Mersin University
Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 1, Issue 1, pp. 1-6, June 2020
ISSN 2687-6612, Turkey
Research Article

COMPARATIVE CONTAINER PORT EFFICIENCY: TURKEY AND EUROPEAN PORTS

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Received: 11/11/2019 Accepted: 21/05/2020

ABSTRACT
Due to the increase in global transportation, companies are now focused on more efficient operation of their systems. In the maritime sector, efficiency studies are carried out on ports which are the place of interaction of land and sea stages of international transportation. Efficiency studies about ports have been carried out in many areas such as capacities of the ports, hinterland, number of incoming and outgoing ships, processing times and handling quantities. Thence, the companies saw the deficiencies in the ports and headed towards shortcomings and aimed to improve their ports efficiency. In this study, the European (15) and Turkey (15) port efficiency was examined by analysis of two different modeling methods. For the port efficiency, the length of the docks, the port depth, the terminal area and the amount of TEU handled were taken into consideration in models. These data were utilized and evaluated separately in Data Envelopment Analysis (DEA) and Hotelling T-square methods. Efficiency values of Europe and Turkey ports were examined with DEA. It is concluded that European ports are used more efficiently than Turkish ports. Even the best Turkish port ranked 10th in the overall ranking. Next, Hotelling T-square analysis were utilized to find out reason of differences between Europe and Turkeys ports.
Results show that almost all Turkey ports has lower efficiency values than European ports. In Turkey ports, it has reached the conclusion that the utilization of terminal area and the quay length are not operating efficiently.

Keywords: *Data Envelopment Analysis (DEA), Hotelling, Maritime, Port Efficiency*

1. INTRODUCTION

Global world trade is increasing day by day and this increase effecting directly to worldwide transportations. Seaway transportation is the most preferred transportation system in the world. More than 80% of all Worldwide transportation is done by seaway transportation (UNCTAD, 2016). Maritime transport is advantageous in terms of high carrying capacity compared to other modes of transport, -depending on distance- economical formation, comfort, environmental friendliness and safer (Ateş, et al, 2013).

The cargo carried by sea transport is made 54% by bulk cargo, 29% by liquid and gas, 17% by container ship (UNCTAD, 2016). Although it is 17% of the total transport, the cargo carried on the container ship is the type of shipping which has the largest economic return. In the same way, investment is high which is made on container shipping.

Ports are places where vessels establish links with the land, and the investments made in these places and the efficiency of the ports are important for the vessels. Capacity of port, sea depths, length of quays effect quality of services and number of ships which coming to ports. This affects the economic return that the ports and the country can obtain (Cullinane et al., 2006). Some of the ports in Europe are involved in the effects of ports on the Gross National Product.

There are many studies and methods on the efficiency of ports. Some of those; total factor productivity on the ports (Kim et al., 1986), method of creating performance indicators (Talley, 1994), multiple regression model (Tongzoni, 1995), benchmarking on updated data and the amount of container handled at a certain time (Talley, 1998), simulation method (Esmer, 2010) and Data Envelopment Analysis (DEA) – the most common one- (Roll et al., (1993), Tongzon (2001), Barros (2003), Cullinane et al., (2005), Bichou (2013), Schøyen et al., (2013), Ateş et al (2013), Baran et al., (2015), Wiśnicki et al., (2017), Gamassa et al., (2017), Mousavizadeh et al., (2017), Gökçek et al., (2018)).

In this study, after examining the efficiency with DEA, Hotelling's T-square test will be applied to benchmark Europe and Turkey ports. The reason for using hotelling technique is that it allows the effect of more than one variable for the two groups to be examined at the same time. The Hotelling test will show the infrastructural differences of the ports as a result of comparison. There are many studies with hotelling, especially in medicine (Adams et al., (1994), Holmes et al., (2008)). It is also utilized in social studies (Bircan et al., 2016), Liu et al., 2018) and industrial research (Çetin et al., 2007).

In the paper, European and Turkish ports are benchmarked. Each groups have 15 members. In the second stage of study, there are models and data which are utilized and an application on ports. The conclusion is at third stage.

2. MODELS AND DATA

2.1. Models

Data Envelopment Analysis (DEA) is non-parametric system and predicts multiple inputs and multiple outputs using mathematical programming techniques and performs efficiency analysis of similar Decision Making Units (DMUs) (Kocakoç, 2003). Specifies the "best" observations that produce the most output composition using the least input composition in any observation set. The boundary -best observation- is considered as "reference" and measures the distance of these inactive decision units as "radial". It measures the efficiency of DMU that are equal to the same number of inputs and outputs. By modeling each unit, solving them with linear programming technique. Inactive units can be made efficient based on the reference point

The main efficiency measure in Data Envelopment Analysis is the weighted sum of the outputs divided by the weighted sum of the inputs. In other words, the criterion of effectiveness of any decision point (j. Decision point) can be defined as in Eq. (1).

$$\frac{u_1 y_1 + u_2 y_2 + \ldots + u_n y_n}{v_1 x_1 + v_2 x_2 + \ldots + v_m x_m} \quad (1)$$

At Eq. (1) there are n outputs and m inputs for the j. decision point. Here, u_n defined as n. the weight of the output, y_n defined as n. the amount of output, v_m defined as m. the weight of the input and x_m defined as m. the amount of input. DEA can be utilized as CCR (Charnes, Cooper and Rhodes, (1978)) and BCC (Banker, Chames ve Cooper, (1984)) approached model. In the CCR-DEA model, since the inputs and outputs of the decision-making units are distinct limited data, the relative efficiency between the decision-making units is evaluated at a point in the time axis (Lovell et al., 2003). Another point in DEA is that model can be utilized as input oriented or output oriented with respect to data. In port efficiency studies, mostly output oriented DEA is utilized because of ensure sustainability of ports global competitiveness (Gökçek et al, 2018). Therefore, in this study Output Oriented CCR-DEA is utilized.

Another model that utilized on this study is Hotelling T-square test. The Hotelling test allows for the evaluation of more than one variable effect of two groups at the same time. The two groups examine the distance between them via the T-square test. The two groups are examined the distance between them via the T-square test. The result is determined by comparing Eq. (2) (observed) to (3) (theoretical).

$$\boldsymbol{T^2 = n\,(\bar{X} - \mu 0)' S^{-1}\,(\bar{X} - \mu 0)} \quad (2)$$

$$\boldsymbol{T^2 = \frac{(n-1)p}{(n-p)}\,F^{p}_{n-p}(\alpha)} \quad (3)$$

Where n is the number of observations, ($\bar{X}$-μ0) gives the mean differences of the groups being compared, S is the standard deviation matrix, p is the number of variables, and α is the confidence interval value of the distribution. It is decided whether or not the hypothesis H_0 is to be rejected in the comparison. H_0, there is no statistically significant difference between the compared groups, H_1 (alternative hypothesis) means that there is a statistically significant difference. It can be shown as below.

$\mathbf{H_0: \mu = \mu_0}$
$\mathbf{H_1: \mu \neq \mu_0}$

If the value of T-square observed in the comparison is greater than the value of F, the hypothesis is rejected. Otherwise, it is not being rejected. If the hypothesis is rejected, the Independent Groups T test will be utilized to find out from which group the differences originate.

2.2. Data

The data to be utilized in the study were obtained from the internet sites of the relevant container ports, Deniz Ticareti paper which is published by IMEAK DTO, Lloyd's List publish Top 100 Container Port's and Statical Information System of Turkish Republic.

The input and output units made in previous studies were checked for use in the DEA method. In this study, terminal area (TA), dock length (RU) and water depth (D) inputs of ports were utilized for drawing attention to infrastructural differences. As an output unit, the amount of annual handled containers was taken into consideration on the basis of TEU. The model which is utilized on this study can be shown as Figure 1.

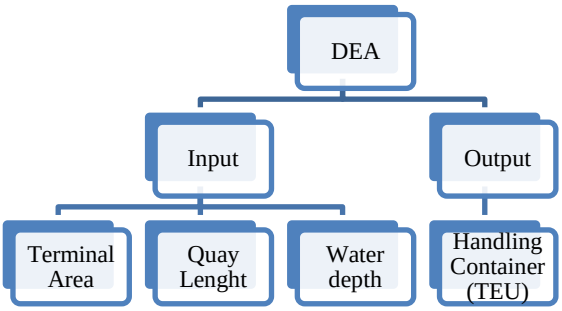

Fig. 1. Data Envelopment Analysis model creation diagram

The data were analyzed and presented through SPSS and MaxDEA software. The summary given in Table 1 below is available.

Table 1. Data summary

Data	Output	Input		
	TEU	*TA(ha)*	*RU(m)*	*D(m)*
Mean	2589300	135,9	3316,3	16,7
Standart Deviation	3092699	159,92	3130,77	4,88
Minimum	11000	20	450	36
Maximum	12385000	799	16325	10

3. IMPLEMENTATION AND RESULTS

First, the DEA method was implemented using MaxDea Basic software. Results are as Table 2. The data were analyzed using the output-oriented constant return on scale (CCR-O) analysis method. The CCR performs an efficiency analysis assuming that it was surveyed do not find a significant relationship between the firm's scale and effectiveness (Ateş et al, 2013). CCR analysis yields the same efficacy results in both orientations when considered to have an impact on all inputs (Ateş et al, 2013).

Table 2. DEA/CCR-O results

DMU	CCR	DMU	CCR
Rotterdam	1	Ambarlı	0,80
Antwerp	1	Mersin	0,44
Hamburg	0,96	Trabzon	0,01
Bremen	0,82	Asyaport	0,43
Algeciras	1	Borusan	0,03
Valencia	0,73	Gemlik	0,20
Felixstowe	0,95	Derince	0,19
Pireas	0,97	Aliağa	0,12
Sines	0,99	Samsun	0,02
Marsaxlokk	1	Antalya	0,21
Southampton	0,78	Bandırma	0,01
Barcelona	0,59	İskenderun	0,12
La Havre	0,68	Evyap	0,16
Genoa	0,42	DP Yarımca	0,11
St. Petersburg	0,75	Yılport	0,34

According to the results of the DEA, it is found that the most efficient ports in the 30 ports are Rotterdam (Netherlands), Antwerp (Belgium), Algeciras (Spain) and Marsaxlokk (Malta). Ambarlı (0.80) is the highest efficient port within Turkey ports, but it is in tenth place even in general rankings. These results are only assessed between the 30 ports that are subject to analysis. It is known that the results may vary if new port(s) included study.

DEA results obtained between the ports of Europe and Turkey to determine whether there is a statistically significant difference was then analyzed by Hotelling's T-square test method. The normality test for the Hotelling test was performed in the SPSS package program, and the test itself was performed at EXCEL. The logarithmic transformation was performed to obtain normality distribution. The normality test results are as shown in Table 3.

The normality test results are Komogorov-Smirmov and Shapiro-Wilk tests which can obtained from SPSS. The Shapiro-Wilk test was utilized in this study because the results of Shapiro-Wilk were more preferred in literature. Since the Significance (Sig.) Values are greater than 0.05, we can say that our data is normally distributed in the 95% confidence interval.

Levene test was conducted to check the homogeneity of the variances of the data. Levene test results are as in Table 4.

As shown in Table 4, value is greater than 0.05, it is concluded that the data show a homogeneous distribution. The results of the Hotelling T-square test made through Excel are given in Table 5.

Table 3. Normality test

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Country	Statistic	df	Sig.	Statistic	df	Sig.
TA	Europe	,210	15	,074	,944	15	,441
	Turkey	,152	15	,200*	,934	15	,309
RU	Europe	,127	15	,200*	,973	15	,897
	Turkey	,178	15	,200*	,946	15	,459
D	Europe	,199	15	,112	,911	15	,138
	Turkey	,253	15	,011	,804	15	,004

* This is a lower bound of the true significance.
[a] Lilliefors Significance Correction

Table 4. Variance homogeneity test results

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
TA	Based on Mean	,856	1	28	,363
	Based on Median	,335	1	28	,567
	Based on Median and with adjusted df	,335	1	24,159	,568
	Based on trimmed mean	,811	1	28	,375
RU	Based on Mean	1,777	1	28	,193
	Based on Median	1,700	1	28	,203
	Based on Median and with adjusted df	1,700	1	27,534	,203
	Based on trimmed mean	1,766	1	28	,195
D	Based on Mean	5,013	1	28	,033
	Based on Median	3,040	1	28	,092
	Based on Median and with adjusted df	3,040	1	17,320	,099
	Based on trimmed mean	3,814	1	28	,061

Table 5. Hotelling T-square test results

Hotelling T-square Test	
Two-samples (equal covariance matrices)	
T-sqaure	21,84277
df1	3
df2	24
F	6,720854
p-value	0,001886

program. The results are given in Table 6.

According to the results in Table 6, sig. value of less than 0.05 TA and RU units to have statistically significant difference from each port as Europe and Turkey, whereas the D unit with a value greater than 0.05 did not have a statistically significant difference.

4. CONCLUSION

In addition to other port efficiency analysis, Hotelling t-square method was utilized. By using Hotelling analysis, unlike other port efficiency studies,

Table 6. Independent Groups T test

t-test for Equality of Means							
						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TA	4,233	28	,000	,48640	,11491	,25102	,72178
RU	2,907	28	,007	,32052	,11026	,09467	,54636
D	-,545	28	,590	-1,00000	1,83459	-4,75798	2,75798

According to Hotelling results, the observed F-value is 6.72. As indicated in the table, sig. value (p-value) was 0.001. H_0, the equality hypothesis of the averages is rejected. Concluded that there is a statistically significant difference between Europe and Turkey ports as an infrastructural has been reached.

However, the Hotelling test does not provide information about which (s) the ports differ in terms of variables. Independent Groups T test was conducted to examine the difference between them in detail. Independent Groups T test was obtained using the SPSS

which of the data causing inefficiency was statistically analyzed. In this study, 15 from Turkey and 15 European container ports are made relative efficiency analysis. With efficiency analysis, efficient ports between 30 ports were determined. According to the results that have been achieved Europe ports are more efficient than Turkish ports. Rotterdam (Netherlands), Antwerp (Belgium), Algeciras (Spain) and Marsaxlokk (Malta), while the most efficient ports, Ambarlı port that the most efficient port in Turkey was ranked tenth among all ports. Hotelling test utilized for determine

which inputs are different behind Europe ports and Turkey ports.

Hotelling T-square test utilized for determine which input(s) that utilized in DEA (Terminal area, Quay length, depth) are different on Turkey and European ports. Based on these test results were statistically significant differences between Europe and Turkey ports. The Independent Groups T test was utilized to find out which unit caused this difference. As indicated in Table 6, there is a statistically significant difference in terminal area and quay length units, but no significant difference in terms of depth.

In the light of this results, it is concluded that Turkey ports are inefficient than European ports in the way of infrastructural. Some of Turkey ports have very large infrastructure, but not enough cargo handling and some of our ports do not have sufficient infrastructure. As seen in Table 2, the most inefficient ports of Trabzon, Borusan, Bandırma and Samsun (0,01 – 0,02 – 0,03) are indications of infrastructural missteps.

There are not only the infrastructural problems that affect the efficiency in the ports and the annual load handling amount. Port management, geographical position of the port, ease of transportation etc., it is considered that the infrastructural factors that having great economic effect should be controlled in a more controlled manner. In this context, this study shows that only improving the capacity of ports is not sufficient for port development.

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