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REVIEW OF FUEL CONSUMPTION AND GHG EMISSIONS DATA OF CONTAINER OPERATORS

Özgür TEZCAN[1]

ABSTRACT

Climate change and global warming phenomena are taking up more and more space in our lives and their negative consequences are becoming more evident day by day. For a more livable planet and future, certain responsibilities fall on the maritime sector as well as on all parties. Ships, with their gigantic machinery that consumes fossil fuels, generate significant amounts of greenhouse gases. The International Maritime Organization aims to reduce greenhouse gas emissions from ships with various sanctions and expects ships to meet the relevant criteria. Ship operators and ship-owners have also started to show sensitivity to energy efficiency and greenhouse gas emission reduction issues due to both the sanctions of international organizations within the scope of climate change and high fuel costs. In this context, by focusing on container operators, this study aims to reveal the current situation of ship operating companies in these matters and to find out the correlation between average fuel consumption and greenhouse gas emission amounts and operator size. The findings show that the average fuel consumption per fleet capacity is related to the size of the operator, pointing to the importance of capacity utilization.

***Keywords**: Climate Action, Container Operators, Energy Efficiency, Fuel Consumption, GHG Emission*

[1] Asst. Prof. Dr., Canakkale Onsekiz Mart University, Marine Science and Technology Faculty, Canakkale, Türkiye, ozgurtezcan@comu.edu.tr, Orcid: 0000-0001-6222-4665.

KONTEYNER OPERATÖRLERİNİN YAKIT HARCAMA VE SERA GAZI SALIM VERİLERİNİN İNCELENMESİ

ÖZ

İklim değişikliği ve küresel ısınma olguları hayatımızda gittikçe daha fazla yer kaplamakta ve ortaya çıkardığı olumsuz sonuçlar etkilerini günden güne belirginleştirmektedir. Daha yaşanılabilir bir gezegen ve gelecek için, tüm paydaşlara olduğu gibi denizcilik sektörüne de belirli sorumluluklar düşmektedir. Fosil yakıt tüketen devasa makineleriyle gemiler, önemli miktarda sera gazı ortaya çıkarmaktadır. Uluslararası Denizcilik Örgütü, çeşitli yaptırım kararları ile gemilerden kaynaklanan sera gazı salımının azaltılmasını hedeflemekte ve gemilerin ilgili kriterleri yerine getirmesini beklemektedir. Gerek iklim değişikliği kapsamında uluslararası kuruluşların yaptırımları gerekse yüksek yakıt maliyetleri nedeniyle gemi işletmecileri ve armatörler de enerji verimliliği ve sera gazı emisyonlarının azaltılması konularında hassasiyet göstermeye başlamıştır. Bu çerçevede bu çalışma, konteyner operatörleri özelinde, gemi işletmecilerinin bu konulardaki mevcut durumunu ortaya koymayı ve ortalama yakıt tüketim ile sera gazı emisyon miktarlarının operatör büyüklüğü ile ilişkisini araştırmayı amaçlamaktadır. Elde edilen bulgular, filo kapasitesine göre ortalama yakıt tüketiminin operatör büyüklüğü ile ilişkili olduğunu göstermekte, kapasite kullanımının önemine işaret etmektedir.

***Anahtar Kelimeler**: İklim Eylemi, Konteyner Operatörleri, Enerji Verimliliği, Yakıt Tüketimi, Sera Gazı Emisyonu*

1. INTRODUCTION

Since the middle of the 20th century, human impacts on the earth have significantly accelerated to cause complex ecological problems (UN, 2019: 2). Dramatically, these ecological problems have started to reflect negative effects on the earth and human beings. Nowadays, the concepts of "climate change" and "global warming" are heard more frequently and their consequences are increasingly affecting the lives of individuals. Accordingly, concerns about the future and sustainability of the earth are increasing day by day.

Concerns about the future of the planet and humanity have become one of the main issues that many international organizations and organizations have focused on for a long time. United Nations (UN) put forward the Sustainable Development Goals (SDG) in 2015 and these were accepted by all member countries. 17 SDG's, consisting of a total of 169 main goals, focus on providing a more livable and sustainable planet for humanity by 2030 (UNDP, 2022b). The "climate action", the 13th SDG, includes an emergency action plan to combat climate change and its effects. The main target for this is to reduce greenhouse gases (GHG) emissions, which are the main element of climate change (UNDP, 2022a).

Maritime transport, which is a vital part of transportation, undertakes nearly 90% of global trade (Mak et al., 2014: 1). Although maritime transport seems to be more economical and more environmentally friendly than other modes of transport, the amount of fossil fuel consumed to perform this huge activity and the amount of GHG resulting from this consumption draw attention within the framework of climate change and global warming. International Maritime Organization (IMO) has strict regulations regarding the GHG emissions and fuel consumption of ships (Soner et al., 2018: 302). With the decision taken at the 62nd meeting of the Marine Environment Protection Committee (MEPC) in 2011, in addition to The International Convention for the Prevention of Pollution from Ships (MARPOL) Chapter VI, a regulation for reducing the GHG caused by ships has entered into force as of 2013.

With this regulation, obligations regarding Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) were imposed on ships (IMO, 2012a, 2012b). According to 2018 data, greenhouse gas emissions from maritime transport account for 2.9% (1076 million tons) of global emissions (EC, 2021). In line with the plan regarding the reduction of greenhouse gases originating from ships, which was decided at the 2015 meeting of IMO, it is obligatory to reduce emissions by 40% in 2030 and 50% in 2050 relatively to 2008 data (Joung et al., 2020: 5). Thus, it is aimed to reduce the amount and share of maritime trade in total greenhouse gas emissions and global emissions. On the other hand, fuel expenses constitute 58-78% of a ship's operating expenses (Mak et al., 2014: 1). With increasing fuel costs, these rates also increase and bring additional costs to the ships. Implementations to reduce fuel expenditures will provide to reduce both the costs and the GHG emissions. In this context, it is seen that the ship operators and ship owners are more sensitive to global warming, climate change (Armstrong and Banks, 2015: 47), fuel consumption, and GHG emissions within the scope of international regulations and energy efficiency.

Abbreviations			
CH_4	Methane	MARPOL	The International Convention for the Prevention of Pollution from Ships
CO_2	Carbon Dioxide	MEPC	Marine Environment Protection Committee
EEDI	Energy Efficiency Design Index	N_2O	Dinitrogen Oxide
FCON	Fuel Consumption	Nm	Nautical Mile
FTC	Fleet TEU Capacity	REV	Annual Revenue
GHG	Greenhouse Gases	SEEMP	Ship Energy Efficiency Management Plan
GHGE	Greenhouse Gases Emission	SDG	Sustainable Development Goals
Gj	Gigajoule	tCO_2e	Tons CO_2 Equivalent
HFO	Heavy Fuel Oil	TEU	Twenty-foot Equivalent Unit
IMO	International Maritime Organization	TEUHD	Annual Amount of TEU Handled
LNG	Liquefied Natural gas	USD	United States Dollar

Figure 1: Abbreviations

The number of researches on fuel efficiency and GHG emissions in shipping has also been increasing lately. There is some research in the literature focused on performance monitoring in terms of fuel efficiency. Aldous et al. (2015: 30), define that ship performance is affected by three-dimensional influencers; *onboard effects, environmental effects*, and *shipping industry effects*. All relevant factors such as ship, weather, loading condition, etc. should be taken into account analyzing a ship's performance (Soner et al., 2018: 303). Some researchers examined the effect of propulsion efficiency to reach better fuel efficiency. Because, both the propeller and its trigger, the engine, are the main couple determining the ship's speed and therefore the fuel efficiency and GHG emissions (Zhao et al., 2015: 813). By log data (Meng et al., 2016), and voyage data (Le et al., 2020), researchers put forward models for efficient use of fuel. Ships emit GHG including methane (CH_4), dinitrogen oxide (N_2O), and especially carbon dioxide (CO_2), which cause global warming. Winnes et al. (2015) told that potential GHG reduction measures could be; *alternative fuels, design-related measures,* and *operations-related* measures. Using Liquefied Natural Gas (LNG) in ship machinery is the one of the efforts to reduce GHG emissions from ships, and the researches show that using LNG could emit 2-10% less GHG from ships using heavy fuel oil (HFO) in engines (Sharafian et al., 2019: 332). Bouman et al. (2017), presented a review of research in terms of technologies, measures, and potential for lowering ship-oriented CO_2 emissions. Besides, the study performed by Joung et al. (2020) summarizes the strategy of the IMO and the regulations that ships and operators have to follow to reduce GHG emissions.

In conventional maritime transport, fuel efficiency was not the top priority for the operators. Similarly, researchers had also focused generally on speed optimization (Meng et al., 2016: 210). Making fast transportation and getting more freight seemed to be more important. Besides, until the MARPOL Annex VI came into force, it can't be said that the GHG emissions had cared so much. However, increasing fuel costs (Mak et al., 2014: 2) and regulations about GHG emissions made the ship operators consider these issues. In this context, this study aims to present a review of the current situation of ship operators regarding the climate action efforts and to statistically compare the data of fuel consumption and GHG emissions of these ship operators in terms of business volume and capacity of the company. For this purpose, answers were sought for the following two research questions:

(i) What are the fuel consumption and GHG emission rates of container operators?
(ii) Is there any correlation between the size of the operator company and the fuel consumption and GHG emission rates?

2. METHODOLOGY

Since it is considered that the fuel consumption and GHG emission data may vary according to the vessel type, it was focused just on container operators named in the list of Alphaliner Top 100 (Alphaliner, 2022).

Step 1. The sustainability reports, annual reports, and web pages of the operators have been reviewed. Due to the global economic and trading circumstances may vary year to year, the data obtained from operators should belong to the same year. Thus, as containing the most common data, the year 2020 was selected to review. The fuel consumption (FCON), and GHG emission (GHGE) data were revealed from the reports. Additionally, fleet TEU (Twenty-foot equivalent unit) capacity (FTC), annual amount of TEU handled (TEUHD), annual revenue (REV) data of the operators were noted. When 2020 reports of the operators investigated, 9 of them was found to present sufficient data. Operators coded as "CO1, CO2..." to keep their names confidential.

Step 2. In line with the first research question, the data obtained from the reports were subjected to descriptive analysis. Descriptive analysis is a frequently used method for researchers to obtain summary information about different phenomena and events they want to study (Büyüköztürk et al., 2013). Ships may use different kinds of fuels like heavy fuel oil, marine diesel oil, liquefied natural gas, etc. Therefore, the total FCON of an operator was calculated in gigajoule (Gj). Similarly, GHGE was calculated in tons CO_2 equivalent (tCO_2e). The average FCON and GHGE rates per FTC, TEUHD, and REV were calculated.

Step 3. To answer the second research question, the correlation between average FCON and GHGE rates and the FTC, TEUHD, and the REV data were investigated. In cases where the number of samples is over 30, it can be examined whether the data show normal distribution characteristics (Baykul, 1999: 290). Since this study was a small-sample study (n=9), it was aimed to examine the correlation by using non-parametric tests. Accordingly, to check the correlation between variables, the Spearman Rho non-parametric test was performed (Can, 2013: 373). SPSS-15 was used to analyze the data. Findings regarding data collection, descriptive analysis and statistical analysis stages are given in the below section.

3. FINDINGS

The findings obtained through data collection are given in the Table 1.

Table 1: Data Obtained from The Reports

Operator	FTC (TEU)	TEUHD (TEU)	REV (1000xUSD)	FCON (Gj)	GHGE (tCO_2e)
CO1	4.044.915	25.268.000	39.740.000	430.495.496	33.902.000
CO2	3.000.000	21.000.000	31.400.000	304.386.642	23.300.000
CO3	2.291.905	18.852.000	18.580.000	318.240.672	15.934.246
CO4	1.719.000	11.838.000	13.300.000	167.186.441	12.800.000
CO5	1.593.793	11.964.000	14.397.000	174.945.000	13.448.125
CO6	1.272.000	7.054.400	5.700.000	75.994.761	5.801.650
CO7	726.019	3.894.000	4.768.000	60.480.000	4.911.970
CO8	620.000	5.070.000	5.024.799	55.845.355	4.316.418
CO9	600.000	2.841.000	3.991.696	38.321.695	2.931.720

Source: Author

According to Table 1, the fleet TEU capacity of the operators ranged between 600.000 TEU and 4.044.900 TEU (mean=1.763.067), handling amount in 2020 is in a range between 2.841.000 TEU and 21.000.000 TEU (mean= 11.975.710), annual revenue of operators in terms of shipping activities in 2020 have a range between 3.991.700 thousand USD and 39.740.000 thousand USD (mean=15.221.278), total fuel consumption with all kind of fuel used in 2020 is ranged between 38.321.700 Gj and 430.495.500 Gj (mean=180.655.120), and finally the emitted GHG of operators have a range between 2.931.700 tCO_2e and 33.902.000 tCO_2e (mean=13.038.460).

The results of the descriptive analysis using above data are given in the Table 2 and 3.

Table 2: Average Fuel Consumption per FTC, TEUHD, and REV.

	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9
FTC	106,4	101,5	95,22	97,26	109,8	59,74	83,30	90,07	63,87
TEUHD	17,04	14,49	11,56	14,12	14,62	10,77	15,53	11,01	13,49
REV	10,83	9,69	11,75	12,57	12,51	13,33	12,68	11,11	9,60

Source: Author

According to Table 2, the FCON per FTC, in other words fuel consumption per a TEU varies between 59,74 and 109,77 in Gj (Gigajoule) (mean=89,68, std=17,73). The FCON per each handled TEU is ranged between 10,77 and 15,53 Gj (mean=13,63, std=2,14). The FCON per gained each thousand USD changes between 9,60 and 13,33 Gj (mean=11,52, std=1,32).

Table 3: Average Greenhouse Gas Emissions per FTC, TEUHD, and REV.

	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9
FTC	8,38	7,77	6,95	7,45	8,44	4,56	6,77	6,96	4,89
TEUHD	1,34	1,11	0,84	1,08	1,12	0,82	1,26	0,85	1,03
REV	0,85	0,74	0,86	0,96	0,93	1,02	1,03	0,86	0,73

Source: Author

Table 3 indicates that the GHGE of the operators per each TEU in capacity is ranged between 4,56 and 8,44 tCO_2e (mean=6,91, std=1,38). On the other hand, the GHGE per each handled TEU is varies between 0,82 and 1,34 tCO_2e (mean=1,05, std=0,19). Besides, GHGE per each thousand USD is ranged between 0,73 and 1,03 tCO_2e (mean=0,89, std=0,11).

The correlation results between the FCON and the GHGE variables obtained from descriptive analysis and the FTC, TEUHD, and REV variables performed by Spearman Rho test are given in the Table 4 and 5.

Correlation is significant at the 0,05 level, and the significance is shown in the tables with "*" (Can, 2013: 375).

Table 4: Spearman Rho Test Results for FCON

		FTC	TEUHD	REV
FCON per FTC	Correlation Coefficient	0,700(*)	0,767(*)	0,767(*)
	Sig. (2-tailed)	0,036	0,016	0,016
	N	9	9	9
FCON per TEUHD	Correlation Coefficient	0,433	0,367	0,367
	Sig. (2-tailed)	0,244	0,332	0,332
	N	9	9	9
FCON per REV	Correlation Coefficient	-0,100	-0,183	-0,183
	Sig. (2-tailed)	0,798	0,637	0,637
	N	9	9	9

Source: Author

Table 4 indicates that, there is positive correlation between FCON per FTC and FTC (r=0,700, p=0,036), FCON per FTC and TEUHD (r=0,767, p=0,016), FCON per FTC and REV (r=0,767, p=0,016). There is no significant correlation detected between other variables.

Table 5: Spearman Rho Test Results for GHGE

		FTC	TEUHD	REV
GHGE per FTC	Correlation Coefficient	0,617	0,700(*)	0,700(*)
	Sig. (2-tailed)	0,077	0,036	0,036
	N	9	9	9
GHGE per TEUHD	Correlation Coefficient	0,350	0,300	0,300
	Sig. (2-tailed)	0,356	0,433	0,433
	N	9	9	9
GHGE per REV	Correlation Coefficient	-0,159	-0,251	-0,251
	Sig. (2-tailed)	0,683	0,515	0,515
	N	9	9	9

Source: Author

Table 5 shows that, there is positive correlation between GHGE per FTC and TEUHD (r=0,700, p=0,066), GHGE per FTC and REV (r=0,700, p=0,036). There is no significant correlation detected between other variables.

4. DISCUSSION AND CONCLUSION

As climate change and global warming concerns rise up, it becomes more evident that all parties that are responsible for this issue must perform their role for a more livable world. The maritime field, the lead actor of global trading activities, also has things to do to fight with this huge threat. The transporting vehicles for carrying huge amount of goods, ships, have powerful engines that are almost all of them use of fossil fuels. Operating these powerful engines require also tons of fuel consumption, which causes significant GHG emissions. In line with climate action studies and related regulations, ships and their operators should reconsider fuel consumption and GHG emission values. In this context, this study aimed to reveal the actual situation of ship operators, by focusing on the container operators, regarding climate actions and investigating the relationship between fuel consumption and greenhouse gas emissions values with the size of their shipping actions.

In the data collection stage, it was seen that the operators have positive efforts through fuel efficiency and GHG emissions reduction, and take into consideration of the IMO regulations. However, the data obtained is limited to a few operators. Most of the operators do not share fuel consumption and GHG emission values in their sustainability or annual reports, or on their websites. The initial aim of the research was to reveal the fuel consumption and GHG emission data per distance traveled by a container (FCON/TEU*Nm, tCO2e/TEU*Nm), and EEDI data of each operator. It was intended to investigate the correlation between these values and the business volume or ranking of the company. However, distance and EEDI data is quite scant. For this reason, test related to distance and EEDI variables could not be made. To find out the actual situation of the operators and to make useful comparisons, it is required for them to demonstrate apparently all these values indicated above.

Consequences of the descriptive analysis show that the average FCON and GHGE values per FTC, TEUHD, and REV are within an acceptable range. Especially the average values per REV are quite similar. This can be an indicator that the operators have evident and similar plans regarding fuel efficiency and GHG reduction measures.

Statistical analysis results also figure out some important points. Although there has been no significant correlation detected between most of the variables, the correlations detected are considerable. The average fuel consumption per fleet capacity has a positive correlation with the FTC, TEUHD, and REV variables. So, it can be said that the operators consume more fuel per fleet capacity which have a bigger fleet, handle more containers, and have higher revenues. Similar words can be said for the average GHG emissions per FTC, except fleet capacity. This situation could be a consequence of the complexity and difficulty of operating bigger shipping companies. It could be a sign for them to plan and consider their climate action efforts more strictly.

Although there are no studies on container operators to compare the results with this study, in their study focusing on container vessels, Le et. al. (2020) oppositely revealed that higher capacitated container vessels have lower average fuel consumption per TEU. This difference could be caused by the differentiation of the ratio of effective usage of TEU capacity. "*Energy efficiency can be defined by the relationship between the benefit or performance of a service and the energy input*" (Winnes et. al.,2015). Therefore, reaching better fuel efficiency results and GHG emission reduction in connection with this is directly related to effective and efficient usage of fleet and vessel capacity.

This study is limited to the data obtained from a few operators' own reports. It is thought that, if more data would be available, quite remarkable consequences could be reached. Especially, further studies investigating the correlation between data on fuel consumption per distance of a container traveled and the business volume of operators could contribute remarkably.

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