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Assessing the technical efficiency of small-scale fisheries in Greece

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Abstract

Small-scale fisheries is an important segment for Greece since it exploits the extended Greek coastlines. This study explores the technical (TE) and scale efficiency (SE) of the Greek small-scale fishing fleet, using Data Envelopment Analysis (DEA). The effect of several characteristics of the vessel and the skipper on TE and SE scores are also tested. Results indicate that small-scale vessels achieve a low average TE but much higher SE. Therefore, there is room for improvement in their efficiency level. Moreover, vessels with length less than 6 meters achieve higher TE, thus, smaller vessels have the ability to manage better their resources. Skipper's experience positively affects TE, while literacy level has no significant effect. The resulting effect of experience on efficiency suggests that the activity of small scale fisheries resembles art rather than science; thus skilful skippers are highly appreciated.

Key words: *Greek small scale fisheries, technical efficiency, scale efficiency, Data Envelopment Analysis (DEA)*

ΑξιολόγησητεχνικήςαποτελεσματικότηταςτηςθαλάσσιαςαλιείαςμικρήςκλίμακαςστηνΕλλάδα

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Περίληψη

Στην εργασία αυτή διερευνάται η τεχνική αποτελεσματικότητα (TE) καθώς και η αποτελεσματικότητα κλίμακας(SE) της παράκτιας αλιείας, η οποία αποτελεί μία πολύ σημαντική οικονομική δραστηριότητα στην Ελλάδα. Για τη μέτρηση της αποτελεσματικότητας χρησιμοποιείται η Περιβάλλουσα Ανάλυση Δεδομένων(DEA), ενώ επίσης διερευνάται και η επίδραση συγκεκριμένων χαρακτηριστικών του σκάφους και του καπετάνιου. Κατά μέσο όρο, τα σκάφη παρουσιάζουν χαμηλή TE και συνεπώς είναι δυνατή η παραγωγή του ίδιου επιπέδου εκροών με τη χρήση μειωμένων εισροών. Επιπλέον, τα σκάφη με μήκος μικρότερο από6μέτραεπιτυγχάνουν υψηλότερη TE, συνεπώς μπορούν να διαχειριστούν αποτελεσματικότερα τους διαθέσιμους πόρους τους. Αξιοσημείωτο είναι επίσης το γεγονός ότι η εμπειρία του καπετάνιου έχει θετική επίδραση στην TE, ενώ, το επίπεδο μόρφωσης δεν την επηρεάζει. Το γεγονός αυτό αναδεικνύει ότι η δραστηριότητα της αλιείας μικρής κλίμακας ομοιάζει περισσότερο με τέχνη παρά με επιστήμη και συνεπώς οι έμπειροι καπετάνιοι είναι αυτοί που μπορούν να αξιοποιήσουν με αποτελεσματικότερο τρόπο τους διαθέσιμους οικονομικούς πόρους.

Λέξεις κλειδιά:*Παράκτια Αλιεία μικρής κλίμακας, Τεχνική Αποτελεσματικότητα, Αποτελεσματικότητα κλίμακας, Περιβάλλουσα Ανάλυση Δεδομένων (Data Envelopment Analysis-DEA)*

1. Introduction

Efficiency in fisheries is, in general, about achieving the best possible outcome with the available resources (fish stock and fishing inputs). Improvements in efficiency are desirable provided that the management structure exists, prevents biological and economic overexploitation. If not, increased efficiency or the ability to catch more fish for a given amount of fishing effort can be detrimental to sustainability (Grafton et al., 2006). Efficiency is strictly related with the concept of overcapacity. Overcapacity equals the difference between the maximum potential output that could be produced - given technology, desired resource conditions, with full and efficient utilization of capital stock, other fixed and variable input - and a desired optimum level of output (e.g. the maximum sustainable yield, MSY or maximum economic yield, MEY) (Pascoe, 2003).

Many studies in the last decade explore efficiency in the European fishing fleet in terms of the optimal combination of inputs to achieve a given level of output using Data Envelopment Analysis (DEA). DEA is a non-parametric approach of estimating efficiency. It was originally proposed by Charnes et al. and is based on Farrell's model. By solving a linear programming problem, it allows us to estimate efficiency in multi-output situations without assuming an a priori functional form for frontier production (Coelli T.J., 2008).Lindebo et al. (2007) investigated the Danish North Sea trawlers and Pascoe et al. (2002) utilized DEA in order to investigate the English Channel fisheries. In the Mediterranean region, Tsitsika and Maravelias (2008; 2009) investigated the efficiency of purse seiners in Greece while Madau et al. (2009) investigated efficiency in the small-scale segment in Sardinia.

The Greek fishing fleet consisted in 2012 of 16,063 registered vessels, with a combined gross tonnage of 79,678 GT and a total engine power of 462,429 kW. In particular, there were 13,918 fishing enterprises in Greece offering employment to 27,558 people. The Greek fishing fleet decreased between 2008 and 2012, with the number of vessels falling by 9% mainly due to the implementation of the fisheries policy to reduce the number of vessels and the fleet capacity, according to the Multiyear Orientation Programs for the Greek fishing fleet.

The Greek fishing fleet has some distinct characteristics that differentiate it from the fisheries sectors of other Mediterranean countries. The main characteristic is that it consists mainly of small vessels of length less than 12 meters, utilize polyvalent passive gear and exploit the extended coastline of the country. In 2012, small scale (coastal) fishery consisted of 14,903 vessels.

The main purpose of this study is to explore the issue of efficiency of the Greek small scale fishing fleet. For this purpose, efficiency was considered using economic capacity analysis (Herrero and Pascoe, 2002; Lindebo et al., 2007), in which a data envelopment model (DEA) was used. The results were then further decomposed into technical, economic and allocative factors thus highlighting the technical and the economic dimensions of efficiency (Lindebo et al., 2007, Madau et al., 2009).

2. Material and Methods

According to Kumbhakar and Lovell (2000), technical efficiency is defined as the ability of a decision-making unit (DMU) to obtain the maximum output from a given set of inputs (output orientation) or to produce an output using the lowest possible amount of inputs (input orientation). One way to do that is to measure a DMU's position relative to an efficient frontier, resulting in an efficiency score for this particular DMU. These efficiency scores will be bounded between zero and one, where a score of one indicates full efficiency. Therefore, efficiency measurement requires knowledge of the efficient production function.

Technical efficiency (TE) and the factors determining it are of crucial importance in production theory. Technical efficiency of a DMU and the degree of use of variable inputs determine both output and capacity utilization. Determining those factors affecting technical efficiency allows stakeholders to take measures to limit or improve it (Grafton et al., 2006).

In the fisheries context, there is a growing interest in the measurement of different fishing fleets technical efficiency. This interest is twofold: to establish the underlying factors (e.g. Kirkley et al., 1998; Sharma and Leung, 1998), and to assess the effects of several socioeconomic variables. In the fisheries economics literature, output-oriented technical efficiency is usually applied, as the main aim is the estimation of capacity utilization, a concept which is basically output-oriented. Moreover, several authors based in output orientation, suggest that fishery managers may reduce technical efficiency by constraining the use of certain inputs (Kirkley et al., 1995; Pascoe et al., 2001), or alternatively, they may improve it by expanding these inputs or by taking measures that properly define the property rights of the fishery (Grafton et al., 2006).

Although usually the efficiency analysis in fisheries investigates the capacity utilization (CU) of the fleet, we have indeed focused our study on the technical efficiency (TE) and the scale efficiency (SE), obtained by an input-oriented DEA. An input-orientated way of defining technical efficiency is the minimum amount of inputs required to produce a given level of output. In many fisheries, fishing vessels are not technically efficient because they use too many inputs, or are overcapitalized in the sense that a lower level of input (often measured in number of vessels) could be used to catch the same total harvest. Technical inefficiency may surface for many reasons, but a major cause is inputs controls that fail to prevent effort creep due to input substitution (Grafton et al., 2006).

Input oriented technical and scale efficiency are particular meaningful in the case of the Greek small-scale fleets since the managerial scheme in force is mainly based on input-control measures, including limited entry plans (licensing), open and closed areas and seasons, minimum length of species harvested and mesh size of nets (Fousekis and Klonaris, 2002). There are instead no limitations on the volume that can be landed per day or year. The limits at the activity are therefore represented by the environmental conditions and the input factors and the market conditions as well. The latter doesn’t represent usually a constraint since the domestic market is characterized by an imbalance between demand and supply that lead the prices at a high level when compared to other European countries.

From the end of the 1970s onwards, several techniques have been developed for efficiency analysis, based on the comparison of the output (input) of a group of DMUs. Methods to measure efficiency can be classified into two groups: non-parametric models (Data Envelopment Analysis - DEA) and parametric models, (Deterministic Frontier Analysis – DFA and Stochastic Frontier Analysis - SFA). Apart from measuring efficiency, applications using DEA have been recommended by FAO (1998) from the late- 1990s onwards to measure also fishing capacity (e.g. Kirkley and Squires, 2002; Reid et al., 2003; Vestergaard et al., 2003; Pascoe et al., 2004).

Data envelopment analysis developed by Charnes et al. (1978). The production frontier constructed by DEA is deterministic, so any deviations from the frontier are related to inefficiency. The idea behind DEA is to use linear programming methods to construct a frontier around the data. Efficiency is then measured relative to this frontier, where all deviations from the frontier are assigned to be inefficiency. Consider *n* DMUs producing *m* different output using *h* different inputs. Thus, **Y** is an mxn matrix of outputs and **X** is an hxn matrix of inputs. Both matrices contain data for all *n* DMUs. The Technical Efficiency (TE) measure can be formulated as follows:

$$\min \theta,$$

subject to:

$$-\mathbf{y}_i + \mathbf{Y}\lambda \geq 0 \quad (1)$$

$$\theta \mathbf{x_i} – \mathbf{X}\lambda \geq 0$$

$$\lambda \geq 0$$

and solved for each DMU in the sample.θ, is DMU's index of technical efficiency, $\mathbf{y_i}$, and $\mathbf{x_i}$, represent the output and input of DMU i respectively and $\mathbf{Y}\lambda$ and $\mathbf{X}\lambda$ are the efficient projections on the frontier. A measure of $\theta_i = 1$ indicates that the DMU is completely technically efficient. Thus, $1 - \theta$, measures how much DMU i's inputs can be proportionally reduced without any loss in output.

Model (1) implies that all vessels are operating under constant returns to scale (CRS). However, the CRS assumption is only appropriate when all DMU's are operating at an optimal scale (i.e one corresponding to the flat portion of the LRAC curve) (Coelli et al., 2002). Several factors like imperfect competition and constraints on finance may cause a DMU not to operate at optimal scale. The use of the CRS specification when not all DMU's are operating at the optimal scale will result in measures of TE which are confounded by scale efficiencies (SE). Simply being technically efficient (producing on the production frontier) does not maximize overall productivity, but instead maximizes productivity only for a given input-output combination (Grafton et al., 2006). When the vessel is scale efficient it also produces at the optimal input-output combination. This means that the vessel operates under constant return to scale (CRS), and therefore one more unit of input-mix will effect in operating under decreasing return to scale.

The use of the Variable Returns to Scale (VRS) specification will permit the calculation of TE devoid of these SE effects. Banker, Charnes and Cooper (1984) suggested an extension of the CRS DEA model to account for VRS situations.

The modified DEA model that accounts for VRS is as follows:

$$\min \theta,$$

subject to:

$$-\mathbf{y_i} + \mathbf{Y}\lambda \geq 0$$

$$\theta x_i – \mathbf{X}\lambda \geq 0 \quad (2)$$

$$\mathbf{NI}'\lambda = 1$$

$$\lambda \geq 0$$

The new constraint is $\mathbf{NI}'\lambda = 1$ where **NI** is a nx1 vector of ones. This constraint makes the comparison of firms of similar size possible, by forming a convex hull of intersecting planes, so that the data is enveloped more tightly. The technical efficiency measures under VRS will always be at least as great as under the CRS assumption (Coelli et al., 1998). Scale efficiency can be calculated by conducting both a CRS and a VRS DEA upon the same data. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency, and that the SE score is equal to the ratio of CRS TE score to VRS TE score.

One shortcoming of this measure of scale efficiency is that the value does not indicate whether the DMU is operating in an area of increasing or decreasing returns to scale. This can be determined by running a modified DEA model where non increasing returns to scale (NIRS) are imposed. In this model, the $NI'\lambda = 1$ restriction is substituted by $\mathbf{NI}'\lambda \leq 1$, to provide:

$$
\begin{aligned}
&\min \theta, \\
&\text{subject to:} \\
&-\mathbf{y_i} + \mathbf{Y}\lambda \geq 0 \\
&\theta \mathbf{x_i} - \mathbf{X}\lambda \geq 0 \quad (3) \\
&\mathbf{NI}'\lambda \leq 1 \\
&\lambda \geq 0
\end{aligned}
$$

The nature of the scale inefficiencies (i.e. due to increasing or decreasing returns to scale) for a particular DMU can be determined by comparison of the NIRS TE score and the VRS TE score. If they are unequal then decreasing returns to scale exist for that DMU, while if they are equal, increasing returns to scale exist.

In this study, DEAP 2.1 software is used for the estimation of the efficiency scores and the multi-stage method proposed by Coelli (1996) to deal with slacks. After the estimation of the above efficiency measures, a second stage statistical analysis is performed to associate efficiency scores with several socio-economic variables. This set of variables includes among others, education and age of the skipper, owner contribution to the vessel, length of the vessel and gross cash flow. This analysis is performed with spearman correlation and Wilcoxon rank-sum test (Mann–Whitney two-sample statistic). In order to perform the Mann-Witney test, vessels are divided in two groups according to a specific characteristic (binary variable). Then, the technical and the scale efficiency scores of the two groups are compared. The Mann-Whitney test is a non-parametric analog to the independent samples t-test that does not require the assumption that the dependent variable is normally distributed (Siegel and Castellan, 1988). As the distribution of the efficiency scores reveals, the assumption of normal distribution is not rational in this study.

This analysis focuses on the efficiency of small scale fisheries in Greece. For this purpose data gathered from 249 vessels of length less than 12 meters that use polyvalent passive fishing gear were used. Data were collected through a sample survey using a wellstructured socio-economic questionnaire. The data used in the analysis is part of a larger data set collected in the framework of the National Program for the Collection, Management and Use (EU). For the purpose of the analysis only data concerning small scale fishing vessels were used.

The variables used for the DEA analysis consist of one fixed input, which is the annual depreciation cost and four variable inputs, namely annual personnel cost, fuel cost, running cost and repair and maintenance cost. The output variable considered in the analysis is the annual revenues of the vessels.

Energy costs refer to the annual cost of fuels for the engine while personnel costs refer to the total cost of paid labour plus the unpaid labour of the owner. Maintenance and repair costs refer to the annual costs of repairs for vessel, the engine as well as the fishing gear and running costs refer to all other operation cost (e.g. bait and hooks) including the cost of lubricants and the commercial costs (e.g. ice, boxes and packages). Other annual expenses of the vessels like dock expenses and book keeping costs, were also included in the running costs. Annual revenues of the vessels were determined through the value of the annual landings. Table 1 contains some descriptive statistics of the main variables used in the DEA analysis.

Table 1. Descriptive statistics of the input and output variables used in the analysis

Variable	**Mean value (€)**	**St. deviation**
Input variables		
Personnel cost	9,068	6,498
Fuel cost	4,699	5,744
Running cost	3,268	5,194
Repair and maintenance cost	2,112	2,268
Output variable		
Revenues	18,869	16,304

As far as the depreciation cost is concerned, it has been estimated according to the Perpetual Inventory Method (PIM methodology) (IREPA et al., 2006). PIM proposes to determine the aggregate value of the tangible capital goods used in the current year by aggregation of the value of all vintages (year classes). Such aggregation can be based either on historical, current or constant prices. Once the value of the capital goods in a given benchmark year has been determined, the capital value of each subsequent year is calculated by adding investments of that year (gross capital formation), revaluing the existing stock and subtracting value of capital goods taken out of operation. The annual depreciation cost is then calculated, using proper depreciation schedule. The assumed depreciation rates used for the different components of the vessel are 7% for hull, 25% for engine, 50% for electronics and 35% for other equipment. The service lives are 25 years for hull, 10 years for engine, 5 years for electronics, 7 years for other equipment. Finally, the macro-economic approach, which values capital at replacement (current) prices and accounts for opportunity costs was usedand price indices derived from the survey have been used to run the model (IREPA et al., 2006).

As mentioned by Tinkley et al. (2005), the use of revenue as the output measure is not ideal, as revenue is a function of prices as well as quantity. Consequently, price changes that affect the output measure independent of input use may be interpreted as changes in technical efficiency. Further, assuming fishers seek to maximize profit, a change in relative prices may result in a change in their fishing strategy. As a result, the function is not truly a production function and the efficiency scores may represent a combination of allocative as well as technical efficiency. However, the potential biases introduced into the analysis from using revenue as the output measure are not likely to be large. Squires (1987) and Sharma and Leung (1998) note that fishers base their fishing strategies on expected prices, the level of technology and resource abundance. However, price expectations are not always accurate, information on the variation in abundance of the stock across the fishery is generally not available, and catch composition is governed largely by fishing gear that is not perfectly species selective.

Changing gears types is time consuming and usually needs to be done on shore rather than at sea. Hence, the ability of fishers to respond to changes in relative prices by varying their fishing activity is limited. Several recent studies (e.g. Holland and Sutinen, 2000) have suggested that fishing activity is largely influenced by habit, with only relatively minor changes in effort allocations in response to price in the short term.

Furthermore, we consider that the Greek small-scale fisheries are operating in a situation of unbalance ratio between demand and supply, where cultural and economic factors generate a high demand for seafood products leading to constantly high prices, not significantly affected by the either landing volume or the season.

Finally, the use of inputs (and outputs) values rather than quantities is very common in efficiency studies. As is recently proved by Portela (2013), and has been previously mentioned by Fare et al. (1990) and Banker et al. (2007), when the assumption that fishermen face equal input prices is hold, then values can be used in the place of quantities and still produce technical efficiency scores.

3. Results

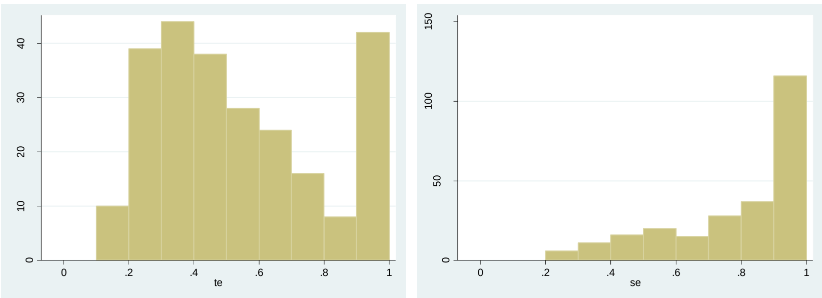
Table 2 provides the descriptive statistics of TE and SE scores for the small-scale vessels in Greece. It also reports the number of vessels that work under constant, increasing and decreasing returns to scale technology. On average, small-scale vessels have 0.54 TE scores and therefore, assuming that they are technically efficient, they can proportionally decrease their inputs by 46% and still produce the same amount of output. The standard deviation, the min and the max score of TE also reveal that the results are characterised by high heterogeneity. According to Figure 1, many vessels have very low efficiency, which suggests that there is room for improvement.

On the other hand, the average scale efficiency score is much higher (0.80). Therefore, on average, small scale vessels operate close to the optimal scale of production. According to Table 2, the vast majority of the vessels (72.7%) operate at increasing returns to scale, while 18.1% operates at decreasing returns to scale. This is a common finding in the relevant literature (e.g. Fousekis and Klonaris, 2003; Garcia Del Hoyo et al., 2004; Esmaeili, 2006).

Table 2. Descriptive statistics of Technical Efficiency (TE), Scale Efficiency (SE) and scale of operation for small scale vessels.

Variable	Average	Std. Deviation	CV	Min	Max
TE	0.54	0.26	47.7%	0.16	1 (34 vessels)
SE	0.80	0.21	26.6%	0.20	1 (23 vessels)
Scale of operation		**Decision Making Units**			
Increasing Returns to Scale		181 vessels (72.7%)			
Constant Returns to Scale		23 vessels (9.2%)			
Decreasing Returns to Scale		45 vessels (18.1%)			

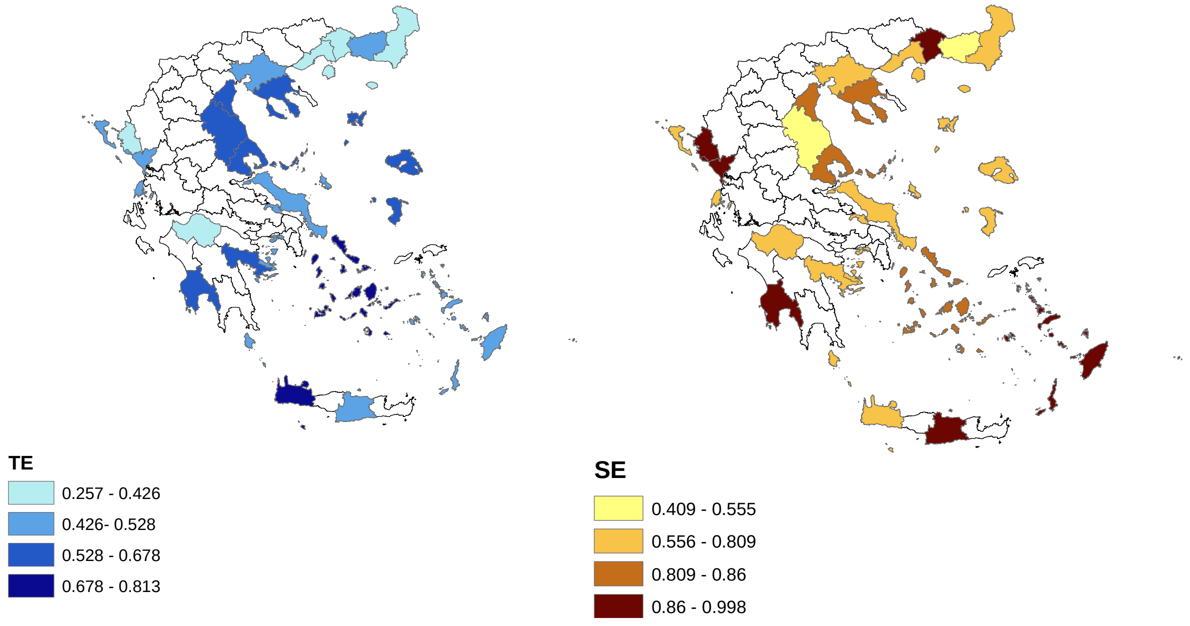
Figure 1.Histograms of a) TE and b) SE scores of the small-scale vessels



Maps 1a 1b, provide the average TE and SE scores per prefecture in Greece. In these maps, the darker the colour, the higher the efficiency scores. TE appears to be high in the south Aegean area, while no clear spatial pattern seems to exist for SE scores.

Table 3 and Table 4 provides the results of the Mann-Witney test. These results suggest that the vessels with length less than 6 meters are more technically efficient. To some extent this can be explained by the high level of flexibility that characterizes small vessels. These vessels can easily adjust their cost determinants according to the seasonal or regional productivity of the harvesting. This can be done for example using alternative fishing gear or moving to a different fishing ground targeting different species or simply by decreasing the level of the activity and operating only during the (potentially) more productive days.

Maps 1a,b. Geographical distribution of TE and SE scores of small-scale fishing segment



A similar result was reported by Fousekis and Klonaris (2002), whose empirical results in the investigation of the Greek trammel netters indicate that larger vessels tend to be less technically efficient than smaller vessels. They also point out that the crew size plays an important role, since larger vessels need larger crew. Thus, a large crew size may reduce the ability of a skipper to adjust the level of other inputs (Fousekis and Klonaris, 2002). Furthermore, it is noteworthy that the small vessels are generally capable of achieving higher selling prices than big vessels. This can be explained by several factors, like the limited volume of landings, better marketing strategy, higher product quality, or, more likely, a combination of these factors. In any case these vessels normally set their selling strategy on direct sales, without any intermediate intervention. This seems to encourage fishermen to focus on the product quality, which leads to high selling prices.

The results also reveal that TE is lower when the vessel is managed by a skipper younger than 40 years of age. Moreover, the literacy level appears to have a weak negative effect on TE. One possible explanation may lie in the fact that in small scale vessels, the outcome of the fishing activity relies on the experience of the skipper rather than on his formal education or on the use of new technologies (commonly associated with younger skippers). Furthermore, the experience of the skipper plays a key role in the selection of the fishing gear, the fishing ground and the fishing day. These results are not always supported by similar studies. For example, Ali et al. (1996) mention that formal education is generally associated with increased efficiency as it broadens the producers' minds and enables them to acquire and process relevant information. Moreover, according to Esmaeili (2006) younger skippers are more efficient than others. Finally, Fousekis and Klonaris (2002), exploring the efficiency of Greek netters, report that the 'good skipper' is aged about 50, has a literacy level higher than the primary, and comes from a fishermen family.

Table 3. Variables that define groups with different Technical Efficiency (TE) scores in the small-scale fishing segment

Variable that define groups		Average TE	Z score	Result
Length class	0-6 m	0.70	4.87**	Small vessels have higher TE
	6-12m	0.50		
Level of education	basic	0.56	1.64*	Skippers with basic education perform better
	advanced	0.51		
Vessels registered in "East Macedonia & Thrace	Yes	0.42	2.83**	Vessels in this region have lower TE
	No	0.57		
Vessels registered in "South Aegean" and "Crete"	Yes	0.69	-2.1**	Vessels in these regions have higher SE
	No	0.54		
Young skipper (less than 40)	Yes	0.50	1.65*	Vessels whose skipper is very young have less TE
	No	0.56		

**0.05 level of significance
*0.10 level of significance

Table 4. Variables that define groups with different Scale Efficiency (SE) scores in the small-scale fishing segment.

Variable that define groups		Average SE	Z score	Result
Length class	<6 m	0.72	-2.00**	Small vessels have lower SE
	≥ 6, <12m	0.82		
Fishing activity is the main source of income	Yes	0.60	-2.89**	Vessels whose skippers' main income is fishing present higher SE
	No	0.54		
Old skipper (more than 65)	Yes	0.66	2.74**	Vessels whose skipper is old, have less SE
	No	0.81		

**0.05 level of significance
*0.10 level of significance

The analysis also detected that the vessels operating in the region of East Macedonia and Thrace score lower TE than the vessels operating in others regions. On the contrary, vessels operating in the Cyclades Islands and Crete have high TE scores. These regional differences in the TE scores can be explained by differences in the composition of the catch or differences in the extent of competition with the large scale vessels for the same fishing ground and/or the same markets. The fishing grounds in the Cyclades Islands and Crete are characterized by rocky bottoms, while in the region of East Macedonia and Thrace, sandy grounds are more common. Moreover a lower number of large scale vessels operate in the Cyclades Islands and Crete.

As far as the scale efficiency is concerned, the analysis indicates that vessels less than 6 meters are less scale efficient. This result are in line with the fact that scale inefficiencies are mainly due to increasing returns to scale (sub-optimum vessel's size). Moreover, when fishing activity is the main source of income, scale efficiency level is higher. This is an indication that the owners are trying to fully exploit returns to scale and thus, to operate very close to constant returns to scale area. Moreover, it is a fact that the bigger vessels, that have higher scale efficiency, belong to owners whose main income source is the fishing activity. Finally, the result that vessels with older skippers are less scale efficient, could be explained by the fact that older skippers are not interested in capital investments, like the purchase of a new bigger vessel.

Table 5 provides the results of the Spearman correlation analysis among the efficiency scores and some technical and economic variables. Vessels with smaller technical characteristics (LOA and GT) have higher TE, as it was expected due to the results of the previous analysis. Moreover, days at sea are negatively correlated with TE. This could be explained by a more rational fishing strategy (i.e. operation only under optimal conditions or a close proxy of them). Finally, a negative correlation was detected between the technical efficiency (TE) and the presence of the owner on board as indicated by the ratio of unpaid labour to total labour costs. This is not a common finding in the relevant literature, as, in general, owner-operated vessels are considered more efficient (Esmaeili, 2006; Sharma and Leung, 1998).

Table 5. Spearman correlations of TE and SE scores of the small-scale vessels with technical and economic variables

	TE	SE
Length	-0.29**	0.23**
Gt	-0.28**	0.23**
Days at sea	-0.10*	0.28**
Unpaid labour to total labour	-0.17**	0.08

** 0.05 level of significance,
* 0.10 level of significance

As far as scale efficiency scores are concerned, they are positively correlated with the length and the capacity of the vessels, as also expected due to the results of Mann-Whitney tests. Moreover, scale efficiency is positively correlated with days at sea. This is expected due to the fact that bigger vessels with higher scale efficiency, usually go fishing more days that small vessels.

4. Conclusions

This study explores the issues of technical and scale efficiency of the Greek small scale fishing fleet. Small scale, costal fisheries represents the main fleet segment of the Greek fleet, differentiating it from other Mediterranean countries. In this analysis, the issue of efficiency was explored using an input oriented data envelopment analysis (DEA) model. The data used in the analysis were collected through a sample data survey and involve cost and revenue parameters. Four variable inputs were taken into consideration, namely, fuel cost, personnel cost, repair and maintenance cost and other running costs. Also, annual depreciation cost was used as a fixed input variable and annual revenues represent the output of the fishing activity. Additional information regarding the characteristics of the vessel (length and capacity) as well as characteristics of the skipper (age and education level) were also available and tested for correlation with the technical and scale efficiency.

The results of the analysis indicate that small-scale vessels achieve a low average technical efficiency of 0.54 but much higher scale efficiency (0.80). The results of the analysis also indicate that vessels with length less than 6 meters achieve higher technical efficiency scores. This means that in coastal fisheries, smaller vessels have the ability to manage better their resources, indicating the higher flexibility that they have.

Another important finding of the analysis is that technical efficiency (TE) is positively correlated with the age and therefore the experience of the skipper, though age is negatively correlated with scale efficiency. Education appears to have no effect on technical and scale efficiency of small scale vessels. The effect of the skipper experience on the efficiency of small scale fisheries, suggests that the activity resembles art rather than science, thus skillful skippers are highly appreciated.

The results of the analysis, suggest that there is room for improvement in the efficiency of small scale vessels, which will allow for the achievement of the same level of output, but with reduced inputs. This can be achieved reducing the level of activity of the segment by decreasing the total number of operating vessels or decreasing the days at sea per vessel. The former proposal is also sought by the Multi Year Orientation Program.

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