THE EFFICIENCY OF WORLD SEABORNE DRY BULK TRANSPORTATION

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Abstract

The maritime sector is a capital intensive sector both in terms of liner and tramp shipping. Unlike liner market, the tramp market is similar to that of the perfect competition market, so entry to and exit from the market is relatively easy. This relative ease allows more players to involve in the market and therefore large fluctuations have often occurred in the market. This situation causes inefficiency especially in dry bulk transportation. In this context, the purpose of this study is to determine the historical efficiency of the world dry bulk cargo transportation. The data set used in the study consists of annual observations covering the years 1980 and 2016. Both the input-oriented and output-oriented CCR models of data envelopment analysis (DEA) were used to determine efficiency of world seaborne dry bulk transportation. The projection values of the analysis were also used for interpretation of the results. As inputs, the world dry bulk cargo fleet and world gross domestic products (GDP) variables were selected, and the total amount of major dry bulk cargo transported in the world was selected as the output. According to the results of the study, it was found that major bulk cargo transportation in the world was efficient between 2004 and 2008, after which the efficiency decreased due to the increasing fleet and the slow economic growth. In addition, in recent years, the efficiency is at 86% level, and according to the projection values, it is necessary to increase the amount of cargo carried by 16% or to decrease dry bulk fleet by 14% in order for dry bulk transportation to be efficient.

Keywords: *Dry bulk transportation, Fleet, Economy, Efficiency.*

DÜNYA DENİZ YOLUYLA KURU DÖKME YÜK TAŞIMACILIĞININ ETKİNLİĞİ

Özet

Denizcilik sektörü hem düzenli hat hem de düzensiz hat taşımacılığı açısından sermaye yoğun bir sektördür. Düzenli hat taşımacılığından farklı olarak, düzensiz hat taşımacılığı tam rekabet piyasasına benzer yapıdadır ve bu yüzden piyasaya giriş ve çıkışlar göreceli olarak kolaydır. Bu göreceli kolaylık, daha fazla oyuncunun piyasayla ilgilenmesine olanak sağlar ve bu yüzden piyasada büyük dalgalanmalar gözlenir. Bu durum özellikle kuru dökme yük taşımacılığında etkinsizliğe neden olur. Bu çerçevede bu çalışmanın amacı dünya kuru dökme yük taşımacılığının tarihsel etkinliğini tespit etmektir. Çalışmada kullanılan veri seti 1980 ve 2016 yılları arasını kapsayan yıllık gözlemlerden oluşmaktadır. Dünya kuru dökme yük taşımacılığının etkinliğini tespit etmek için hem girdi odaklı hem de çıktı odaklı veri zarflama analizi (VZA) modelleri kullanılmıştır. Analizlerin projeksiyon değerleri de sonuçların yorumlanması için kullanılmışlardır. Girdi olarak, dünya kuru dökme yük filosu ve gayri safi yurt içi hâsıla (GSYİH) değerleri, çıktı olarak ise dünyada taşınan toplam ana kuru dökme yük tonaj miktarı seçilmiştir. Çalışmanın sonuçlarına göre, dünya ana kuru dökme yük taşımacılığı 2004 ve 2008 yılları arasında etkindir, ancak daha sonra etkinlik artan filo hacminden ve yavaş ekonomik büyümeden dolayı düşmüştür. Ek olarak, son yıllarda etkinlik oranı %86'dır, ve projeksiyon değerlerine göre, kuru dökme yük taşımacılığının etkin olabilmesi için taşınan kuru yük miktarının %16 artması veya kuru dökme yük filosunun %14 azalması gerekmektedir.

Anahtar Kelimeler: *Kuru dökme yük taşımacılığı, Filo, Ekonomi, Etkinlik.*

1. Introduction

Tramp shipping market is very different from the liner shipping market. The liner shipping companies carries different cargoes, provides different services and has a different economic structure than bulk shipping which handle few transactions but much larger amount of cargoes (Stopford, 2009: 33,53). The bulk shipping market mainly focused on minimizing unit cost, while the liner shipping industry is more concerned with speed, reliability and quality of service (Stopford, 2009: 78). The main aim of bulk transportation is to move the cargo as cheaply and efficiently as possible.

The bulk shipping market is generally taken as a real world example of a perfect competition (Norman, 1979; Marlow and Gardner, 1980; Scarsi, 2007; Adland et al., 2016) in which, there are huge amount of vessels operated by many ship owners competing for the same basic transportation service (Adland et al., 2016: 69). The freight rates levels and quantities demanded and supplied are determined by the market interactions, so the ship owners or operators are price takers (Marlow and Gardner, 1980:71; Scarsi, 2007:581).

The dry bulk shipping market is an important part of the international shipping market and characterized by extremely high volatility (Scarsi, 2007; Jing et al., 2008; Chistè and Van Vuuren, 2014; Yin et al., 2017). One of the main reason for the cyclical behavior of the dry bulk market is the fluctuations in the global economic activities (world trade patterns) and world economy (Jing et al.,2008: 237; Yin et al., 2017: 271). The length and volatility of the market cycles are affected by the developments in the global economy (Chistè and Van Vuuren, 2014:3).

Because the shipping demand is a derived (derivative) demand, it is dependent on the demand for the cargoes shipped (Marlow and Gardner, 1980:72). Bulk shipping is deal with the transportation of raw materials for heavy industries (iron ore, coal or oil). The demand for dry bulk transportation is directed by changes in world consumption of bulk commodities. If the world economy expands, the demand for raw materials increases, and so the transportation demand increases. During economic downturns, the raw material demand decreases, and the transportation demand decreases (Scarsi, 2007: 577).

When the global economy expands, seaborne trade increases which in turn influences the freight rates. Changes in the freight rate may affect the supply of bulk shipping services by influencing carriers' decisions about fleet (Chistè and Van Vuuren, 2014:1). On the other hand, Xu et al.'s (2011) study results state that an increase in the change of the supply of fleet in the market may result into an increase in freight rate volatility in dry bulk shipping markets.

When ship supply becomes short in relation to demand, freight rates can rise to extremely high levels. Increases in demand or decreases in supply may result a freight rate increases or vice versa (Evans, 1994: 320, 323). High freight rates may stimulate the order of new vessels, which will cause a descending pressure on freight rates when the vessels are delivered. But, it takes time from ordering a vessel until delivery which is called as ''time to build effect''. So it is difficult to balance the demand and supply every time (Tvedt, 2003: 222, 228). On the other hand, the low freight rates and supply surplus stimulate to decrease supply through the vessel lay-up and vessel scrapping (Evans, 1994: 322; Tvedt, 2003: 228). A shortage of tonnage (supply) is a great contradiction for the bulk markets because of the inability to satisfy demand fully; on the contrary a vessel (supply) surplus is also wasteful and may be worse (Evans, 1994:328).

The structure of the dry bulk market has been evaluated in short and the market mechanisms have been explained up to this point; the dry bulk cargo market is more concerned with the transport of raw materials; it is directly influenced by developments in the world economy as it is a derived demand; the dry bulk market is very close to perfect competitive market conditions; supply and demand balance constitutes freight rates; entry to and exit from the market is relatively easy, causing large fluctuations in freight rates; new-order transport capacity increases during periods of rising incomes and leads to a surge in freight by creating more supply in the market. With the overall framework being this shape, both for shipowners to maintain a sustainable income stream and for shippers to be exposed to the sustainable transportation costs for their comparative advantages, it is important that the seaborne transport of dry bulk cargo is carried out efficiently. In this context, measuring the efficiency of past events can be significant contributions to policymakers and maritime sector stakeholders.

Data envelopment analysis is a very powerful tool for measuring activity, however DEA in the maritime literature is mostly used in port studies. Moreover, no empirical study has been spotted that measures the productivity of world seaborne trade as a production mechanism. It was thought that as an intersection of these points, it was important to contribute to the maritime literature by measuring the efficiency of the world dry bulk cargo transport. This intention generated the motivation for this study. As a result of the study, efficiency of the dry bulk cargo carriage from 1980 to 2016 was measured by both input-oriented and output-oriented DEA models, and then results were evaluated.

The rest of the study has been organized as follows; the method used is introduced in the second section; findings and results are discussed in the third section; and evaluations are made in the last section.

2. Methodology

The DEA method is based on an efficiency concept originally developed by Farrell (1957) and was first developed by Charnes et al. (1978). The efficiency frontier is determined according to the homogenous decision making units (DMU) and the units at that frontier are defined as efficient. Efficiency scores of the other units are assigned according to their position to the frontier. The efficient DMUs in the classical model have score of 1 and those who are not efficient have scores smaller than 1 according to their inefficiency levels.

The most widely used models in DEA models are CCR and BBC models. The CCR model was developed by Charnes et al. (1978) and was based on the constant return to scale assumption. The BCC model was developed by Banker et al. (1984) and was based on the variable return to scale assumption. In order to be able to examine the change in efficiency during the covered years in this study, constant return to scale model was used.

The DEA method can be used as input-oriented or output-oriented in the direction of the objectives of the study. In the input-oriented model, efficiency can be obtained by reducing inputs, while efficiency can be obtained by increasing output in the output-oriented model (Cook et al., 2014). In this study, the input-oriented model was used to see the supply surplus on the fleet side, and the output-oriented model was used to see what the tonnage carried should actually be based on the current transport capacity.

World dry bulk fleet and world total gross domestic product variables were selected as inputs while world total transported major dry bulk cargo (coal, iron ore, grain, bauxite/alumina, phosphate rock) tonnage was selected as output. GDP measures the value of production that takes place within a specific interval of time that is usually a year or a quarter. GDP measures the economy’s flow of income and expenditure during that interval (Mankiw and Taylor, 2014:439). So increase in GDP means increase in demand for products and services, which also means increase in transport demand. So it was selected as an input for the analysis. The fleet can be seen as an intercontinental worker and constitutes the most important input for transportation production in this study. Descriptive statistics of inputs and output used in the study were presented in Table 1. The data set consists of 37 observations on an annual basis covering the years between 1980 and 2016.

Table 1. Raw Data of the DEA Analysis

	Inputs		Output
	Fleet (000 DWT) (X_1)	**GDP ($ 000.000.000) (X_2)**	**Major Dry Bulk Transported (000.000 mt) (Y_1)**
Mean	337534.5	38118.55	1500.892
Median	274445.4	31552.41	1170.000
Maximum	779289.3	79090.92	3172.000
Minimum	181880.3	11172.11	732.0000
Std. Dev.	171682.9	22429.54	750.8094
Skewness	1.506929	0.562520	1.007504
Kurtosis	4.008103	1.978393	2.708819
Jarque-Bera	15.57023	3.560317	6.390282
Probability	0.000416	0.168611	0.040961
Observations	37	37	37

Source: UNCTAD, WORLDBANK

3. Findings and Results

In this section, the results and projection values obtained as a result of DEA were presented and examined. The results were presented in Figure 1 and Table 2. According to the results obtained, efficient transportation operations were carried out in some periods. For instance, the process that was effectively carried out in 1980 continued in 1981 and then began to decline. The next efficient process started in 2004 and remained efficient until the global economic crisis in 2008. The most recent point is that in 2016 the efficiency was 0,86. According to the output-oriented interpretation, this value implies that the efficiency can be reached when the dry load tonnage carried increases by approximately 16% ((100-86)/86) while inputs are fixed. According to the input-oriented interpretation, a reduction of approximately 14% ((100-86)/100) of the input quantities must occur in order to achieve efficiency. The projection values in the continuation of the section also help to understand this situation.

However, it should not be forgotten that the efficiency calculation was based on the most efficient year in the studied sample. In other words, the years in which the maximum output was obtained with minimum input in the considered period were chosen as the threshold for others. For this reason, the efficiency that is the subject here does not cover profitability, and efficient years must not be considered the most profitable times. But it is also a fact that the most profitable times correspond to the most efficient times. As a supporting argument for this, a positive significant correlation of 0.74 (t-stat: 6.15) between the efficiency score obtained in the study and the Baltic Dry Index (BDI) was also found. Figure 1 also presents the relationship between efficiency score and BDI, one of the most important indicators of freight rates in the dry bulk market (Angelopoulos, 2017). Although not very clear on this chart, there is a strong positive relationship between the stationary forms of the series.

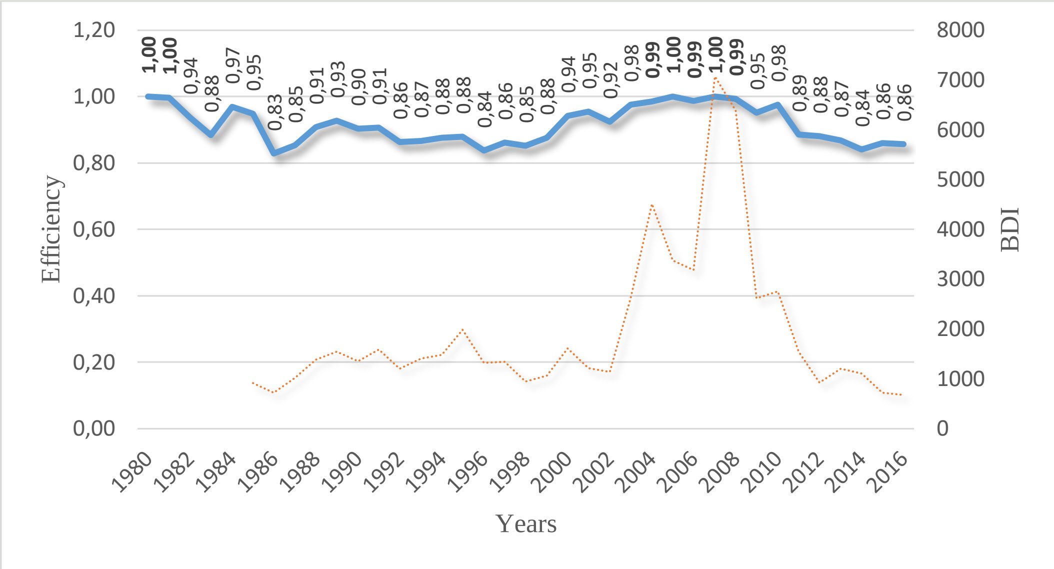

Figure 1. CCR I and CCR O Analysis Results

Source: Bloomberg

Table 2. DEA Analysis Results

Years	CCR O	Years	CCR O	Years	CCR O
1980	1,00	1993	0,87	2006	0,99
1981	1,00	1994	0,88	2007	1,00
1982	0,94	1995	0,88	2008	0,99
1983	0,88	1996	0,84	2009	0,95
1984	0,97	1997	0,86	2010	0,98
1985	0,95	1998	0,85	2011	0,89
1986	0,83	1999	0,88	2012	0,88
1987	0,85	2000	0,94	2013	0,87
1988	0,91	2001	0,95	2014	0,84
1989	0,93	2002	0,92	2015	0,86
1990	0,90	2003	0,98	2016	0,86
1991	0,91	2004	0,99		
1992	0,86	2005	1,00		

According to the projection values obtained in the output-oriented DEA result, the amount of actual major dry bulk cargo and the required amount to be transported for become efficient were presented in Figure 2. As seen, the red columns show the actual amount transported, while the blue columns show the tonnage required for the efficiency. In recent years the gap between the two variables has increased considerably and this has led a great recession in freight market.

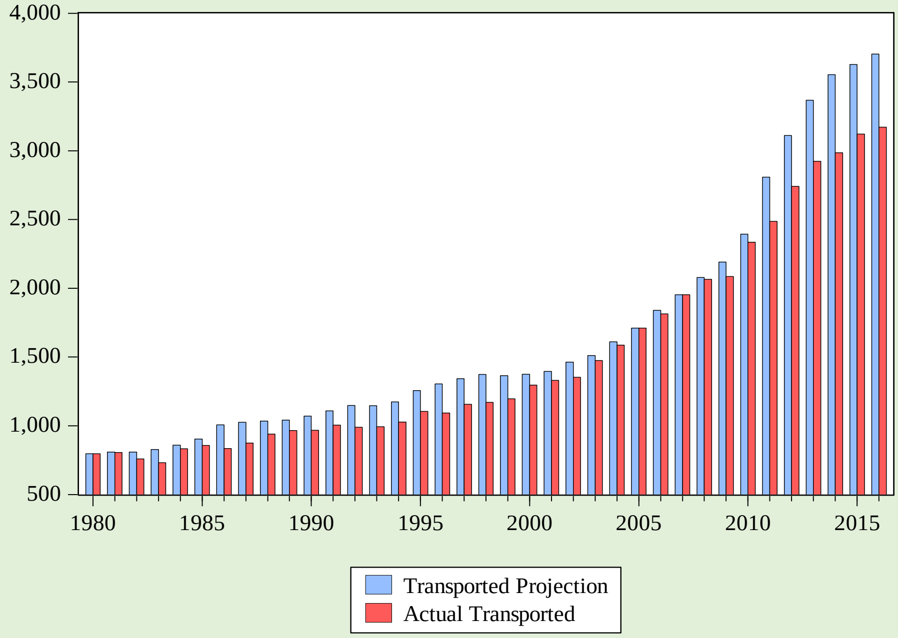

Figure 2. CCR O Transported Cargo Projections

According to the input-oriented DEA analysis results, the projection values of the fleet variable, one of the inputs, were presented in Figure 3. The blue column shows the actual fleet capacity, while the red one shows the sufficient capacity for the actual amount of transport processes. The difference between the two values indicates the excess capacity and indicates that there was concentration on the supply side after the freight boom actualized until 2007. This is most likely due to the increase in freight rates leading to excessive increases in the carrying capacity by increasing new orders and the slowdown in economic growth.

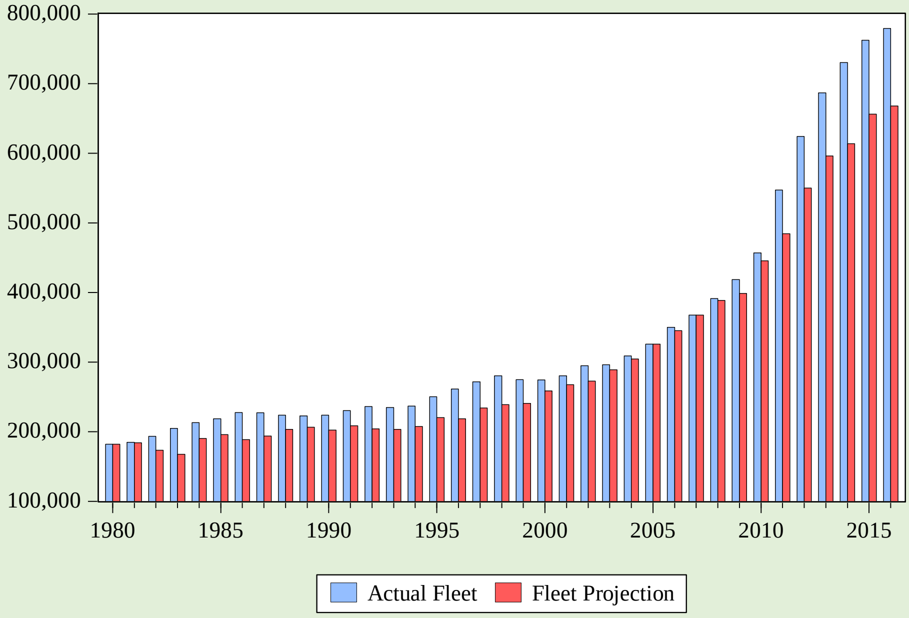

Figure 3. CCR I Fleet Projections

The projection values of the GDP variable, which was one of the inputs in the analysis, were presented in Figure 4. However, this variable was not evaluated in terms of input surplus, since the descriptions such as “economic activities must be reduced” or “excess input was used” would be wrong. Because the transportation sector has derived demand structure and main demand side of it is the world economy (Stopford, 2009:610). In addition, one of the main tasks of the transport sector is to serve global economic activities. For all these reasons, the source of inefficiency appears to be the fleet, the other input in the study.

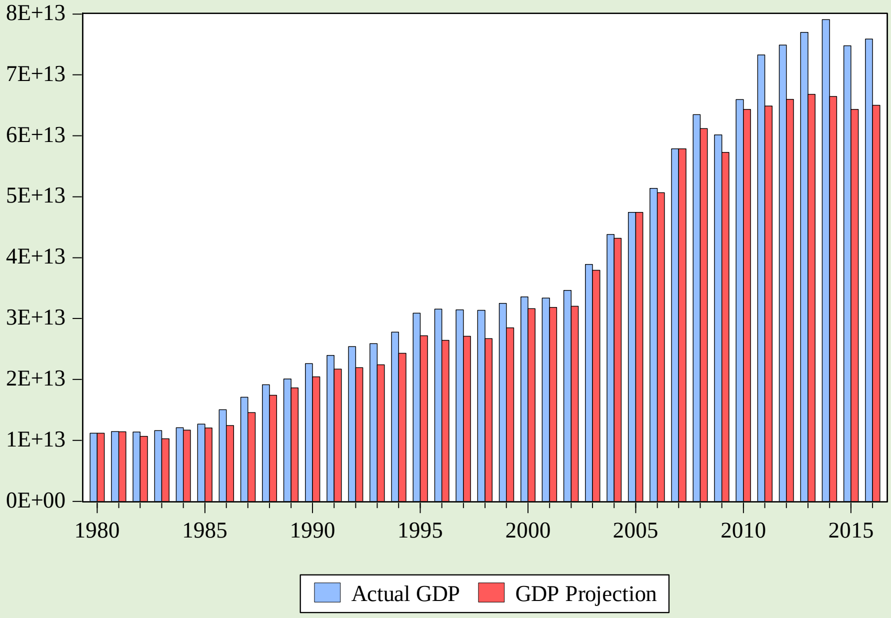

Figure 4. CCR I GDP Projections

Conclusion

The short run supply curve in the maritime market is inelastic, so prices may go up too much after reaching a certain physical capacity. Because the vessels ordered at the time of high freight rates take 1-3 years to enter the market (Başer and Açık, 2018). So the only way to increase the supply in the short run is to increase the speed of the vessels. These sudden increases in freight cause an increase in new orders and after a certain time new transport capacity begins to enter the market. If the rate of increase in supply during this period exceeds the rate of increase in demand, there is a drastic decline in freight rates due to the shifts in the inealstic supply curve. Moreover, if the demand falls, the decline in the freights will be much more devastating.

Within the framework of all this mechanism, it is crucial that the maritime transportation is at an efficient level to ensure sustainable profits and income to shipowners, as well as to protect shippers from the high costs of the freight bubbles. This efficiency in the maritime transportation will also contribute to continuity and sustainability of the global trade.

At this point, this study aims to analyze the efficiency of dry bulk cargo transport used in the world's raw material transport by both input and output oriented Data Envelopment Analysis. In the analysis, the world GDP and dry bulk fleet variables were selected as inputs, while the total seaborne dry cargo carried was selected as output. The data was constituted from annual 37 observations covering the years 1980 to 2016. According to the results of the analysis, it was determined that the efficient years were 1980, 1981, 2004, 2005, 2006, 2007 and 2008. Especially, the coupling of the highest freight rates of all years in the 2000s with the highest efficiency scores showed a positive relationship between efficiency and income. On the other hand, the lowest efficiency score was 0.84 in 1986 which may be considered as not being a very low score. Collapses in freight rates, although there has not been a huge decline in activity, can be explained by the "L" shaped inealstic supply curve in the maritime market. Because large changes in demand up to a certain point do not cause a change in freight rates, but a small change after a certain point causes very extreme changes in freight rates. At this point, the projection values obtained in the analysis have helped clarify the issue. There is a relatively large difference between the enough fleet and the existing fleet for efficient transport, as compared to the projection result of the input oriented model. Approximately 14% less of the fleet will be sufficient for efficient dry bulk transport. From another point of view, transport will become efficient if the tonnage transported increases by approximately 16% compared to the output-oriented projection value.

As a result, efficient transport is a must for both shipowners and shippers to stay in a sustainable trading environment. Therefore, subsequent ship investments should be planned with due regard to efficient transportation and the excess capacity which reduces the efficient transportation should be avoided. At this point there is a great deal of responsibility for potential shipbuilders as well as policy makers.

One of the limitation of the study is that the minor bulk cargo data cannot be reached for the covered period. Because minor bulk as well as major bulk can be carried by bulk ships. Thus, inclusion of minor bulk cargoes data can make the results of the analysis more accurate. Further studies may also be done on other maritime markets such as liquid bulk cargo and container.

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