with laboratory analysis | 0.120 |
| ISO 9000 certificate | 0.083 |

**Calculated by the authors based on the survey results.*

Table 3 - *Descriptions of the technical efficiency scores for partial and meta frontier.*

| Partial Group Efficiency | Cooperatives | | | Private Firms | | |
|---|---|---|---|---|---|---|
| | BCC | CCR | SCA | BCC | CCR | SCA |
| Mean | 0.95 | 0.92 | 0.97 | 0.86 | 0.75 | 0.87 |
| Minimum | 0.60 | 0.60 | 0.78 | 0.48 | 0.24 | 0.24 |
| Maximum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Standard Deviation | 0.10 | 0.12 | 0.06 | 0.16 | 0.21 | 0.17 |
| Efficient Firms % | 70 | 50 | 65 | 41 | 27 | 27 |
| Correlation Between BCC-CCR | | 0.929*** | | | 0.711*** | |
| Correlation Between BCC-SCA | | 0.541** | | | 0.579** | |
| Correlation Between CCR-SCA | | 0.809*** | | | 0.634*** | |
| **Meta Frontier Efficiency** | **Cooperatives** | | | **Private Firms** | | |
| | BCC | CCR | SCA | BCC | CCR | SCA |
| Mean | 0.75 | 0.67 | 0.80 | 0.84 | 0.72 | 0.87 |
| Minimum | 0.51 | 0.36 | 0.64 | 0.47 | 0.23 | 0.23 |
| Maximum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Standard Deviation | 0.18 | 0.18 | 0.10 | 0.17 | 0.22 | 0.19 |
| Efficient Firms % | 25 | 15 | 15 | 38 | 20 | 23 |
| Correlation Between BCC-CCR | | 0.935*** | | | 0.723*** | |
| Correlation Between BCC-SCA | | 0.578** | | | 0.513** | |
| Correlation Between CCR-SCA | | 0.633*** | | | 0.644*** | |

****Significant at level 0.01, **Significant at level 0.05.*

Table 4 - *Descriptions of the Meta Technology Ratios.*

| | Cooperative Firms | | | Private Firms | | |
|---|---|---|---|---|---|---|
| | BCC | CCR | SCA | BCC | CCR | SCA |
| Mean | 0.79 | 0.73 | 0.93 | 0.97 | 0.96 | 0.99 |
| Min. | 0.52 | 0.52 | 0.79 | 0.74 | 0.82 | 0.84 |
| Max. | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| SD | 0.17 | 0.15 | 0.07 | 0.06 | 0.05 | 0.06 |

these values are likely to be rather high. It demonstrates that work is carried on out of season. Nevertheless, other values were similar in both groups and it can be understood that firms, in particular, must adjust the amount of fixed capital to their scale.

Table 5 - *Means of the Total Improvements (%).*

| | Olive Oil Production | Processed Olives | Skilled Labour | Unskilled Labour | Floating Capital | Fixed Capital |
|---|---|---|---|---|---|---|
| **Cooperative Firms** | 13.41 (24.16) | 6.86 (9.19) | 28.41 (37.71) | 31.78 (51.47) | 7.42 (17.98) | 17.21 (32.47) |
| **Private Firms** | 11.84 (21.14) | 7,94 (21.47) | 4.16 (21.43) | 7.51 (14.50) | 11.48 (16.62) | 21.35 (44.57) |
| **All Firms** | 12.21 (21.86) | 7.68 (18.55) | 9.93 (25.31) | 13.29 (23.30) | 10.51 (16.94) | 20.36 (41.69) |

**Values in parentheses are standard deviations.*

Bootstrapped truncated regression was applied to determine the factors that effects technical efficiency scores. Basic descriptives of the Efficiency factors belongs to cooperative firms, private firms and pooled firms were given in Table 1. It is seen that the percentage of the membership of marketing association is very low in both groups.

The results of bootstrapped truncated regressions were estimated for both partial groups and for meta frontier. All results were also estimated for the models BCC, CCR and SCA. For cooperative firms, it is concluded that, *number of permanent unskilled labour* (BCC, CCR, SCA) had a direct impact on technical efficiency and a new permanent unskilled labour reduced the technical efficiency score by 1% (Table 6).

For private firms, the variables which had a direct effect on technical efficiency scores are *Number of Partners* (CCR, SCA), *Number of Permanent Unskilled Labour* (BCC, CCR, SCA), *Experience of Production Manager* (CCR, SCA), *Specially Trained Technician* (BCC, CCR, SCA), and *Environmental indice* (BCC, CCR, SCA). The number of partners affects efficiency negatively, but this impact is very low. Private firms demonstrate nearly the same behavior as cooperatives for employment. Firms, which had specifically trained technicians in olive oil production, were 1.28%, 1.20% and 1.30%, and firms, which had a more experienced production manager, were 1.41%, 1.45% more efficient. Firms which cared about environmental compliance were 0.66%, 0.30%, 0.54% less efficient than the rest (Table 7).

In order to consider all firms, the variable *"being a member of a cooperative"* (Ownership Structure) was included in the analysis. As a result of analysis, Ownership structure seems to have a direct impact on the efficiency scores. The firms which were not a member of a cooperative are 6.33% (BCC), 5.13% (CCR), 6.35% (SCA) on average more efficient. The results match with the relationships proposed by Dios-Palomares and Martínez-Paz (2011), Dios-Palomares *et al.* (2013), Kanter *et al.* (2013), Ozden and Dios-Palomares (2015). The relationship between the low technical efficiency and cooperative firms also underlined by Kanter *et al.* (2013). However, the results were in contrast to Abate *et al.* (2014) and Alonso de Magdaleno and Garcia-Garcia (2009), who also indicated that agricultural cooperative membership has no significant effect on technical efficiency. This can be explained as, in contrast to private firms, cooperative firms have no flexibilities, decision-making processes are very slow and the members are not effective in the decision-making process (Vakoufaris *et al.,* 2007). In parallel with the other results, variables *experience of production manager* and *specially trained technician* on average had a 1% positive impact on the scores. In contrast, the *number of partners* and the *number of permanent unskilled labour* had a 1.7% and 1% negative impact on the scores, respectively. When the environmental indice was increased, efficiency was decreased (0.14%-BCC, 0.18%-CCR, 0.11-SCA) (Table 8). Considering environmental awareness, it can be said that, this variable has not a huge impact.

Table 6 - *Bootstrapped Truncated Regressions for Cooperative Firms*[1].

| | Observed Coefficient | Bootstrap Std. Err. | P>\|z\| | Normal-Based (95% Confidence Interval) | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| **BCC** | | | | | |
| Number of Partners | -0.0174 | 0.0437 | 0.6910 | -0.1030 | 0.0682 |
| Permanent Unskilled Workers | -1.0019 | 0.3493 | 0.0790* | -1.0201 | 0.0163 |
| Experience of Production Manager | -0.0004 | 0.0062 | 0.9480 | -0.0125 | 0.0117 |
| Specially Trained Technician | 0.1459 | 0.1445 | 0.3130 | -0.1374 | 0.4292 |
| Membership of Mills Association | 0.2681 | 0.2110 | 0.2040 | -0.1455 | 0.6817 |
| Membership of Marketing Association | 0.3407 | 0.1928 | 0.1770 | -0.0372 | 0.7185 |
| Internet Promotion | -0.0986 | 0.0910 | 0.2790 | -0.2769 | 0.0798 |
| Quality Indice | 0.3038 | 0.3630 | 0.4030 | -0.4077 | 1.0154 |
| Environmental Indice | -0.1720 | 0.4476 | 0.7010 | -1.0492 | 0.7053 |
| **CCR** | | | | | |
| Number of Partners | -0.0004 | 0.0009 | 0.6470 | -0.0022 | 0.0014 |
| Permanent Unskilled Workers | -1.0040 | 0.1930 | 0.0403** | -1.7019 | 0.0098 |
| Experience of Production Manager | -0.0003 | 0.0025 | 0.9110 | -0.0052 | 0.0046 |
| Specially Trained Technician | 0.0492 | 0.0602 | 0.4140 | -0.0688 | 0.1672 |
| Membership of Mills Association | -0.0315 | 0.0824 | 0.7030 | -0.1930 | 0.1300 |
| Membership of Marketing Association | 0.2660 | 0.0918 | 0.1040 | 0.0860 | 0.4460 |
| Internet Promotion | -0.1005 | 0.0438 | 0.1220 | -0.1862 | -0.0147 |
| Quality Indice | -0.0270 | 0.1595 | 0.8650 | -0.3397 | 0.2856 |
| Environmental Indice | 0.0333 | 0.1598 | 0.8350 | -0.2799 | 0.3465 |
| **SCA** | | | | | |
| Number of Partners | -0.0639 | 0.0448 | 0.1540 | -0.1517 | 0.0239 |
| Permanent Unskilled Workers | -1.0041 | 0.1170 | 0.0315** | -1.0293 | 0.0375 |
| Experience of Production Manager | -0.0118 | 0.0079 | 0.1360 | -0.0273 | 0.0037 |
| Specially Trained Technician | -0.0958 | 0.1798 | 0.5940 | -0.4482 | 0.2567 |
| Membership of Mills Association | -0.2277 | 0.5974 | 0.7030 | -1.3985 | 0.9432 |
| Membership of Marketing Association | 6.3253 | 3.1380 | 0.1440 | 0.1750 | 12.4756 |
| Internet Promotion | -0.3491 | 0.1991 | 0.1800 | -0.7392 | 0.0411 |
| Quality Indice | 0.0907 | 0.6267 | 0.8850 | -1.1376 | 1.3189 |
| Environmental Indice | -0.1100 | 0.5829 | 0.8500 | -1.2525 | 1.0324 |

[1]*Observation number = 20; replications number = 1000.*
**P<0.1, **P<0.05, ***P<0.001.*

## 4. Conclusions

As a conclusion, quality and environmental compliance of firms located in the region were to be found with average values. If Turkey wants to be in the same category with countries which are leading to olive oil marketing, there needs to be considerable improvement in product quality and environmental compatibility issues. In Turkey, in the production of olive oil, legal pressures occur for the adaptation of two-phase systems. However,

Table 7 - *Bootstrapped Truncated Regressions for Private Firms*[1].

| | Observed Coefficient | Bootstrap Std. Err. | P>\|z\| | Normal-Based (95% Confidence Interval) | |
|---|---|---|---|---|---|
| **BCC** | | | | Lower | Upper |
| Number of Partners | 0.0040 | 0.0144 | 0.7790 | -0.0241 | 0.0322 |
| Permanent Unskilled Workers | -1.0034 | 0.1839 | 0.0386** | -2.0443 | 0.0110 |
| Experience of Production Manager | 0.2208 | 0.0923 | 0.7240 | 0.0053 | 0.3937 |
| Specially Trained Technician | 1.2785 | 0.1395 | 0.0000*** | 0.2011 | 1.7558 |
| Membership of Mills Association | 0.1031 | 0.0864 | 0.2330 | -0.0663 | 0.2724 |
| Membership of Marketing Association | 0.0320 | 0.0891 | 0.7190 | -0.1426 | 0.2065 |
| Internet Promotion | -0.0447 | 0.0398 | 0.2620 | -0.1228 | 0.0334 |
| Quality Indice | 0.2047 | 0.1371 | 0.1350 | -0.0641 | 0.4735 |
| Environmental Indice | -0.0572 | 0.1533 | 0.0090** | -0.3576 | 0.2432 |
| **CCR** | | | | | |
| Number of Partners | -0.1325 | 0.0123 | 0.0080** | -0.1566 | -0.0084 |
| Permanent Unskilled Workers | -1.0009 | 0.0134 | 0.0200** | -1.0375 | 0.0058 |
| Experience of Production Manager | 1.4122 | 0.1718 | 0.0430** | 0.0058 | 2.7215 |
| Specially Trained Technician | 1.2037 | 0.1409 | 0.0000*** | 0.1236 | 1.5838 |
| Membership of Mills Association | 0.0855 | 0.0564 | 0.1290 | -0.0250 | 0.1961 |
| Membership of Marketing Association | 0.1999 | 0.0571 | 1.0000 | 0.0879 | 0.3119 |
| Internet Promotion | -0.0981 | 0.0353 | 1.0060 | -0.1673 | -0.0288 |
| Quality Indice | 0.0975 | 0.0754 | 0.1960 | -0.0502 | 0.2452 |
| Environmental Indice | -0.2977 | 0.2187 | 0.0030** | -0.7264 | 0.1310 |
| **SCA** | | | | | |
| Number of Partners | -0.0106 | 0.0167 | 0.0130** | -0.0325 | 0.0238 |
| Permanent Unskilled Workers | -1.0043 | 0.1038 | 0.0254** | -1.7117 | 0.1231 |
| Experience of Production Manager | 1.4571 | 0.1245 | 0.0000*** | 0.2131 | 1.7011 |
| Specially Trained Technician | 1.3345 | 0.1395 | 0.0170** | 0.6080 | 1.6010 |
| Membership of Mills Association | 0.8938 | 0.3122 | 0.3040 | 0.2819 | 1.5057 |
| Membership of Marketing Association | 0.0754 | 0.0544 | 0.1660 | -0.0312 | 0.1820 |
| Internet Promotion | -0.1160 | 0.1927 | 0.5470 | -0.4938 | 0.2617 |
| Quality Indice | -0.1233 | 0.3218 | 0.7020 | -0.7540 | 0.5074 |
| Environmental Indice | -0.9409 | 0.2442 | 0.0000*** | -1.4623 | 1.4195 |

[1]*Observation number = 64; replications number = 1000.*
**P<0.1, **P<0.05, ***P<0.001.*

Table 8 - *Bootstrapped truncated regressions for all firms (Metafrontier)*[1].

| | Observed Coefficient | Bootstrap Std. Err. | P>\|z\| | Normal-Based (95% Confidence Interval) | |
|---|---|---|---|---|---|
| **BCC** | | | | Lower | Upper |
| Number of Partners | -0.1001 | 0.0081 | 0.0480** | -0.2001 | 0.0002 |
| Permanent Unskilled Workers | -1.7029 | 0.3030 | 0.0370** | -2.9030 | 0.2087 |
| Experience of Production Manager | 1.0013 | 0.0211 | 0.0080** | -0.0036 | 1.4199 |
| Specially Trained Technician | 1.1277 | 0.0288 | 0.0000*** | 0.0713 | 1.8840 |
| Membership of Mills Association | -1.1265 | 0.0593 | 0.1330 | 0.0102 | 0.2429 |
| Membership of Marketing Association | 0.0545 | 0.0530 | 0.3040 | -0.0495 | 0.1585 |
| Internet Promotion | -0.0443 | 0.0332 | 0.1820 | -0.1094 | 0.0208 |
| Ownership Structure | -6.3253 | 1.1380 | 0.0040** | -12.4756 | 0.1750 |
| Quality Indice | 0.1234 | 0.1153 | 0.2840 | -0.1025 | 0.3493 |
| Environmental Indice | -0.1366 | 0.0538 | 0.0310** | -0.2420 | -0.0312 |
| **CCR** | | | | | |
| Number of Partners | -0.1001 | 0.0701 | 0.0210** | -0.4001 | 0.2002 |
| Permanent Unskilled Workers | -1.0052 | 0.1025 | 0.0340** | -2.0004 | 0.1100 |
| Experience of Production Manager | 1.0001 | 0.0117 | 0.4660 | -0.0032 | 1.0033 |
| Specially Trained Technician | 1.1040 | 0.0311 | 0.0010** | 0.0430 | 1.8649 |
| Membership of Mills Association | -0.0940 | 0.0451 | 0.2370 | 0.0056 | 0.1824 |
| Membership of Marketing Association | 1.1012 | 0.0334 | 0.1420 | 0.0358 | 0.1667 |
| Internet Promotion | -0.0437 | 0.0298 | 0.3420 | -0.1020 | 0.0146 |
| Ownership Structure | -5.1251 | 1.0282 | 0.0000*** | -11.1804 | -0.0698 |
| Quality Indice | 0.0284 | 0.1211 | 0.8140 | -0.2089 | 0.2658 |
| Environmental Indice | -0.1812 | 0.0691 | 0.0590** | -0.3167 | -0.0457 |
| **SCA** | | | | | |
| Number of Partners | -0.0450 | 0.0053 | 0.0330** | -0.0706 | 0.0075 |
| Permanent Unskilled Workers | -1.7073 | 0.4139 | 0.0580* | -3.0346 | 0.5199 |
| Experience of Production Manager | 1.0130 | 0.1257 | 0.0230** | -0.0241 | 2.0018 |
| Specially Trained Technician | 1.2129 | 0.1325 | 0.0080** | -0.0469 | 2.4727 |
| Membership of Mills Association | -0.2925 | 0.2301 | 0.2040 | -0.7435 | 0.1585 |
| Membership of Marketing Association | 0.3125 | 0.1969 | 0.1130 | -0.0735 | 0.6985 |
| Internet Promotion | -0.2573 | 0.1073 | 0.4170 | -0.4676 | -0.0469 |
| Ownership Structure | -6.3548 | 1.1768 | 0.0000*** | -10.7012 | -0.0083 |
| Quality Indice | -0.1416 | 0.4067 | 0.7280 | -0.9388 | 0.6556 |
| Environmental Indice | -0.1098 | 0.2927 | 0.0630* | -0.5638 | 0.5835 |

[1]*Observation number = 84; replications number = 1000.*
**P<0.1, **P<0.05, ***P<0.001.*

the producers are not fully convinced about the environmental impacts of the two-phase system. Likewise, producers believe that the impact of ISO certification ownership on quality and environment, is not much. When we concentrate on technical efficiency, the efficiency of private firms was much higher than cooperatives. Means of meta technology ratios show that the groups are technologically different. It can be also concluded that the olive oil firms can perform to the same efficiency when they decrease their olives milled (7.68), skilled labour (9.93%), unskilled labour (13.29%), floating capital (10.51%) and especially fixed capital (20.36%). Also, they can improve their output (12.21%) with the same set of inputs. At the same time, cooperatives should decrease labour input. Results of bootstrapped truncated regression indicate that, when experienced product managers, with extensive specialized training within the industry, occurs together with ownership structure a positive effect is produced. However the number of partners, number of permanent unskilled labour and environmental indice causes negative effects. Contrary to what the manufacturers think there is no significant impact on quality and efficiency and reducing environmental damage has a very minor effect on efficiency. Consequently, the results of this paper show that, there is a negative significant impact between the cooperative membership and technical efficiency scores. Private firms are better than the cooperative firms producing maximum possible output with the same input set by at least six percent. These results are contrary to the objectives of the agricultural cooperatives. They can not increase their efficiency with easy access to inputs, extension services and regular training. However, private firms have the advantage of fewer partners, flexible working constraints and quick adaptation to market conditions in comparison to cooperatives. On the other hand, in order to highlight production quality and environmental awareness, it should be noted that intensive capital requirements need to be considered. In this study, it can be seen that firms' capital accumulation was not routed correctly. Therefore, it is necessary to state that sectoral organizations are important. Training and extension services, marketing services, food security and environmental controls could be made

much easier for organizations. Also, it is concluded that olive oil firms should solve their environmental and quality problems and reduce their fixed capital**.**

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