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Marine transportation optimization for hazardous and noxious substances by implementing Fuzzy-AHP

Yunus Emre Nazligul*[1], Devran Yazir [1]

[1]Karadeniz Technical University, Department of Maritime Transportation and Management Engineering, Türkiye
yunusemrenazligul@ktu.edu.tr; dyazir@ktu.edu.tr

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Abstract

Carefully selected ship will be helpful to decrease fuel consumption at sea and minimize the companies' variable costs. The selection process can be very complex, which requires a lot of calculation and qualified people on maritime business and can be highly time-consuming to determine all available ships during the comparison has been made. To solve this problem questionnaires have been answered by qualified 30 experts who are already experienced in marine-field. According to both literature and marine experts selected "safety of cargo", "freight cost", "duration of transportation", "ease of transition to new cargo", "maximum load-carrying capacity in a single voyage" criteria have been pair-wisely compared and ranked. Criteria ranking has resulted as C1 > C2 > C5 > C3 > C4 > C6 > C7. The ranked criteria names accordingly are "Safety of cargo" > "Freight cost"> "Maximum load-carrying capacity in a single voyage"> "Duration of transportation"> "Ease of transition to new cargo" > "Cargo handling duration" > "Transportation of different cargo together". In further articles, it is believed that by adding the "frequency of voyage" and "total voyage length" criteria and comparing vessel types as alternatives may be very useful for literature.

Introduction

As the global trade and maritime transportation tends to increase, transportation of chemical products has emerged as the one of most important factors in the global economy. Because of this situation, these large quantities of goods flowed from production areas to consumption areas. Growth in the chemical industries has resulted in a significant increase in the proportion of maritime transportation by carrying dangerous and hazardous chemicals. According to research it has known that about 2000 of 37 million different chemicals used by the world population are transported regularly by sea [1]. Global chemical sales through 2009 and 2019 have increased from 1,832 billion Euros (€) to 3,669 billion €, which means that the chemical business overall has tripled its size in 10 years [2]. Packaged forms of these dangerous goods carried by sea consist of the 10% of containers transported around the world, and non-packaged liquid in bulk dangerous goods by chemical tankers are also consist of 2% of all vessels [3].

The incorrect vessel selection could have a great impact on the freight costs by increasing fuel oil consumption. Therefore, a suitable vessel selection would be dependent on including all available alternatives, criteria and defining them too as well. About the selection of vessels, research shows that the decision-making criteria of shippers are changed [4]. In the research, it has been stated that while the frequency of services and the cost of service were much more important, but the door-to-door transportation period becoming the only determining criteria. According to literature, it has been reached that these criteria could affect the choice of transportation type: cost, service characteristics, reliability, transportation time, transportation frequency, distance, speed, flexibility, infrastructure, vehicle characteristics, inventory, and cargo. It has been also determined that the company's characteristics, annual transaction volume, loss/loss ratio, traceability and previous experience that can affect the choice of a vessel [5].

Method

The F-AHP method has only emerged because of the human logic is not working as a binary logic system like yes or not. Binary logic does explain only in the 0 or 1 binary form, and it is inadequate to explain these in-between thoughts by using these forms. To solve this fuzzy logic the remaining gray area in the binary system complements with triangular fuzzy numbers. These triangular fuzzy numbers consist of triangular membership functions which are defined as, $x = \{l, m, u\}$ the m is being the vertex of this triangle.

Apart from the literature, in this research, the decision-making group is considered not equal and consists of different l decision-makers. All decision-makers are different from each other due to their relative importance and, the decision-makers are non-identical. Unequal decision-makers can be either less or more important than the other decision-makers due to their different experiences and knowledge. The weight vector of decision-makers is shown as $\lambda = \{\lambda_1, \lambda_2 \dots \lambda_l\}$ and explained as $\lambda \geq 0, k = 1,2, \dots, l$. The weight vectors of each decision-maker are expressed as λ.

Application

Step 1: The geometric average of the results of the questionnaire, which have been made in consultation with 30 experts, has combined and formed into a matrix. Then, all decision-maker's answers to are represented as geometrical means, which the decisions are pairwise compared of each criterion to another.

Step 2: Because of the pairwise comparison of each criterion to another, the weights of each criterion have been measured. The weights of all seven criteria are shown in Table 1.

Results

Table 1. Weights of criteria

	Criteria	Results
C1	Safety of cargo	0.2477
C2	Freight cost	0.2146
C3	Maximum load-carrying capacity	0.1138
C4	Duration of transportation	0.1554
C5	Ease of transition to new cargo	0.1248
C6	Cargo handling duration	0.0922
C7	Transportation of different cargo together	0.0515

According to the weights of criteria table, criteria ranking has resulted as C1 > C2 > C5 > C3 > C4 > C6 > C7. The ranked criteria names accordingly are "Safety of cargo" (24.77%) > "Freight cost" (21.46%)> "Maximum load-carrying capacity in a single voyage" (15.54%)> "Duration of transportation" (12.48%)> "Ease of transition to new cargo" (11.38%)> "Cargo handling duration" (9.22%)> "Transportation of different cargo together" (5.15%).

Discussion

In literature, there is not sufficient research has been conducted. Although studies have conducted by few authors, the vessel types are restricted to fewer criteria. Also, the existing literature on vessel selections is less consistent due to using of only the statistical data analysis method, in which we have been argued that previous literature suffers from a lack of "decision-makers" affect value on result." Therefore, the existing research has much the problem in representing of large section of criteria, alternatives and not able to address the problem of decision-makers' lack of experience. Even sometimes, the lesser-experienced decision-makers have been represented more on the results in literature.

Conclusion

While the chemical tanker market cap was United States Dollar (USD) 25.59 billion in 2016, the expectation in 2022 is it will reach USD 33.11 billion with an annual growth of 4.5 percent. It is estimated that the most growth will be in the Asia-Pacific and Middle East-Africa regions [7]. So, it can be referred from that research, on selecting the most suitable merchant vessel type could be useful to minimize the true effort, reduce costs and increase efficiency for charterers and brokers who are working in the carriage of bulk hazardous liquid and noxious liquid substance cargoes.

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In further articles, it is believed that by adding the "frequency of voyage" and "total voyage length" criteria may be useful for literature. Also, in future research it is kindly advised to authors that making a pair-wise comparison of Baltic and International Maritime Council Charter Party Agreements (BIMCO C/P) such as BIMCHEMVOY2008, BOXLEASE, ROPAXTIME, and using of some type of newly constructed methods such as intuitionistic fuzzy TOPSIS method or newer equivalent method may be beneficial to the literature.

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