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Productive Efficiency of Commercial Fishing: Evidence from the Samsun Province of Black Sea, Turkey

Vedat Ceyhan[1,]*, Hanife Gene[2]

[1]University of Ondokuz Mayıs, Department of Agricultural Economics, 55139, Samsun, Turkey.
[2] Turkish Statistical Institutes, Samsun, Turkey.

* Corresponding Author: Tel.: +90.5334390805; Fax: +90.3624576034;
E-mail: vceyhan@omu.edu.tr

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Abstract

Most commercial fisheries have experienced dramatic declines in fish stocks sourced by overcapacity, and thus, there has been a decline in the economic benefits of fishermen, industries, and regions that rely on fisheries for their support in Samsun. Therefore, the study evaluated productive efficiency measures for large scale modern commercial fishermen in Samsun Province, Turkey. Data envelopment analysis (DEA) was used to calculate productive efficiency measures. 55 trawlers and 65 fishermen who prefer to use trawlers together with seine fishing were interviewed in the 2007–2008 production periods. Research results showed that the mean economic efficiency of trawlers and the fishermen preferring to use trawlers together with seine fishing were 0.535 and 0.667, respectively. In Samsun, the primary source of economic inefficiency for trawlers was allocative inefficiency, while that of mixed fishermen was technical inefficiency. Decomposition of the technical efficiency showed that pure technical efficiency was the primary cause of the technical inefficiency for both trawlers and mixed fishermen. Most fishermen in both fishing types exhibited increasing return to scale. Research findings also revealed that basic source of inefficiency was overcapacity problems sourced by market failures and restrictions on season length in the research area. Policy measures aimed at developing training and extension programs, helping fishermen improve their technical information, eliminating inefficiency sourced by overcapacity, sustainable use of the fish stocks, and encouraging fishermen to obtain higher added value from fish and other sea products via processing, packing and storing fish instead of increasing fish production are recommended to increase productive efficiency in the research area.

Keywords: DEA, efficiency measures, bootstrapping, fisheries, Samsun, Turkey

Ticari Balıkçılıkta Üretim Etkinliği: Karadeniz Bölgesi Samsun İli Örneği, Türkiye

Özet

Samsun ili balıkçılarının sahip olduğu aşırı avlanma kapasitesinin balık türleri üzerine oluşturduğu baskı; hem kendilerinin, hem de balık endüstrisinde faaliyet gösteren işletmelerin ve bölgede balıkçılığa dayalı işlerde çalışanların gelirinde azalmalar meydana getirmiştir. Bu sebeple çalışmamızda, Samsun ilinde faaliyet gösteren büyük ölçekli modern balıkçıların üretim etkinliği değerlendirilmiştir. Üretim Etkinliği ölçümlerinin hesaplanmasında Veri Zarflama Yönteminden (VZY) yararlanılmıştır. Araştırma verileri 2007-2008 üretim döneminde trol ile balıkçılık yapan 55, gırgır ve trolü birlikte kullanarak balıkçılık yapan 65 balıkçıdan anket yoluyla toplanmıştır. Araştırma sonuçları, ortalama ekonomik etkinlik skorunun trolle balıkçılık yapanlar için 0.535, gırgır ve trolü birlikte kullanarak balıkçılık yapanlar için 0.667 olduğunu göstermiştir. Samsun ili ticari balıkçılığında ekonomik yetersizliğin temel kaynağı trol ile balıkçılık yapanlar için tahsis yetersizliği iken, gırgır ve trolü birlikte kullanarak balıkçılık yapanlar için teknik yetersizliktir. Teknik etkinlik analizi sonuçları, inceleme alanında her iki grup balıkçı için teknik yetersizliğin ana sebebinin saf teknik etkinlik olduğunu göstermiştir. İncelenen balıkçıların büyük bir çoğunluğu ölçeğe artan getiriye sahiptir. Araştırma sonuçları ayrıca inceleme alanındaki ekonomik yetersizliğin bir diğer sebebinin de avlanma sezonunun kısıtlanmasının ve piyasa başarısızlığının yol açtığı aşırı kapasite problemi olduğunu göstermiştir. Balıkçılara yönelik eğitim ve yayım çalışmaları geliştirerek balıkçıların teknik bilgi düzeyinin artırılması, aşırı kapasiteden kaynaklanan yetersizliğin ortadan kaldırılması, balık stoklarının sürdürülebilir kullanımı ve balıkçıların balık ve diğer deniz ürünlerinin katma değerini yükseltmek için işleme, paketleme ve depolama gibi faaliyetlerle özendirilmesi inceleme alanında üretim etkinliğini artırabilecektir.

Anahtar Kelimeler: Veri Zarflama Yöntemi, etkinlik ölçümleri, bootstrap metodu, balıkçılık, Samsun, Türkiye.

Introduction

Fish is vital all over the world due to its being an important source of protein and healthy fats. People, therefore, have fished to feed families and local communities for years. Recently, many problems such as rising fish demand for human consumption, overexploitation of certain fish stocks, over capacity, problem of managing fish stocks, and impacts of climate change, carbon emissions and energy prices on the fisheries sector, prices and margins throughout the fisheries value chain and lack of well-defined property rights have occurred in fisheries all over the world. Swartz *et al.* (2010) and Anticamara *et al.* (2011) suggested that since the onset of the industrial revolution, fisheries worldwide have been severely expanding their fishing grounds and consequently altering the balance of ecosystem dynamics worldwide. The case is nearly the same in Turkish fisheries. The problems of consumption pressure on fish stocks, impact of climate and energy prices, over capacity and problems arise in marketing channel are the challenges for Turkish fisheries. There have been also some additional micro and macro level genuine problems arise in Turkey. The problem of inefficient fisheries management due to absence of sufficient information about the fish stocks, common informality in fishing sector, insufficient monitoring and control in Turkish fisheries, problems sourced by multispecies fishing such as catching undersized fish etc., small scale fishing, technological incompetence of fishermen, risks sourced by job and economic security in the Turkish fisheries, insufficient information about the socio-economic structure of the fishermen in Turkey, insufficient technical information of fishermen, corruption between the authorities and large-scale commercial fishermen, weakness of fish processing industry are some of original problems in Turkish fisheries. Yılmaz and Yılmaz (2009) reported that the basic problems of Turkish fisheries were not having a macro Turkish fisheries policy and structural problems such as hunting, unconscious and destructive hunting, technical and technological incompetence and lack of entrepreneurship and incentives, which were reducing the competitiveness of Turkish fisheries. Regarding the Black Sea fisheries, the fishing problems arising in the region is parallel with Turkish case. Ulman *et al*. (2013) suggested that Black Sea Marine Ecosystem faced with environmental stressors such as pollution, eutrophication, over fishing, introduction to alien species, removal of top predators and climatic variation. They also suggested that monitoring and control, corruption between the authorities and large-scale commercial fishers, credit risk, outpacing the natural population growth in most fish stocks due to technology, multispecies fishing and population pressure have been challenge in Black Sea, as well as Samsun. Similarly, Zengin (2006) stated that the construction of many dams on the Kızılırmak and Yeşilırmak rivers have significantly reduced nutrient availability to the Turkish continental shelf, which resulted in decreased marine productivity of the area.

Fishery production is one of the traditional industries in Turkey. Fisheries sector employ directly approximately 47 thousands of people and its contribution to gross domestic product is 0.4% in Turkey. Based on the results of the assessment and scored, Turkey ranked 46 out of 53 evaluated countries (Ulman *et al*., 2013). Turkey take place the 35th order all over the world and 7th order among EU countries in terms of fishing. A fishery production in Turkey was 704 thousand tons in 2011 and 61% of it was constituted by capturing, while the ratio of sea products, inland capturing and aquaculture were 6.5%, 5.3% and 26.8%, respectively (TURKSTAT, 2013).Turkey has dominated the fisheries within the Black Sea (GFCM, 2011). The Black Sea is the most important fishery production area in Turkey and constitutes about 80% of the total Turkish fishery production (TURKSTAT, 2013). Marmara, Aegean and Mediterranean followed it. Regarding the type of fish, 75% of the caught fish is anchovy and 80% of it is captured in the Black Sea. Anchovy is caught exclusively by purse seiners, ranging from 15 m to 50 m in length, with a net mesh size of 16 mm (Öztürk *et al*., 2011). Turbot stocks are very abundant in the Black Sea (Knudsen *et al.*, 2010). Over the last 40 years, the highest Black Sea catches of Mediterranean horse mackerel preceded the jellyfish invasion of the Black Sea. The Black Sea, including the Sea of Azov, was a major contributor to global sturgeon biomass, but this has changed in recent decades (Ustaoğlu and Okumuş, 2004). Despite many legal measures to protect sturgeons, they are mainly caught as by-catch, especially due to the increasing power and pressure of the bottom trawl fishery, and to a lesser extent from sea snail dredges and extension nets in the Samsun region (Zengin *et al.*, 2011). Samsun is one of the most important fishery production areas in the Black Sea and constitutes 15% of the total fishery production of the Black Sea. Total quantity of caught sea fish in Samsun was 23.5 thousand tons. 65% of it was anchovy while that of whiting was 5%. Red mullet, scad, blue fish, twaite shad, bonito, grey mullet and turbot followed them, respectively (Hekimoğlu and Altındeğer, 2012; Samsun *et al*., 2006).

For the last decades, the problem of over capacity has been moved to higher into the fisheries agenda, and this made fisheries management more important than past worldwide. Ward *et al*. (2004) reported that there has been profit maximization by increasing their fishing effort on one side of the coin, while cost minimization has been on other side of the coin for fisheries managers. Therefore balancing them is a new challenge for many fisheries managers. In fisheries management, the responses of the two different objectives to the problems of excess capacity were different. If the vessels fished for fewer days, then the level of effort would decrease and the problem of overcapacity would disappear from the perspective of the fisheries scientist. However, the problem would remain for the manager, and be worsened for the economist, as the reduced utilization would result in even lower levels of profitability. Since economic inefficiency of fisheries might be result of over capacity, many researchers focused on the measurement of efficiency and overcapacity. Pascoe *et al*. (2002) stated that measurement of efficiency in fisheries is important for several reasons, particularly when input controls are in place. As well as the obvious impact on the harvesting capacity, increases in efficiency over time could result in biased effort measures and hence affect stock assessments. Of course the same development has been observed in Turkey, as well as Samsun. Many fisheries managers in Samsun have focused on reaching maximum yield by increasing their fishing capacity. However, fishermen in Samsun have conducted their activities with higher fleet size and lower yields due to environmental stressors such as pollution, eutrophication, over fishing, introduction to alien species, removal of top predators and climatic variation in Black Sea and some institutional registration, resulting in lower profitability. It may be stressed that one of the sources of economic inefficiency is over capacity problem. Estimating efficiency scores is also crucial part of designing efficient fisheries management. In this context, examining the economic efficiency of fishermen in Samsun has come to agenda. Similarly, Pascoe *et al*. (2002) stated that measurement of efficiency in fisheries is important for several reasons, particularly when input controls are in place. As well as the obvious impact on the harvesting capacity, increases in efficiency over time could result in biased effort measures and hence affect stock assessments. On the other hand, in Black Sea, fishermen’s understanding and adopting of new production technologies are often hindered due to having inefficient scale, high level of production costs, insufficient investment, and low levels of education, unskilled employees, poor extension services, and lack of credit. Yücel (2006) and Çeliker *et al*. (2006) suggested that education level of fishermen and the experience of crew were moderate in Black Sea fisheries. The production cost was high and there was technical and economic information need of Black Sea fishermen. In these circumstances, fishermen have failed to fully exploit potential technologies and have made inefficient decisions, resulting in low level of economic return. Achieving optimum economic return from harvesting the fish resources, and considering biological safe limits of fish stocks increased in importance. Many policymakers have therefore focused on improving productivity and efficiency to meet current and future demands for food fish supplies and design efficient fisheries management. However, such efforts have been slowed by insufficient information on productive efficiency and productivity at the fishermen level.

Since the Data Envelopment Analysis (DEA), which is non-parametric methods, was more appropriate for multispecies catching compared to stochastic frontier, it has been applied when estimating efficiency scores in fisheries all over the world (Kirkley *et al*., 1995; Kirkley *et al*., 1998; Paul, 2000; Alvares and Orea, 2001; Pascoe and Coglan, 2002; Pascoe and Herrero, 2004; Coppola *et al*., 2004; Signorello *et al*., 2004; Tingley and Pascoe, 2005; Herrero *et al*., 2006; Esmaeili and Ormani, 2007; Idda *et al*., 2009; Hoff *et al*., 2009, Thean *et al*., 2011;Oliveira *et al*., 2010). Despite the common use of DEA worldwide, no study has been focused on examining fishermen-level productive efficiency measures for commercial fishery by using DEA not only in Black Sea but also in Turkey.

Therefore, the objectives of this study were (i) explore and compare the socio-economic characteristics of commercial fishermen associated with fishing gear type in Samsun province of Turkey, which has a coast in the Black Sea, (ii) to calculate fishermen-level productive efficiency measures for commercial fishermen, and (iii) to develop policies based on these productive efficiency measures.

In this paper, characteristics of fishermen associated with fishing gear type such as trawlers and mixed fishing gear type, trawling and purse seining, were explored. Efficiency scores were also estimated by using the input oriented DEA models. Implications for future policy measure to increase efficiency in fisheries are then drawn from the results of the analyses.

Materials and Methods

The Research Area

The study was conducted in Samsun (40°50′-41°51′ N latitudes and 37°08′ - 34°25′ E longitudes), a province in northern Turkey. Samsun is located along the Black Sea. The water surface area of the Black Sea is 432000 km^2 and it is connected to the Marmara Sea and the Aegean Sea through the Bosphorus and the Dardanelles (Figure 1). There have been 2343 fishermen in Samsun. They continue their activities with 741 active vessels. Small scale fisheries are most common in Samsun and 84% of the total vessels is small scale and allocated to artisanal fishing. The rest, 120 vessels, are allocated to large scale commercial fisheries. 23% of them have 12 m length while rest is below 12 m. Trawl constitutes 28% of the active vessels having more than 12 m length. The rest is mixed fishing gear type, which is trawl together with purse seiners. Small scale fishermen generally capture red mullet and whiting together with some pelagic fish type such as horse mackerel, blue fish and bonito by using net. However, large scale fishermen tend to capture anchovies, sprat, whiting, blue fish, turbot and bonito by using trawlers and seine fishing.

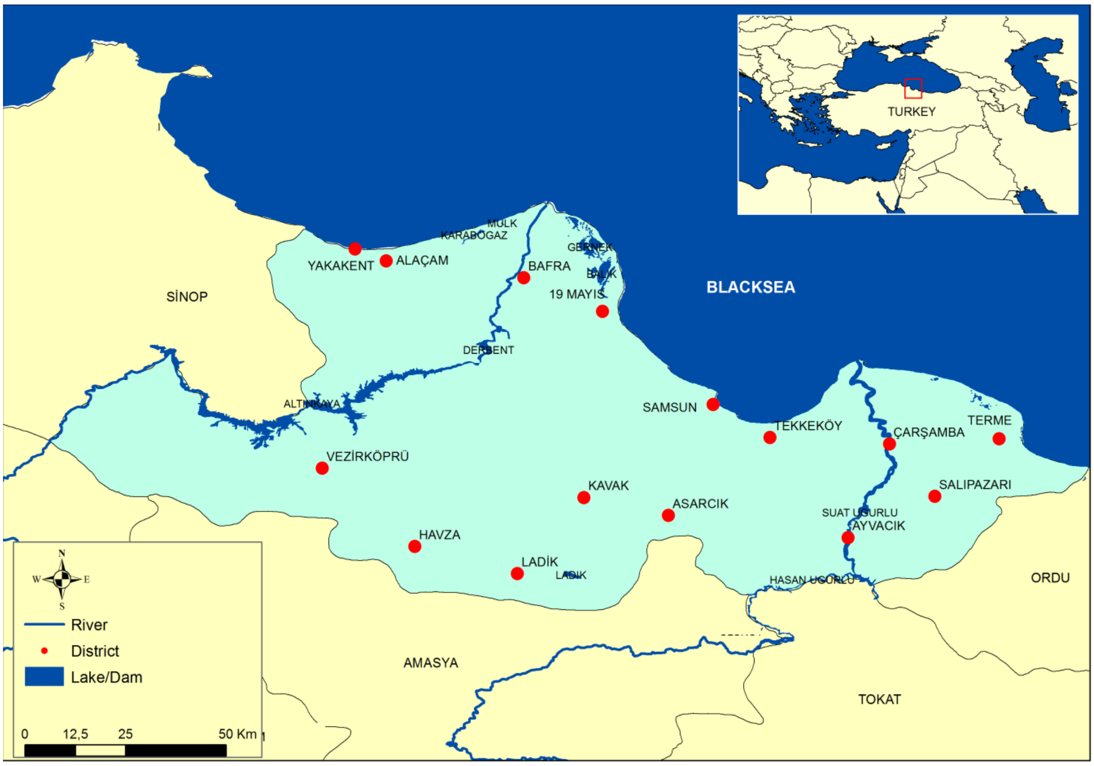

Figure 1. The map of the research area.

Fishermen Level DEA Model

Data envelopment analysis (DEA) was used to estimate productive efficiency measures. DEA is one of the most popular methods for estimating the best-practice production frontier and provides an analytical tool for determining efficient and inefficient behavior. Since DEA is less data-demanding, works with small sample sizes, and does not require knowledge of the proper functional form of the frontier, error, and inefficiency structures, it has been preferred over stochastic frontier analysis (SFA). Stochastic models such as SFA necessitate a large sample size to make reliable estimations (Coelli *et al*., 2005).

Efficiency is defined in a relative sense as the distance between observed input–output combinations and the best-practice frontier. The best-practice frontier represents the maximum output attainable from each input level. The Farrell input-orientated measure of technical efficiency was used as a measure of productive efficiencies, as fishermen tend to have greater control over their inputs than they have over their outputs. The efficiency of fishermen consists of two components: technical efficiency (TE), which reflects the ability of a fisherman to use minimal input to reach given the level of output, and allocative efficiency (AE), which reflects the ability of a fisherman to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure of economic efficiency (EE). The Farrell measure equals 1 for efficient fishermen, and then decreases with inefficiency (Farrell, 1957).

Based on the suggestion by Charnes *et al*. (1978), we constructed two different DEA models for trawling and for mixed one (trawling and seine fishing) assuming that each decision making unit (DMU), which is fishermen in the research, quantity of fish captured and other sea products (y_i) using multiple inputs such as labor (hours), daily cost ($) and total fixed asset ($)(x_i) and that each fishermen (*i*) is allowed to set its own set of weights for both inputs and output. The data for all fishermen are denoted by the $K \times N$ input matrix (X) and $M \times N$ output matrix (Y). Using piecewise technology, an input-oriented measure of TE can be calculated for the *i*-the fishermen the solution to linear programming (LP):

$$\begin{aligned} &Minimize_{\theta,\lambda} \\ &\theta \; Subject \; to -y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \tag{1}$$

where θ is the TE score having a value $0 \leq \theta \leq 1$. If the value equals 1, the fishermen is on the frontier; the vector λ is an $N \times 1$ vector of weights which defines the linear combination of the peers of the i -th fishermen.

The input-based minimum cost for the *i*-th fishermen can be obtained by solving the following LP problem:

$$Minimize_{\lambda,xi*}\ w_i^T x_i^*$$
$$Subject\ to - y_i + Y\lambda \geq 0 \quad (2)$$
$$x_i^* - X\lambda \geq 0$$
$$\lambda \geq 0,$$

where w_i is a vector of input prices for the *i*-th fishermen; superscript *T* is the transpose function; x_i^* is the cost-minimizing vector of quantities of labor, daily cost and total fixed cost for the *i*-th fishermen calculated by the LP, given the input prices w_i and output level y_i; and λ is a *N*x1 vector of constant. Equation 1 and 2 represents the cost minimization under constant returns-to-scale (CRS) technology. CRS means that output increases in proportion to changes in all inputs. The economic efficiency ($EE_{i,CRS}$) of the *i*-th fishermen is calculated as:

$$EE_{i,CRS} = w_i^T x_i^* / w_i^T x_i \quad (3)$$

That is, $EE_{i,CRS}$ is the ratio of the minimum cost to the observed cost, given input prices and CRS technology (Charnes *et al*., 1978).

Coelli *et al*. (2005) pointed out that the CRS model is only appropriate when the DMU is operating at an optimal scale. Factors such as imperfect competition and financial constraints may prevent a DMU from operating at optimal scale. Since fishermen, as an DMU, in the research area conducted their activities under imperfect competition due to imperfect information about market such as input and output prices, and because the size of many fishermen made them ineligible for institutional loans, we transformed equation (1) to the variable returns-to-scale (VRS) technology model by adding the convexity constraint: $N1\lambda = 1$, where $N1$ is an $N \times 1$ vector of ones and λ is an*N*x1 vector of constant to the equation (1) based on suggestion by Banker *et al*. (1984). In this case, TE scores under VRS were calculated using equation (1), with the convexity constraint added to decompose the TE scores into two components: "pure technical efficiency" (PTE), which reflects the ability of a fishermen to obtain maximal outputs at an optimal scale, and "scale efficiency" (SE), which reflects the distance of an observed fishermen from the most productive scale size. Fishermen that are efficient scales are of appropriate size and thus do not need to be reorganized to improve output or earnings. Scale efficiency was calculated as the ratio of the TE score of the fishermen under CRS technology to the TE score of the fishermen VRS technology. Fishermen in the research area were classified as efficient scale if the $SE = 1$ or if the $TE_{VRS} = TE_{CRS}$. Fishermen level scale inefficiency was determined by comparing TE score under non-increasing returns to scale (NIRS) with TE score under CRS. If SE < 1 and $TE_{NIRS} = TE_{CRS}$, fishermen was classified as scale inefficient due to increasing returns to scale (IRS). If SE < 1 and $TE_{NIRS} > TE_{CRS}$, fishermen was classified as scale inefficient due to decreasing return to scale (DRS). The allocative efficiency was calculated residually by

$$AE_i = EE_{i,VRS} / TE_i \quad (4)$$

Efficiency measures under CRS and VRS were calculated by using DEAP 2.1 developed by Coelli (1996).

Bootstrap

We used the bootstrapping method introduced by Efron (1979) and Efron and Tibshirani (1993) to assess the confidence intervals of the efficiency scores. Bootstrapping is a general approach to statistical inference based on building a sampling distribution for a statistic by re-sampling from the data. In last decades, the application of bootstrap to DEA estimators has increased. In previous studies, many researchers have been used bootstrap techniques on DEA estimators (Gstach, 1995; Simar and Wilson, 1997; Ferrier and Hirshberg, 1999; Simar and Wilson, 2000). The procedure applied in this study consists of the following steps. First, bootstrap samples were created by sampling with replacement from the original random sampling. Second, the bootstrap distribution was derived by calculating statistic for each resample. Finally, 95% bootstrap percentile confidence interval for the efficiency scores were constructed by using the interval between the 2.5th and 97.5th percentiles of the bootstrap distribution.

The results throughout the paper were obtained from 120 bootstrap iterations. The bootstrap standard error based on re-samples is (Hesterberg *et al*. (2003):

$$SE_{boot,\bar{X}} = \sqrt{\frac{1}{B-1}\sum(\bar{x}* - \frac{1}{B}\sum\bar{x}*)^2}$$

In this expression, $\bar{x}*$ is the mean value of an individual re-samples and B is the number of resample.

Data

Since 377 fishermen were small scale and tend to conduct subsistence fishing practices by using traditional fishing techniques in Samsun, fishermen who conduct their activities by using trawlers and seine or dragnet were considered as DMUs. Vessels coming from out of Samsun were not considered as part of the population. So, all large scale modern commercial fishermen (120) who conducted their activities in Samsun were interviewed in the 2007–2008 production periods. Of the total large scale modern commercial fishermen in Samsun, 46% and 54% were trawling and mixed, preferred to use trawlers together with seine fishing, respectively. The economic efficiency of DMUs was modeled in a three-input, two-output framework. The quantity of fish captured and other sea products during the period of 2008 was used to measure the outputs (kg). Labor (hours), daily cost ($) and total fixed asset ($) were inputs in the efficiency model.

Table 1 presents descriptive statistics of the variables used in the study. The examined fishermen captured 258 tons of fish and 22.5 tons of other sea products, on average. The quantity of harvested fish of trawling was more comparing to mixed one (P<0.10). To reach the present level of production, trawlers used approximately 1014labor days while that of mixed ones was 1180 days. Regarding the daily variable cost, examined fishermen spent $301, on average, during the harvesting period and cost of trawlers was more than mixed fishermen (P<0.05). Total fixed asset of trawlers and mixed fishing were $115000 and $101000, respectively and was $107000, on average.

The other variables included in the study were broadly categorized into three groups: personal characteristics of fishermen (age, education, experience and family size); fishery characteristics (length of vessel, tonnage of vessel, average motor power, days in sea, average crew size); and access to institutions (use of credit, the percentage of cooperative membership and extension services).

In Samsun, there had been no difference between trawlers and mixed fishing in terms of age, experience and educational level of fishermen. However, trawlers have larger families than mixed fishermen (P<0.05). Trawlers had longer, stronger, weightier and more equipped vessels and spent much more time at sea compared to mixed ones (P<0.01). However, crew size and return on asset of fishermen preferred trawlers together with seine fishing was much more than trawlers (P<0.10). When considering

Table 1. Descriptive Statistics of Variables Used in the Study

Variables	Trawling (n=55)		Trawling + seine fishing (n=65)	
	Mean	Standard deviation	Mean	Standard deviation
DEA model				
Quantity of fish captured (thousand ton) *	230.34	322.60	325.33	126.98
Quantity of other sea product captured (thousand ton)	224.68	199.08	226.14	221.41
Labor (day) **	1013.82	725.17	1180.39	991.05
Daily variable cost ($) **	301.21	256.69	220.90	145.05
Total asset (thousand $) *	115.10	156.38	101.04	197.69
Other variables				
Personal characteristics				
The age of the fishermen (in years)	42.13	10.09	40.75	9.49
The education level of fishermen (in years)[1]	3.29	0.69	3.38	0.72
The experience of fishermen (in years)	23.13	11.16	21.89	11.05
Family size (person) **	5.71	1.66	5.25	1.99
Fishery characteristics				
The length of the vessel (m) **	17.62	4.61	15.28	5.68
The mean age of the vessel (m) ***	19.31	12.62	13.31	7.84
Average tonnage of the vessel (gross ton) *	42.03	38.37	36.13	42.11
Average motor power (HP) **	306.04	159.54	243.36	160.98
Days in sea (days/year) ***	195.00	53.86	174.14	52.21
Average crew size (person) *	2.25	2.76	3.20	3.74
Investment during last 5 years (thousand $)	43.47	47.70	51.43	155.63
The value of the vessel equipment (thousand $)[2]*	19.59	14.08	17.95	19.19
Cooling room in vessel (m^3)	6.58	11.74	4.87	7.89
Return on asset *	0.31	0.78	0.53	0.28
Access to institutions				
Credit use (thousand $)	6.60	13.74	8.05	14.53
The ratio of cooperative membership	0.65	0.42	0.66	0.38
The ratio of course participation *	0.45	0.39	0.52	0.41

[1]From the start of the schooling period.
[2]Equipment includes radar, sonar, GPS Satellite, eco-sounder, generator, wireless installation, ice machine and cooling room.
[3] Single (*), double (**) or third (***) denotes significance at the 10%, 5% and 1% level, respectively.

access to institutions, there was no difference between trawlers and fishermen who preferred to use trawlers together with seine fishing in terms of credit use and cooperative membership. But, participation of the fishermen who preferred to use trawlers together with seine fishing to the courses related with fishing activities was higher than that of trawlers (Table 1).

Results

In Samsun, the ratio of captured sea fish was 0.92 for fishermen, while that of the average Turkish fishermen is 0.91. Similarly, the ratio of other sea product for fishermen in Samsun and Turkish average were 0.09 and 0.08, respectively. Regarding the distribution of the captured fish type, the percentages of anchovies and sprat were 54% and 14% in Samsun, while that of Turkish average value were 63% and 33%. The percentage of pilchard, horse mackerel and whiting were 7%, 4% and 3%, respectively in Samsun. The percentage of mussel in Samsun (70%) was doubled of Turkish average value.The percentage of sea snail in Samsun and Turkey were 13% and 24%, respectively. Two out of the third of the examined fishermen had vessel smaller than 12m length, while that of the Turkish average value was 88%. Regarding the characteristics of fishing activity, the average value of days in the sea, crew size and daily cost in Samsun were 195 days, $258 and 3 people, respectively. Turkish average values for them were 182 days, $394 and 3.1 people, respectively (Table 2).

The results of the efficiency analysis showed that the mean economic efficiency of trawlers and the fishermen preferred to use trawlers together with seine fishing in Samsun were 0.535 and 0.667, respectively. On average, inefficient trawlers and mixed fishermen would have needed to lower labor, daily costs and fixed asset by 49% to perform as well as the best-practice fishermen in the research area (Table 3).

Efficiency measures for fishermen in Samsun were presented in Table 3. Almost 93% of the trawlers were allocatively inefficient in Samsun. These fishermen employed the wrong input mix, given input prices, so that their costs were 37% higher than the cost-minimizing level. The estimated TE measures for the trawlers varied from 0.53 to 1, with a sample average of 0.84. The trawlers could reduce their input use by16% level without output reduction. Decomposition of the technical efficiency showed that PTE was the primary cause of the technical inefficiency for trawlers and PTE was 0.50, on average. SE was 0.58, on average, with a standard deviation of 0.28 (Table 3).

Regarding the fishermen who preferred to use trawlers together with seine fishing, almost 93% of them were technically inefficient. These fishermen employed the wrong input mix, given input prices, so that their costs were 18% higher than the cost-minimizing level. The estimated TE measures for the mixed fishermen varied from 0.37 to 1, with a sample average of 0.81. The mixed fishermen could reduce their input use by 19% level without output reduction. Decomposition of the technical efficiency showed that PTE was the primary cause of the technical inefficiency for mixed fishermen and PTE was 0.48, on average. SE was 0.68, on average, with a standard deviation of 0.28 (Table 3).

Table 4 reports the bias and the lower and upper bounds of the efficiency scores. The biases were small for all efficiency measures. Bootstrapping showed that the confidence intervals for efficiency measures did not vary considerably over the re-samples. Based on the results of bootstrapping, the lower and upper bound of technical efficiency scores for trawlers were 0.753 and 0.923, respectively while that of allocative efficiency scores were 0.559 and 0.703. Lower bound for PTE was smaller than that of SE. The same was the case for the upper bounds of PTE and SE. The overall economic efficiency scores varied from 0.46 to 0.62. For trawlers, standard error for TE, AE and EE derived from bootstrapping distributions were 0.033, 0.028 and 0.031, respectively. For the fishermen preferred to use trawlers together with seine fishing, the lower and upper bound of technical efficiency scores for trawlers were 0.65 and 0.96, respectively while that of allocative efficiency scores were 0.773 and 0.865.Lower bound for PTE was smaller than that of SE. The same was the case for the upper bounds of PTE and SE. The overall economic efficiency scores varied from 0.51 to 0.82. For mixed fishermen, standard error for TE, AE and EE derived from bootstrapping distributions were 0.063, 0.018 and 0.061, respectively

Of the trawlers, 20% had CRS, whereas 77% exhibited a situation in which an increase in input caused output to increase to a larger proportion, termed IRS. 3% of the trawlers had DRS, which refers to output increasing by less than that the proportion of all inputs. Approximately, the same was the case for fishermen preferred to use trawlers together with seine fishing. 47 mixed fishermen out of the 55 exhibited IRS while 9% of them had CRS.6% of the mixed fishermen had DRS (Table 5).

Since scale refers to size, we included the descriptive statistics of variables such as quantity of fish captured, quantity of sea product captured, average daily cost, average crew size, and days in sea, average tonnage and length of vessel, return on equity and total asset. As shown in Table 5, the 5 scale-efficient fishermen in trawling were large in terms of days in sea, and total asset. In addition, scale-efficient fishermen had less daily variable cost and average tonnage and length of vessel compared to inefficient fishermen. When focusing on fishermen preferred to use trawlers together with seine fishing, the 13 scale-efficient fishermen were large in terms of fish production, crew size and return on asset. In addition, scale-efficient mixed fishermen had less length of

Table 2. Characteristics of Examined Fishermen Compared to the Average Turkish Fishermen

Characteristics	Average Turkish value*	Examined fishermen**
Statistics for commercial fisheries		
Total fishery production (1000 ton)	477.66	281.79
The ratio of captured sea fish	0.91	0.92
The ratio of other sea product	0.09	0.08
Distribution of captured fish type		
The percentage of anchovies (%)	57.30	61.08
The percentage of horse mackerel (%)	3.60	0.94
The percentage of whiting (%)	3.39	5.46
The percentage of pilchard (%)	6.91	0. 01
The percentage of sprat (%)	14.26	33.27
The percentage of red mullet (%)	0.58	0.49
Distribution of captured sea product	0.20	0.91
The percentage of sea snail (%)	14.38	23.84
The percentage of mussel (%)	70.42	35.21
The percentage of prawn (%)	10.49	7.02
Type of fishing		
Trawling	543.00	55.00
Trawling + seine fishing	526.00	65.00
Seine fishing	469.00	-
Distribution of size of vessel (%)		
The number of vessel with 1–4.9 m length	0.92	-
The number of vessel with 5–7.9 m length	55.05	20.83
The number of vessel with 8–11.9 m length	32.17	36.67
The number of vessel with 12–29.9 m length	10.27	42.50
The number of vessel with >30 m length	1.59	-
Characteristics of fishing activities		
Days in sea (number)	182.00	195.00
Daily variable cost ($)	394.00	258.00
Crew size (person)	3.10	2.76
Total asset (1000 $)	64.52	107.48

*Average Turkish values was based on the results of Ünal (2004), Yücel (2006), Rad and Delioğlan (2008), Çeliker *et al.* (2006 and 2008) and Taşdan *et al.* (2010).

Table 3. Efficiency Measures for Examined Fishermen

Efficiency measures	Trawling (n=55)			Trawling + seine fishing (n=65)		
	Mean	Standard deviation	Efficient DMU	Mean	Standard deviation	Efficient DMU
Economic efficiency (EE)	0.535	0.219	4	0.667	0.219	7
Allocative efficiency (AE)	0.631	0.199	4	0.819	0.159	7
Technical efficiency (TE)	0.838	0.151	17	0.805	0.195	22
Pure technical efficiency (PTE)	0.496	0.281	5	0.481	0.304	12
Scale efficiency (SE)	0.581	0.277	5	0.676	0.283	12

Table 4. Confidence Intervals Bounds for the Efficiency Measures

Efficiency measures	Standard DEA estimation	Bias	SE_{boot}	Lower bound	Upper bound
Trawling					
Economic efficiency (EE)	0.535	+0.048	0.031	0.455	0.615
Allocative efficiency (AE)	0.631	+0.032	0.028	0.559	0.703
Technical efficiency (TE)	0.838	+0.053	0.033	0.753	0.923
Pure technical efficiency (PTE)	0.496	+0.032	0.018	0.450	0.542
Scale efficiency (SE)	0.581	+0.024	0.019	0.532	0.630
Trawling+seine fishing					
Economic efficiency (EE)	0.667	+0.025	0.061	0.510	0.824
Allocative efficiency (AE)	0.819	+0.059	0.018	0.773	0.865
Technical efficiency (TE)	0.805	+0.048	0.061	0.650	0.959
Pure technical efficiency (PTE)	0.481	+0.082	0.014	0.445	0.517
Scale efficiency (SE)	0.676	+0.032	0.027	0.606	0.746

vessel compared to inefficient fishermen (Table 6).

Discussion

Under the light of the research findings, large scale modern commercial fishermen had similar characteristics of Turkish average commercial fishermen. The ratio of fish production and other sea product for fishermen in Samsun did not differ from Turkish average value. Anchovies were the most common fish species for not only sample fishermen but also Turkish average fishermen. The percentage of sea snail was higher than that of Turkish average values, while the percentage of mussel was higher in Samsun. Most of the fishermen had vessel smaller than 30 m length in Samsun. Regarding the characteristics of fishing activity, the average value of days in the sea in Samsun case was more than that of Turkish and Italy, and the same with the value of Denmark. The crew size and daily cost were lower in Samsun comparing to Turkish and Denmark average ones (Hoff *et al*., 2009; Idda *et al*., 2009).

It was clear from the research findings that inefficiency source was different for trawlers and fishermen preferred to use trawlers together with seine fishing in Samsun. The primary source of economic inefficiency for trawlers was allocative inefficiency while that of mixed fishermen was technical inefficiency. Based on the results of the decomposition, it was fixed that most trawlers and mixed fishermen exhibited increasing return to scale in Samsun. It means that there has been in need of size variation to increase efficiency. But, they should be considered the fish population and sustainability of their activities. In addition, scale efficiency scores revealed that the performance of the scale-efficient trawlers and mixed fishermen were much more than inefficient ones. The main difference between scale efficient and scale inefficient fishermen was the variables of days in sea. Efficiency increased associated with days in sea. Similarly Hoff *et al*. (2009) reported that days in sea for efficient fishermen were more than inefficient one in Denmark.

Research findings also revealed that basic source of inefficiency was overcapacity problems sourced by market failures and restrictions on season length in the research area. Mace (1996) identified overcapacity as the single most important factor threatening the long-term viability of exploited fish stocks and the fisheries that depend on them. Season length restriction made sample fishermen not only to purchase larger vessel for benefiting limited season, but also to increase their fishing effort resulting in declining in stock abundance. The overcapacity problem led to increase the capturing cost of fishermen. So, the net benefits of fishing fleet and quality of fishermen' life decreased over time in the research area. Ward *et al*. (2004) pointed out that the full costs of production are not realized by the fishermen due to neglecting the cost of stock input. They also suggested that without strong property rights for the in situ resource, the market mis-allocates

Table 5. Summary of returns to scale results for trawlers in Samsun

Variables	IRS	*CRS*	*DRS*
Average number of fisherman	47	5	3
Average fish production (ton)	209.28[a]	475.31[a]	152.14[a]
Average sea product production (ton)	17.61[a]	49.60[b]	53.33[b]
Average daily variable cost ($)	300.71[a]	205.73[a]	484.72[a]
Average crew size (person)	5.04[a]	6.00[a]	7.33[a]
Days in sea (days/year)	193.40[a]	218.00[a]	181.67[a]
Average tonnage of the vessel (gross ton)	40.11[a]	31.40[a]	90.00[b]
Average length of the vessel (m)	17.70[ab]	14.40[a]	21.67[b]
Return on asset (ratio)	0.27[a]	0.79[a]	0.03[a]
Total asset (thousand $)	114.61[a]	75.88[a]	254.17[a]

Returns to scales with same letter(s) are not significantly different.

Table 6. Summary of returns to scale results for trawling together with seine fishing in Samsun

Variables	IRS	*CRS*	*DRS*
Average number of fisherman	50	13	2
Average fish production (ton)	202.43[a]	888.13[b]	21.23[a]
Average sea product production (ton)	15.71 [a]	43.50 [b]	70.00[c]
Average daily variable cost ($)	360.84[a]	364.38[a]	456.29[b]
Average crew size (person)	2.84 [a]	4.75[b]	3.00[a]
Days in sea (days/year)	173.46[a]	171.42[a]	207.50[a]
Average tonnage of the vessel (gross ton)	41.13[a]	19.54[b]	10.50 [b]
Average length of the vessel (m)	15.90 [a]	12.75[a]	15.00[a]
Return on asset (ratio)	0.03[a]	0.13[b]	0.01[a]
Total asset (thousand $)	92.37[a]	161.45[a]	56.25[a]

Returns to scales with same letter(s) are not significantly different.

capital, labor, and the fish stock in the production decisions of the fishers, and profits are not maximized by the industry. Despite the arising many problems in fisheries in the research area, effective management measures have not been put into practice. Neglecting the property rights, uncontrollable incentives and technological development enhanced the overcapacity problems and the pressure on stocks. Similarly Ward *et al*. (2004) stressed that in most fisheries, management has not fully addressed the problem associated with the absence of succinct property rights, and many of the incentives associated with free and open access still exist even if the number of participants is now constrained.

Conclusions

The results of this study suggest that substantial decreases in inputs or gains in outputs could be attained by improving and better utilizing the existing technology in fishery activities. Policymakers should focus on (i) enhancing fishermen's access to information via better extension services and fishermen training programs, (ii) eliminating inefficiency sourced by overcapacity, (iii) encouraging them to obtain higher added value from fish and other sea product via processing, packing and storing fish instead of increasing fish production and (iv) improving fixed asset to increase efficiency.

Training and extension programs for fishermen, especially for mixed ones, should be provided in the research area to improve the economic efficiency of individual fishermen up to at least the level of the best fishermen. Training focusing on the technical aspect of fisheries and management recordkeeping may help increase efficiency in Samsun. Training and extension activities are relatively low-cost methods of achieving increases in productive efficiency. In addition, monitoring input and output market in order to allocate production factors based on input and output prices may be beneficial for both groups of fishermen.

Defining user rights may be useful for solution for the problems of overfishing, excess capacity and overcapacity, which are symptoms of user rights in the research area. Current incentive blocking measures such as time restriction, limited entry, buyback program, gear and vessel restrictions, aggregate quotas, non-transferable vessel catch limits, individual effort quota to reduce overcapacity problem in Turkey, as well as Samsun should be based on healthy economic and biological data. Increasing the efficiency of buyback program may be decreased the inefficiency sourced by overcapacity in the research area. In addition, incentive adjusting instruments should be used to reduce overcapacity problems in the research area.

Increasing the value added of fish and other sea products by means of enhancing the capability of storage, packing and processing may increase efficiency of fishermen and decrease the pressure of fishermen on fish stocks. Supporting the cooperation and encouraging fishermen's organization to establish processing, packing and storing facilities may accelerate the increase of fishermen's efficiency level.

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