Efficiency and Ship Class of Shipping Companies: The Case of Greek-owned Shipping Companies

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***Abstract*—Transport industry is a very important factor for country's development in various fields. One of them is economic, since the development of transport reinforces the trade relationships between countries and companies. This helps countries and firms to utilize the competitive advantage which may have. Therefore, the volume of transport carried out by countries could reflect their growth. This study aims to examine the efficiency (by ship class) of Greek-owed shipping companies, listed on New York stock markets. The analysis was performed via BCC model of Data Envelopment Analysis (inputs orientation).**

***Keywords*—** *efficiency; shipping; DEA; transport*

1. Introduction

Shipping is the most optimized way of transport that a country could develop, whether it is geographically possible, because it provides cheap and reliable goods transportation. It also constitutes along with telecommunications, inter-national standardization and commercial liberalization the cornerstones of globalization [25].

Merchant shipping is essentially a market that is mainly used for the transport of goods. Thereby, the identification of factors that affect both supply and demand is very important.

Global economy is the major factor that can influence the demand. In addition, political events such as Tripartite Aggression have also a huge impact on it. Finally, the transportation costs also affect the demand in the shipping industry. In contrast, the supply is determined primarily by factors related to the global fleet: age, type, capacity and productivity of ships. For example, the increase of the number of vessels leads to increase the supply.

In the next section, the literature review of relationship between efficiency and ship class of Greek-owned shipping companies is presented. The third section presents the methodology of this study and the fourth section discuss-es the results. In the end, conclusions of this study are presented.

2. Literature Review

Maritime is divided in two freight markets: a) the charter and b) the liner. In the first market, a ship-owner charterer provides the ship in terms of charter to a charterer. The price paid by charterer called freight are and the amount of this fare is set between them, taking into account the supply and demand of transports. Ref [32] characterized charters market as perfectly competitive. This charter could be used from a single trip up to decades and charterer could use the ship in any way he wants. In this market tankers and dry bulk carriers are primarily operating.

On the other side, in liner market, ship-owners are organized in joint ventures in order to establish the freight fare for each type of goods. Therefore, this market could be identified as oligopolistic, if not monopolistic. The common characteristics of joint ventures are the uniformity of freight fares and the common effort to face the external and limit the internal competition. In this market, vessels are carrying the consumer goods through regular and specific routes around the world. Cargo is not homogenous as charter market and the goods are not transported in bulk, but packaged. In this market, vessels are mainly general cargo but there are specialized too such as containerships. According to [37], total capacity, in deadweight tonnage, of global fleet in 2012 increased by 9.9% compared to 2011, while capacity of oil tankers increased by 6.9% (table 1).

Table 1: World fleet by Ship Category

Ship Category		2012	2011	Change
Bulk carriers	**Capacity**	**622536**	**532039**	**17.01%**
	Percentage of total fleet	40.60%	38.10%	
Containers ships	**Capacity**	**198002**	**183859**	**7.69%**
	Percentage of total fleet	12.90%	13.20%	
Tankers	**Capacity**	**507454**	**474846**	**6.87%**
	Percentage of total fleet	33.10%	34.00%	
General Cargo Ships	**Capacity**	**106385**	**108971**	**-2.37%**
	Percentage of total fleet	6.90%	7.80%	
Other ships	**Capacity**	**99642**	**96028**	**3.76%**
	Percentage of total fleet	6.50%	6.90%	
Total		**1534019**	**1395743**	**9.91%**

The greatest increase occurred in the bulk carriers 17%, thus the vessels cate-gory occupy the 40.6% of the world fleet, increasing its market share by 2.5 % compared to 2011. That was the result of larger used vessels in order to achieve economies of scale. The second largest increase recorded by containerships, increasing their participation in global fleet, but their market share presented a decrease of 0.3%. However, according to [37], in terms of $ instead of deadweight tonnage, the 52% of world trade transport via shipping, carried out by containerships. Further on, if we notice the containerships growth in Twenty-two foot Equivalent Units (TEU), then it is obvious that the capacity increases 9.41%. Additionally, a decrease by 2.4% observed in general cargo ships, while their percentage of world fleet reduced by 0.9% compared to 2011. The other classes of vessels increased their capacity in dwt by 3.8% with their participation to world trade falling by 0.4% compared to 2011.

Regarding the age of the world fleet, it presents decreasing trend during 2011 and that is reflected to the increase in deliveries of newly-manufactured vessels. In fact, the average age per dwt in 2012 was 11.5 years. It is notable the fact that 41.5% of dry bulk cargo fleet, in deadweight tonnage, is younger than 5 years old, while 64% of containerships are younger than 10 years.

The 49.7% of capacity of the world fleet belongs to Greece, Japan, Germany and China. Therefore, it is obvious the significant contribution of the Greek fleet consisting of 3321 ships that have the largest capacity than any other fleet. The Greek fleet decays according to the operation's flag that ships have. Greece in 2012 had the 6.8% of the world capacity of containerships and holds the 19.9% of vessels which carrying dry bulk cargoes, the 20.8% of the tankers and the 2.4% of general cargo vessels (see tables 2 and 3).

Table 2: Percentage per country of the total capacity calculated in dwt

	Germany	Japan	Greece	China	Denmark	Other countries
Container ships	37.00%	8.80%	**6.80%**	6.30%	8.80%	32.30%
Bulk carriers	4.80%	22.70%	**19.90%**	14.00%	1.10%	37.50%
Tankers	4.60%	12.50%	**20.80%**	5.20%	3.40%	53.50%
General Cargo Ships	13.30%	12.40%	**2.40%**	11.00%	1.10%	59.80%

Table 3: Percentage per country of the total world trade calculated in $

	Germany	Japan	Greece	China	Denmark	Other countries
Container ships	19.20%	4.60%	**3.50%**	3.30%	4.60%	16.80%
Bulk carriers	0.30%	1.40%	**1.20%**	0.80%	0.10%	2.30%
Tankers	1.00%	2.70%	**4.60%**	1.10%	0.70%	11.90%
General Cargo Ships	2.70%	2.50%	**0.50%**	2.20%	0.20%	11.90%
Total	23.20%	11.20%	**9.80%**	7.40%	5.60%	42.90%

The above fact demonstrates the value of maritime in international trade and in global economy. Shipping firms like any other organization want to be able to know their efficiency. This is accomplished by controlling the transforming process factors of production into goods or services.

In recent years, various parametric approaches for the measurement of efficiency have been developed such as: Stochastic Frontier Approach (SFA), where the inefficiency follows asymmetric distribution, while random error follows a normal distribution [3]. Distribution Free Approach (DFA),

where there are no assumptions about distribution for both in-efficiency and random error, but it is assumed that efficiency is constant over time and that random error tends to be zero. Finally, Trick Frontier Approach- TFA, in which there are no initial assumptions of the distribution [10].
However, non-parametric methods for measuring the efficiency have been developed too. The most widespread non- parametric methods are the Free Disposal Hull- FDH and the Data Envelopment Analysis (DEA) [12]. During this study, it is used the DEA method.

3. Discussion

Data Envelopment Analysis (DEA) method's foundations were placed by [12] redefining and expanding the work of [18] which analysed the relative efficiency based on studies of [33], [17], and [24]. In continue, [4] and [5] developed it further creating the theoretical background of the method. Nowadays DEA is applied to applications in various organizations in Greece [41]; [26], or in other countries such as Norway [29] and China [44].
DEA method which is used to calculate the relative efficiency of a set of homogeneous units regarding operation, called Decision Making Units (DMU) [11]. A decision making unit is independent and responsible for converting inputs into outputs. This method is based on linear programming theory, but it evaluates a set of decision-making units. It essentially compares the efficiency of each decision-making unit with every other. Therefore, it is called the relative efficiency or comparative [13]; [45] and in literature appears as Technical Efficiency (TE).

Another concept of efficiency is allocative efficiency (AE), which studies whether inputs for a given level of production were chosen in a way that the production cost is minimized. Moreover, the combination technique with allocative efficiency leads on the concept of economic efficiency (EE) or cost efficiency. As non-parametric method, the determination of the relationship in which inputs are converted into outputs is not necessary.

4. Methodology

Various models have been developed after the first implementation of DEA, the best known of all is the model of [12] known as the CCR model, and its expansion by [5] called the BCC model. The models are separated depending a) on orientation to input oriented models, for a given level of output to minimize inputs, and output oriented models, for a given level of inputs to maximize outputs b) on economies of scale to: constant returns of scale and variables returns of scale.

4.1. CCR Method

The method CCR is described in study of [12] and takes into account several outputs and the profitability of each production unit. The maximization efficiency function for each decision-making unit that should be evaluated is: (Weighted sum output) / (Weighted Sum input)
It is assumed that the DMUs (j) require m inputs x i,j to convert s y r,j. Inputs x i,j must be positive that is one of the assumption of DEA. The other assumptions are the homogeneity of DMUs, the results take value from zero to one and the weights should be the same as the other units.
Therefore, the efficiency of each decision-making unit shall be as follows:

$$\max h_0(u,v) = \frac{\sum_{r=1}^{s} u_r y_{r,0}}{\sum_{i=1}^{m} v_i x_{i,0}}$$

Under the restrictions that:

$$\frac{\sum_{r=1}^{s} u_r y_{r,j}}{\sum_{i=1}^{m} v_i x_{i,j}} \leq 1$$

ur and vi ≥ 0 for r =1, … , s and for i= 1, … , m
j = 0,…, n
ur and vi are the weight variables r output and input i, determined by the solution of the problem.

When a DMU takes value equals to one is effective and if get less, there is another DMU in respect of which is not efficient. However, for the implementation of the above efficiency maximization function the relationship has to be converted to linear.

Thereby:

$$max h_0 = \sum_{r=1}^{s} \mu_r y_{r,0}$$

Under the restrictions that:

$$\sum_{i=1}^{m} v_i x_{i,j} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{r,0} - \sum_{i=1}^{m} v_i x_{i,j} \leq 0$$

μr and vi ≥ 0 forr =1, … , s and for i= 1, … , m

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j = 0, … ,n

The dual model of the above:
TECRSλ,θ = minθ (in the assumption of constant returns to scale)

Under the restrictions that:

$$\sum_{j=1}^{n} x_{i.j}\lambda_j \leq \theta x_{i.0}$$

$$\sum_{j=1}^{n} y_{r.j}\lambda_j \geq \theta y_{r.0}$$

r =1, …s and for i = 1, … , m
j = 0, …n

$$\lambda_{j\geq 0}$$

«θ»: minimum level at which reduction of inputs will not change the level of outputs «λ»: vector of N+1

4.2. BCC Method

Ref [5] expanded the DEA under the assumption of variable returns to scale (TEVRC). Hence, the hypotheses made in model CCR should be changed and convexity constraints must be added. Therefore, the BBC model will be:

$$\sum_{j=1}^{n} \lambda_j = 1$$

The ratio of technical efficiency under constant returns to scale with the technical efficiency under variable returns to scale, gives the degree of efficiency:

$$SE = \frac{TEcrs_{\lambda,\theta}}{TEvrs_{\lambda,\theta}}$$

When the ratio is equal to one, efficient return scale or constant returns to scales exist and when is less than one, inefficient. Hence, some DMUs are effective under the assumption of variable returns to scale but ineffective under the assumption of constant returns to scale.

4.3. Variables selection

The selection of variables used as inputs and outputs depends on the institutional framework in which operates the examining field of the study. Inputs and outputs can be defined either by physical units, such as the number of containers, or financial variables, derived from the financial statements of companies- financial information. Ref [9]; [11]; [19] have studied their importance and have been used in several studies such as [1], or as a combination of the above [21].

Various studies have been carried on the efficiency of transport industry: overland [6] [23] air transport [20] and maritime transport [32]; [43], or on the respective stations of these such as ports [42]; [27]; [39]; [36]; [8]; [34]; [28]; [38]; [14]; [15]; [7] and airports [22]; [16]; [35]; [40]; [2].
Ref [32] based on market assumption, that profit and book value carry important information for assessing market equity, leading to developed a model with inputs earning and book value of equity and output cur-rent value of equity (SFA model). In the same study, DEA model is used with input variables such as total assets, the number of employees and capital expenditure and as sales output variable.
Ref [43] developed a method for the evaluation of the ship-ping industry using economic and financial indicators with DEA model. The variables used as inputs were stockholders' equity and total assets of companies, while the variables used as outputs were operating revenue and net prof-it.
Following [32] and [43] in this study as input variables were used: Total Shareholders' Equity, Total Assets, Capital Expenditure -Addition to Fixed Assets and the Cost Of Goods Sold, while as output variable sales will be used.
This study attempts to identify which class of vessels was more efficient during the time period of 2007-2011. The data sample consisting of Greek ship-ping companies that are listed on the stock exchanges markets of New York.
The data were drawn from the database of Thomson one of Thomson Reuters and the financial data from the annual reports that are published on the companies' websites. For the purposes of our study, MS-Excel software with the help of additional DEA Frontier (www.deafrontier.net) were used.

Shipping companies traded on stock exchange markets of New York and ap-pear as origin country Greece are the following:

1. Aegean marine petroleum network Inc.(ANW)	12. Globus Maritime Ltd.(GLBS)
2. Box ships Inc.(TEU)	13. Navios maritime holdin Inc. (NM)
3. Capital product partner L.P.(CPLP)	14. Navios maritime partners L.P.(NMM)
4. Costamare Inc.(CMRE	15. Newlead holding Ltd.(NEWL)
5. Danaos Corporation(DAC)	16. Paragon shipping Inc.(PRGN)

6. Dianna containerships Inc.(DCIX)	17. Safe bulkers Inc.(SB)
7. Dianna shipping (DSX	18. Seanargy maritime holdings Corporation(SHIP)
8. Dryships Inc. (DRYS)	19. Star bulk carriers Corporation(SBLK)
9. Euroseas Ltd.(ESEA)	20. StealthGas Inc.(GASS)
10. Excel maritime carriers Ltd. (EXM)	21. Top ships Inc. (TOPSD)
11. Freeseas Inc. (FREE)	22. Tsakos energy navigation Ltd.(TNP)

The companies that were excluded from our sample are:

• Euroseas Ltd. was not possible to be classified in one category.

• Costamare Inc., Dianna containerships Inc. and Box ships Inc., because there are no data for all the years of examining period exist.

• Danaos Corporation was the only container shipping company, and there was no sense to include it.

5. Empirical results

In this study, BCC model is chosen because of the variables return of scale and orientation of inputs (input oriented model). Every year examined separately and consist 17 DMUs. This number covers the Treaty of Tone (1993) where the number of DMUs is higher or equal to 3* (number of input + output number).

The solution of DEA model was made with the use of MS-Excel program with the help of additional DEA Frontier. Table 4 shows the average efficiency per ship type, and the number of DMUs. According to table 4, firms with dry bulk carriers operate more effectively than others with average efficiency of 0.90. The average efficiency for companies with tankers does not exceed 0.80.

Table 4: Average efficiency per ship type, and the number of DMUs

	Average efficiency		Number of DMUs.	
Year	Companies with goods bulk carriers	Companies with tankers	Companies with goods bulk carriers	Companies with tankers
2007	0.77943424	0.70480103	6	1
2008	0.93713166	0.83926393	9	2
2009	0.91168694	0.69763822	8	0
2010	0.93895587	0.85741751	8	2
2011	0.95784819	0.83411652	8	2
Total	0.90242425	0.79619897	-	-

The worst year for companies with bulk carries was 2007 with six effective DMUs and average efficiency of 0.78, while the best year was 2008 with 9 regarding effective DMUs and 2011 regarding average efficiency- 0.96. The worst year of tankers operated firms was 2009 when there are zero effective DMUs and the best year was when 2 of 5 DMUs were effective.

6. Conclusions

Maritime transport is the ideal way to transport goods over long distances. It is divided into two freight markets, the charter and liner. In the first, vessel of the class of tankers and bulk carriers operate, while in the second there are mostly containerships.

The importance of shipping is obviously undeniable for economic growth and development. Therefore, measuring the efficiency of shipping companies in general, and per vessel class in particular, is very important. In recent years various parametric and non-parametric approaches have been developed in order to measure efficiency. The most widely used approach is the method of Data Envelopment Analysis.

In this study the efficiency per vessel class was measured and concluded that firms with dry bulk carriers operate more effectively than others. The difficulty of this study was in collecting the necessary data, since the number of ships is huge and the data published about them, limited. In this paper, first the effectiveness 17 listed on the stock exchanges markets of New York Greek-owned shipping companies for the period 2007- 2011, through the model BCC (with orientation of inputs) of DEA.

In general, the firms we studied had a downtrend efficiency route. This reflect the impact of global financial crisis to shipping companies and to maritime sector.

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