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A Dry Cargo Coaster Tonnage Selection Model for Shipping Companies in Turkey

Türkiye'deki Denizcilik Firmaları İçin Bir Kuru Yük Kosteri Tonajı Belirleme Modeli

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Öz

Ürünlerin üretim, kullanım ve tüketim noktaları arasında genellikle fiziksel bir mesafe bulunması gerektiğinden, tedarik zincirinde ürünlerin müşteri ile buluşturulmasında en önemli lojistik faaliyetlerden biri de taşımadır. Taşımacılığın dünya üzerinde en geniş alanlara ulaşmasını sağlayan yöntem ise deniz taşımacılığıdır. Deniz taşımacılığı sayesinde kıtalar ve ülkeler birbirleriyle bağlanarak tedarik zincirini gerçekleştirmektedirler. Deniz taşımacılığın iki ana unsuru gemiler ve limanlardır. Deniz taşımacılığında kullanılan gemilerin yük, mesafe ve konuma göre farklı tiplerde olmalarıda ideal gemi boyutunun belirlenmesi için çok önemlidir. Gemilerin ideal boyutlarının belirlenmesinde birden çok fazla karar verme modeli ve karar kriteri bulunmaktadır. Bu nedenle denizcilik şirketleri, gemi konusunda yatırım ve işletme kararlarında doğru gemi boyutunu seçmenin zorluklarıyla karşı karşıya kalmaktadırlar.

Gemi tiplerinde iki ana kriter bulunmaktadır. Uzak mesafe denizyolu taşımacılığı ve kısa mesafe denizyolu taşımacılığı yapan gemilerdir. Denizcilik şirketleri uzak mesafe denizyolu taşımacılığı konusunda gemileriyle her türlü yük bulma şansına sahiptirler. Kısa mesafe denizyolu taşımacılığında ise gemi seçimi daha sınırlı kalmaktadır. Kısa mesafe denizyolu taşımacılığında en çok kullanılan gemi tipi olan kosterler, Türk Denizcilik Sektöründe önemli bir rol oynamaktadırlar. Bu nedenle, Türkiye'deki denizcilik şirketleri için bir kuru yük kosterinin ideal deadweight (DWT) ortaya çıkarmak için bu çalışmada çok kriterli karar verme yöntemlerinden biri olan Electre yöntemi kullanılmıştır. Kosterler, tonaj kapasitelerine göre beş kategoriye ayrılmış ve ardından kuru yük koster gemileri konusunda uzmanlardan beş tonaj kategorisi için görüş istenmiştir. Elde edilen veriler Electre yöntemi ile değerlendirilmiş ve optimal koster tonajı ortaya çıkarılmıştır.

Anahtar Kelimeler: Kuru Yük Gemileri, Koster Gemileri, Electre Yöntemi, Gemi Tonaj Seçimi, Denizcilik Şirketleri

ABSTRACT

There should usually be a physical distance between the production, use and consumption points of the products, and one of the most important logistics activities in the supply chain is transportation. The method that enables transportation to reach the widest areas in the world is sea transportation. With maritime transport, continents and countries connect with each other and realize the supply chain. The two main criteria of maritime transport are ships and ports. It is very important to determine the ideal ship size that the ships used in maritime transportation are of different types according to the load, distance and location. There are more than one decision making model

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and decision criteria in determining the ideal dimensions of the ships. For this reason, shipping companies have difficulties in choosing the right ship size in their investment and operation decisions.

There are two main criteria in ship types. They are ships engaged in long-distance sea transport and short-distance sea transport. Maritime companies have the chance to find all kinds of cargo with their ships regarding long-distance maritime transport. In short-distance maritime transport, the choice of ship is more limited. Coasters, which are the most used ship type in short-distance sea transportation, play an important role in the Turkish Maritime Industry. Therefore, Electre method, which is one of the multi-criteria decision-making methods, was used in this study to reveal the ideal dead weight tonnage (DWT) of a dry cargo coaster for shipping companies in Turkey. The coasters were divided into five categories according to their tonnage capacities, and then dry cargo coaster experts were asked for their opinions on five tonnage categories. The obtained data were evaluated with the Electre method and the optimal coaster tonnage was revealed

Keywords: Dry Cargo Ships, Coaster Ships, Electre Method, Ship Tonnage Selection, Shipping Companies

INTRODUCTION:

Maritime transport has an important situation in the world economy as it provides safe transportation over long distances. Among all modes of transportation, maritime transportation comes to the fore as low unit transportation costs, fast, cargo handling large tonnage cargoes by one time. When it comes to means of transporting cargo at sea, ships come to mind for everyone. Maritime transport is carried out by many different ships. Especially the different tonnage and types of dry cargo ships affect the working areas. Various ships that can carry all kinds of cargo are available in the world's seas (Malaksiano, & Melnyk, 2020). The existence of ships of all sizes in maritime transport that it easier to carry cargo today (Andersson, et al., 2021). According to the 2021 Chamber of Commerce data, 5.5 million tons of total cargo is transported by bulk and dry cargo ships (DTO, 2021).

The diversity of these ship types is related to the different nature of the cargoes. Detailed identification of these ships is important for their cargo and tonnage. In Table 1, the percentage rates of cargoes in ship types in world trade are indicated. In Figure 1, minor cargoes and bulk cargoes are transported by dry cargo type ship. 52.2 % of all cargoes are transported by this type of ship.

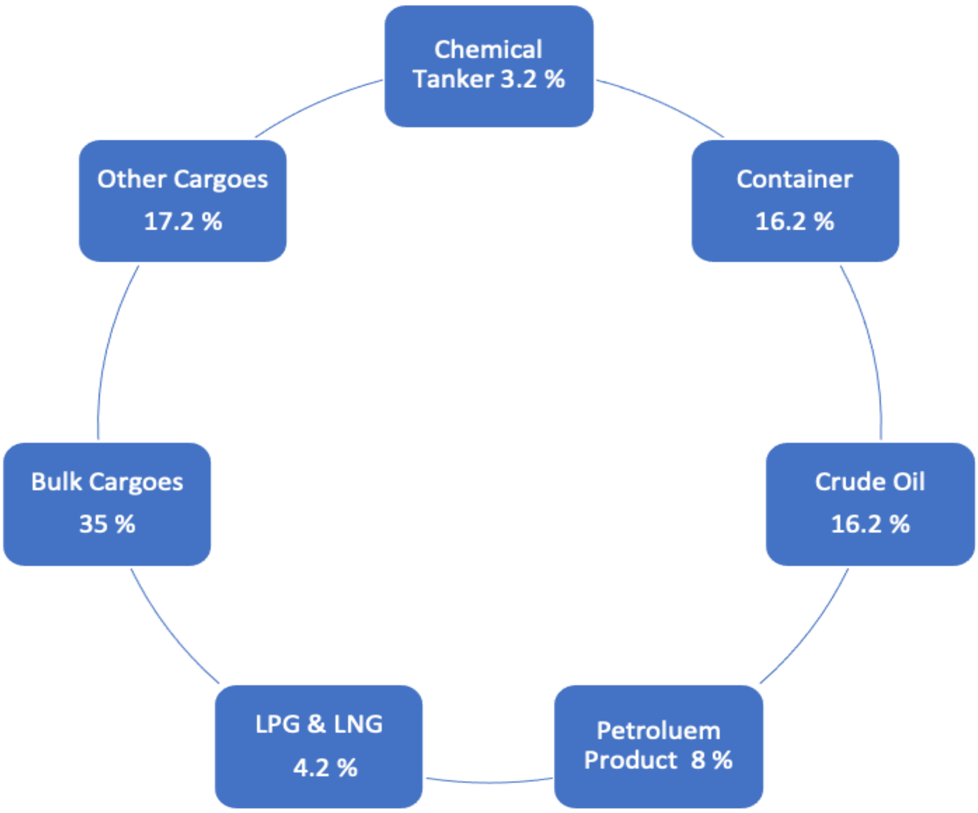

Figure 1: Percentage of All Cargo Maritime Transportation (DTO, 2021)

One of the most used types of dry cargo ships in the maritime market is coaster ships. In Turkey, ship companies are often has this type of ships. Due to the increase in their number, it has been seen that the selection of ships of this type to be transported is an important issue. Technological developments and globalization force shipping companies, which are the main elements of maritime transport, to maintain their existence in an increasingly competitive environment (Arslan, 2021).

1. Dry Cargo Ships

Coaster ships allow the transportation of all kinds of non-liquid cargo. They are the ships in which containers, vehicles, dry bulk cargo such as grain are transported (Yang, et al., 2011). Coster ship type, they are called ships designed to carry cargoes in bulk and which do not need any packaging or boxing. It has been recorded that a total of 1 million bulk and dry cargo ships are operating in the world's seas in 2021 (DTO, 2021). Bulk carriers can be divided into six size categories. Table 1 shows the differences of these categories.

Table 1: Classification Differences in Bulker Ships

Type	Dwt	Cargo Handling	Number
Handysize	<39.999	By crane	58.000
Handymax/Supramax	40.000-60.000	By crane	35.000
Panamax	60.000-79.000	By crane	26.000
Postpanamax	80.000-109.999	By Shore Crane /Equipment	27.000
Capesize	110.000-199.999	By Shore Crane /Equipment	33.000
Vloc	>200.000	By Shore Crane /Equipment	12.000

As can be seen in Table 1, there are a significant number of bulk cargo ships in maritime trade. Handysize, Handymax and Panamax types of vessels can easily operate in the port as they have their own cargo handling equipment. Again, on Postpanamax, Capesize and VLOC (Very Large Ore Carrier) type ships, mostly unloading and loading operations are carried out by port equipment. These three ships transfer cargo from ship to ship, especially in the open seas, not in shallow ports. Their operations in ports are limited. They are more common on Handysize, Handymax and Panamax type vessels. There are also the most Handysize ships in terms of number. The least number of them appear as VLOC type ships.

1.1.Coaster Ship

It is the merchant ships that go from port to port along the coast and form the basis of maritime transportation. Trade by ships called "Coaster", which has a cargo carrying capacity of 1.000 to 12.000 tons and used in close maritime transport, in today's Black Sea and Mediterranean Sea, at the beginning of the 20th century, after the industrial revolution. It has been a form of trade that we can call the roots or backbone of trade (Jing, et al., 2008). As can be seen in Table 1, although the growth of tonnages is reflected well for cargo transportation, ships face to operational difficulties in ports with draft restrictions. At one of these difficulties is not being able to get a full cargo or not being able to carry part cargoes.

2. Literature Review

Different studies have been carried out on ship selection. Some of these studies are:

Maleksiano M. and Melnyk O. (2020) conducted research on the selection of ships for the transport of large-sized cargoes in their study. In the research, evaluation was made on the basis of large-size cargo dimensions, freight costs and time-term rental principles. In the study, evaluation was made by finding some criteria based on project type cargoes and speed/fuel consumption in ship selection. Maritime companies and businesses indicate that in calculating the expenses of ships, the comparison between voyage charter ships and time charter ships is made with calculations over time-term charters (Malaksiano & Melnyk, 2020).

Anderson J. et al. (2021) studied on the propeller system and design of a cargo ship. Parameters were determined upon the selection of the propeller system on a 120m dry cargo ship. Simulation-based modeling was used as a method (Andersson, et al., 2021).

Arican, O. H., et al. (2020) conducted research on the selection of equipment related to the chemical cargo handling system in ship operations. In the research, a detailed explanation of the operations on the ship was made (Arıcan, O. H., et al., 2020).

Yang Z. et al. (2011) conducted a study on ship selection using fuzzy logic. Ship selection criteria were determined by methods and these criteria were evaluated in alternative ships by the TOPSIS method (Yang, et al., 2011).

Yang Z. et al. (2009) conducted a study on ship selection based on uncertain environmental conditions. In this study, alternative ships were selected by determining criteria and sub-criteria by fuzzy logic. It is stated by which criteria the best ship is determined. Here, large-tonnage crude oil tankers were studied as a type (Yang, et al., 2009).

Malchow, M. B., & Kanafani, A. (2004) studied on bulk cargo port selection by multi-criteria decision-making methods. In this selection model, criteria were determined by researching the diversity of cargoes and the use of the port area (Malchow & Kanafani, 2004).

Erikstad, S.O. et al. (2011) proposed an optimization model for ships. By this model, they evaluated the loading and unloading characteristics of the ships. In addition, they presented a method which is determining their properties. The study is a study on the selection of more than one ship at the same time (Erikstad, et al., 2011).

Sellars, F.H. and Martin, J.P. (1992) made assesment on ship stability systems. They studied on the characteristics of the tanks that affect the stability of the ships (Sellars & Martin, 1992).

Balakrishnan, A. and Karsten, C. V. (2017) studied on ship selection for the problems encountered in container transportation in the sector. In the study, they proposed a model for the transfer of containers on container ships. With this model, it is aimed to achieve optimization and recommended to reduce operations on ships (Balakrishnan & Karsten, 2017).

When these studies are examined, it is seen that there is no study on the selection of small tonnage dry cargo ship (coaster) in the literature. In order to increase the importance of tonnage values in dry cargo maritime transportation and to indicate the effect of important criteria, a different opinion was expressed from other studies.

3. Research Methodology

In the study, concept about dry cargo ships is given in section 1. It has been stated that coaster ships, ships with small tonnage, make the operations in the port areas easier. In the literature review, studies on coaster type ships were examined. As a result of the research, it was seen that there were studies related to ship selection, but especially the coaster type was not discussed. It is thought that there may be differences in ships due to different equipment features in their tonnage. The selection of ships of this type in terms of tonnage started with the selection of experts from companies operating coaster ships. The methodology to be used in the research was carried out as in the flow chart in Figure 2.

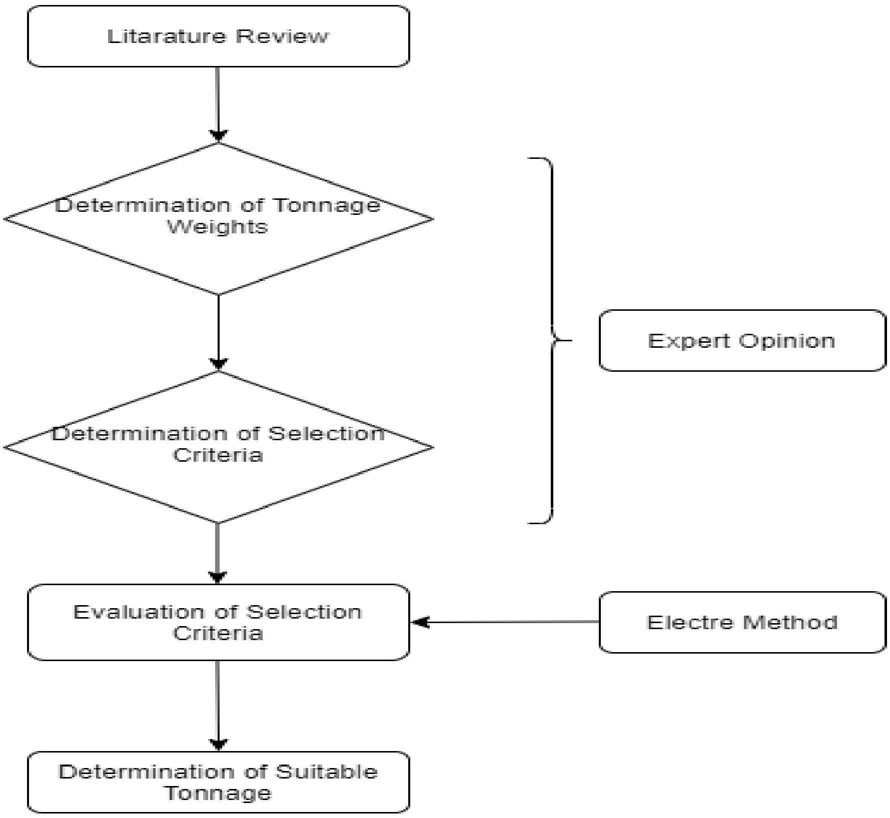

Figure 2: Flow Chart of the Study

4. Method

4.1. Electre Method

ELECTRE (Elemination and Choice Translating Reality English) method, which is one of the multiple decision making methods, was created by Beneytoun in 1966. In this method, for each of the evaluation factors, the result is based on the double superiority of the alternatives. This method is similarly based on superiority and being ahead. Efficiency and benefit are defined for each evaluation criterion. Each option is given points on efficiency criteria. Expert decision makers should especially determine the limits of compatibility and incompatibility. This method goes to the solution in eight steps in total. The stepas are below.

Step 1: Creating the Decision Matrix (A)

The decision matrix includes decision points and evaluation factors. Decision points are given in rows. Evaluation factors are given in the columns. A matrix is defined as the first decision matrix created by the decision makers. The following equation (1) shows the decision matrix (Benayoun, et al., 1966).

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad \textbf{(1)}$$

In the Aij matrix, m gives the number of decision points, n the number of evaluation factors.

Step 2: Creating the Standard Decision Matrix (X)

By making use of the elements that make up the A matrix, the standard decision matrix is created with the calculation specified in the equation (2) (Yanie, et al., 2018).

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{n}^{m} a_{kj}^{2}}} \tag{2}$$

For example, to calculate x11 in matrix X, the element a11 in matrix A in equation 1 is found by dividing the square root of all the elements of column 1 of the Amatrix. The expression applied here is to weight the value by the decision points when associating the evaluation factor of a decision expression. As a result of the calculation, the X matrix is calculated as in the equation (3) (Urošević, et al., 2017).

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{3}$$

Step 3: Making a Weighted Standard Decision Matrix (Y)

The importance of evaluation factors is different for decision makers. To reflect these differences in the EECTRE solution, the Y matrix should be created. Expert decision makers should determine the weights (wi) of the evaluation criteria. The calculation of the weights of the evaluation criteria is given in equation (4). (Bogdanovic & Miletic, 2014).

$$\sum_{i=1}^{n} w_i = 1 \tag{4}$$

Then, multiplying the elements in each column of the X matrix with the value of wi in the relevant equation (4) to form the Y matrix.. Y matrix is shown in equation (5) (Afshari, et al., 2010):

$$Y_{ij} = \begin{bmatrix} w_1 x_{11} & w_2 x_{12} & \cdots & w_n x_{1n} \\ w_1 x_{21} & w_2 x_{22} & \cdots & w_{1n} x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_1 x_{m1} & w_2 x_{m2} & \cdots & w_n x_{mn} \end{bmatrix} \tag{5}$$

Step 4: Compliance detection (Ckl) and Incompatibility (Dkl) Values

In order to determine the fit values, the Y matrix is used, the decision points are compared with each other in terms of evaluation factors, and the values are determined with the help of the relationship shown in the equation (6) (Benayoun, et al., 1966):

$$C_{kl} = \{j, y_{kj} \geq y_{ij}\} \tag{6}$$

Basically, the equation is formed by comparing the qualitative sizes of the row elements with respect to each other. In a very stable problem (m.m-m), the number of fit values becomes one. Because while creating the fit sets, k ≠ l should be for the k and l indicators. If the number of elements in a fit set is m, the maximum number of evaluation factors can be (n). For example, for k = 1 and l = 2, for C12 fit set, the 1st and 2nd row elements of the Y matrix are compared with each other, and if there are 4 evaluation factors here, the C12 fit set will have at most 4 elements. In the example given, it is the 1st and 2nd row comparison (Urošević, et al., 2017),

$$y_{11} > y_{21}$$
$$y_{12} < y_{22}$$
$$y_{13} < y_{23} \quad (7)$$
$$y_{14} = y_{24}$$

The j = 1 and j4 values will match the condition in the equation (7) and C12 fit set be formed as C12 = {1,4}.

Step 5: Creating Concordance (C) and Discordance Matrices (D)

Fit sets are used to construct the fit matrix (C). The C matrix is (mxm) dimensional and takes no value for k = l. The elements of C matrix are calculated with help of the relationship shown in the equation (8) (Yanie, et al., 2018).

$$c_{kl} = \sum_{j \in C_{kl}} w_j \quad (8)$$

For example, if C12 = {1,4}, the value of the c12 element of the C matrix will be c12 = w1+ w4. The C matrix is shown in equation (9):

$$C = \begin{bmatrix} - & c_{12} & \cdots & c_{1m} \\ c_{21} & - & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ c_{ml} & c_{m2} & \cdots & - \end{bmatrix} \quad (9)$$

The elements of the discordance matrix (D) are calculated with the help of equation (10).

$$d_{kl} = \frac{max|y_{kj} - y_{lj}|}{max|y_{kj} - y_{lj}|}\,{}_{j \in} D_{kl} \quad (10)$$

For example, when comparing the 1st and 2nd row elements of the Y matrix, the element d12 (k = 1 and l = 2) is obtained. For d12, in the numerator part of the equation (10), the values j = 2 and j = 3 forming the D12 = {2,3} discordance set are considered and the larger of the absolute differences y12 – y22 and y13 – y23 is selected. For the denominator part of the equation, the mutual absolute differences of all the elements in the 1st and 2nd rows of the Y matrix are found and the largest one is selected (Bogdanovic & Miletic, 2014).

D matrix is maximum like C matrix, in size and takes no value for k = l. The D matrix is shown in equation (11):

$$D = \begin{bmatrix} - & d_{12} & \cdots & d_{1m} \\ d_{21} & - & \cdots & d_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ d_{m1} & c_{m2} & \cdots & - \end{bmatrix} \quad (11)$$

Step 6: Establishing Concordance Superiority (F) and Incongruity Superiority (G) Matrices

The fit superiority matrix (F) is mxm dimensional and the elements of the matrix are obtained by comparing the fit threshold value (c) with the elements of the fit matrix (ckl). The fit threshold value (c) is obtained with the help of equation (12) (Yanie, et al., 2018):

$$c = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} c_{kl} \quad (12)$$

m in the equation represents the number of decision points. More precisely, the value of c is equal to the product of $\frac{1}{m(m-1)}$and the sum of the elements that make up the matrix C.

The elements of matrix F (f_{kl}) take the value either 1 or 0 and have no value because they represent the same decision points on the diagonal of the matrix. If c is $c_{kl} \geq d \Rightarrow f_{kl}$, if $c_{kl} < d \Rightarrow f_{kl} = 0$ dır [16].

The discordance superiority matrix (G) is mxm in size and is constructed similarly to the F matrix. The discordance threshold value d is obtained with the help of equation (13):

$$d = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl} \quad (13)$$

In other words, the value of d is equal to the product of $\frac{1}{m(m-1)}$ and the sum of the elements that make up the matrix D.

The elements of matrix G also take the value (g_{kl}), either 1 or 0, and there is no value because they represent the same decision points on the diagonal of the matrix. If $d_{kl} \geq d \Rightarrow g_{kl}$, if $d_{kl} < d \Rightarrow g_{kl} = 0$ is (Bogdanovic & Miletic, 2014).

Step 7: Creating the Total Dominance Matrix (E)

The elements of the Total Dominance Matrix (E) (e_{kl}) are equal to the reciprocal product of the elements f_{kl} and g_{kl} as shown in the equation below. Here, the E matrix, depending on the C and D matrices, has m x m dimensions and again consists of 1 or 0 values (Afshari, et al., 2010).

Step 8: Determining the Importance Priority of Decision Points

The rows and columns of the E matrix represent the decision points. For example, if the matrix E is calculated as an equation. (14),

$$E = \begin{bmatrix} - & 0 & 0 \\ 1 & - & 0 \\ 1 & 1 & - \end{bmatrix} \quad (14)$$

It takes $e_{21} = 1, e_{31} = 1, e_{32} = 1$ values. This shows the absolute superiority of the 2nd decision point to the 1st decision point, the 3rd decision point to the 1st decision point and the 3rd decision point to the 2nd decision point. In this case, if the decision points are expressed with the symbol $A_i \ (i = 1,2....m)$, the order of importance of the decision points will be $A_1, A_2 \ ve \ A_i$ (Benayoun, et al., 1966).

5. Analysis & Findings

5.1.Criterias in Practice

The data obtained are presented by taking the expert opinions in Table 2. Experts are selected from the managers who have been active in the maritime sector for at least 10 years in dry cargo ship companies. The data transmitted by the experts are of great importance for the analysis. Therefore, it is necessary to make a correct assessment. It has been determined what the coaster ship operators pay attention to in the selection of deadweight tonnage and to what extent they attach importance to these criteria.

Table 2: Qualification of Experts

	Rank	Years in Rank	Number of Ships	Tonnage Range
Expert 1	Ship Operation	6	4	1.000-20.000
Expert 2	Charter Department	11	5	1.000-10.000
Expert 3	Charter Department	7	3	5.000-15.000
Expert 4	Ship Operation	8	8	1.000-25.000
Expert 5	Charter Department	4	11	1.000-12.000
Expert 6	Ship Operation	9	4	3.000-9.0000
Expert 7	Charter Department	7	5	5.000-45.000
Expert 8	Charter Department	6	3	2.000-12.000
Expert 9	Ship Operation	10	6	1.000-37.500
Expert 10	Charter Department	11	12	2.500-17.750

Five deadweight tonnage ranges for dry cargo ship operators were determined by experts and listed in order of importance.

1. 1000-3000 deadweight
2. 3001-5000 deadweight
3. 5001-7000 deadweight
4. 7001-9000 deadweight
5. 9001 and above deadweight

There are also criteria that determine the importance of the five determined ranges. These criteria have a high impact on the selection of these tonnages. It is asked with open-ended questions to experts, which criteria might be effective in the selection of tonnage. In total, twelve different criteria are taken, but the common ones were included in the study. Among the received answers, five common criteria were determined. Determined measurement criteria and explanations are as in Table 3.

Table 3: Explanations of the Criteria

Selection Criteria	Explanation
C1: Freight Revenues	As in every type of transportation, there is a fee to be paid for the cargo in maritime transportation. The high revenues of freight means an advantage for the party carrying the cargo on board.
C2: Suitability to ports (depth and berth length)	Today, ships must meet certain features in order to dock at ports and to load / unload. It should be suitable for port loading and unloading systems in parallel with the tonnage of the ship. The port length should be specified in parallel with the ship's equipment systems design. Depth and berth length are an important scale.
C3: Availability to find cargo	It is very important that a ship is suitable for finding a cargo because not every cargo is suitable for every ship, due to the physical structure of the ships and the maximum cargo capacity. The idea that time equals money in the maritime industry motivates many shipowners. The inability to find cargo in large dwt tonnage makes ships with small dwt tonnage advantageous. Thanks to this advantage, it means that the waiting times of small dwt vessels are reduced and more cargo can be carried.
C4: Costs (Bunker, Insurance, Classification, Supplementary Cost)	It consists of the expenses necessary for the ship to carry cargo. Expenses of all repairs costs while the ship is underway, shipyard costs entered for maintenance and expenses paid for periodically entered shipyard maintenance, hull, machinery and P&I insurance fees paid for the ship, company-office expenses for the operation, all kinds of certification expenses, These are the expenses made for the company officials and other organizations to inspect the ship in order to ensure its safety.
C5: Personnel expenses	It is necessary to meet all the needs of the personnel on board. This brings with it being prepared for all kinds of expenses and giving importance to the living standards of the personnel on board. The higher the number of crew/personnel on a ship, the higher the expense on that ship. These expenses can be defined as the salary, nutrition, premium, insurance, transportation, training and health expenses of all personnel on board. In addition, if there is a human resources company where the personnel is provided, these fees and if the personnel are kept ready to be sent to the ship, these costs are also among the personnel costs.

5.2.Scale Range and Criterias Weights

In order to apply the Electre method, each of the criteria must have a numerical weight and scale value. While determining the scale ranges of the criteria, the scale length can be chosen arbitrarily, but considering the order of importance of the criteria, it is beneficial to assign the largest scale value to the criterion with the highest degree of importance. The same logic applies to weights. The criterion with the highest importance has the highest weight. Table 4 shows ship tonnages and criteria. For convenience, the scale values of the criteria with the same weights are also taken as the same. Freight revenues, suitability for ports and availability to find cargo have the same importance. It was decided jointly to have the same importance within the framework of the information received from the experts. Therefore, the same scale and weight were taken.

5.3.Matrices

In the Electre method, three types of matrices are used to solve the problem.

1. Concordance Matrix

2. First Discordance Matrix

3. Second Discordance Matrix

Table 4: Ship Tonnage Selection and Criteria

	Deadweight Tonnage (DWT)						
Selection Criteria	1000 - 3000	3001 -5000	5001 - 7000	7001 - 9000	>9001	Weight	Scale
Freight Revenues	6	8	7	6	7	5	1-9
Suitability to ports (depth and berth length)	9	8	7	6	5	5	1-9
Availability to Find Cargo	7	9	8	6	5	5	1-9
Costs (Bunker, Insurance, Classification, Supplementary Cost)	6	8	7	7	8	3	1-8
Personnel Expenses	5	6	5	7	7	2	1-7

5.3.1.Concordance Matrix

The cases where the options are dominate or equal to each other are taken. For example, if the dominance and equality situations between 3001-5000 dwt and 1000-3000 dwt are examined, ships with 3001-5000 dwt received higher scores than 1000-3000 dwt in Freight Revenues, Availability of Cargo, Costs and Personnel Expenses. Also, there is no equality. The weights of the criteria where 3001-5000 dwt is greater than or equal to 1000-3000 dwt are taken and divided by the sum of the weights.

The superiority of 3001-5000 dwt over 1000-3000 dwt = (5+5+3+2) / 20 = 0.75 is found. The value found is written in the area where the column of 3001-5000 dwt and the row of 1000-3000 dwt overlap. The operations performed to create the fit matrix are repeated and the options are compared with each other. Table 5 shows the concordance matrix.

Table 5: Concordance Matrix

Deadweight Tonnage

	Options/ Criteria	1000-3000	3001-5000	5001-7000	7001-9000	> 9001
Deadweight Tonnage	1000-3000	-	0,75	0,75	0,50	0,50
	3001-5000	0,25	-	0	0,10	0,25
	5001-7000	0,35	1,0	-	0,25	0,50
	7001-9000	0,85	0,90	0,90	-	0,50
	>9001	0,50	0,90	0,75	0,75	-

5.3.2.First Discordance Matrix

The criteria in which the options dominate each other are selected and the criterion with the highest score difference for the options is determined. The difference value is divided by the largest scale length and the first discordance number is found. For example, the criteria where 3001-5000 dwt is dominant over 7001-9000 dwt (Freight Revenues, Availability to Ports, Availability to Find Cargo and Costs) is the criterion with the highest score difference among these criteria, ((8-6=2), (8 -6=2), (9-6=3), (8-7=1)) =3, availability to find cargo is found. The highest scale value is 9. The value 3/9 = 0.33 is found as the first discordance number.

While creating the matrix, the first discordance number is written in the area where the 7001-9000 dwt column and the 3001-5000 dwt line overlap. When comparing the options with each other, the same operations are repeated, and the first discordance matrix is created. Table 6 shows the first discordance matrix.

Table 6: First Discordance Matrix

	Deadweight Tonnage					
	Options/ Criteria	1000-3000	3001-5000	5001-7000	7001-9000	>9001

Deadweight Tonnage	1000-3000	-	0,11	0,22	0,33	0,44
	3001-5000	0,22	-	0,11	0,33	0,44
	5001-7000	0,11	0,0	-	0,22	0,33
	7001-9000	0,22	0,11	0,22	-	0,11
	>9001	0,22	0,11	0,22	0,11	-

The criteria in which the options dominate each other are selected and the criterion with the second highest score difference is determined for the options. The difference value is divided by the largest scale length to find the second discordance number. Example The criteria in which 3001-5000 dwt dominates 7001-9000 dwt (Freight Revenues, Availability to Ports, Availability to Find Cargo) is the criterion with the highest score difference among these criteria, ((8-6=2), (8- As 6=2), (9-6=3), (8-7=1)) = 2, Ports Availability and Costs are found. The highest scale value is 9. The value 2/9 = 0.22 is found as the second discordance number.

While creating the second incompatibility matrix, the second incompatibility number is written where the 7001-9000 dwt column and the 3001-5000 dwt line overlap. Table 7 shows the second discordance matrix.

Table 7: Second Discordance Matrix

		Deadweight Tonnage				
	Options/ Criteria	1000-3000	3001-5000	5001-7000	7001-9000	>9001 dwt
Deadweight Tonnage	1000-3000	-	0,0	0,00	0,11	0,22
	3001-5000	0,11	-	0,00	0,22	0,33
	5001-7000	0,00	0,00	-	0,11	0,22
	7001-9000	0,11	0,00	0,00	-	0,00
	>9001	0,11	0,00	0,11	0,00	-

5.4.Threshold Value and Threshold Matrix

Threshold Values required to reach the solution from the matrices. These numbers are p; Shows the fit matrix, boxes greater than or equal to this value are selected, q; Shows the discordance matrices, boxes less than or equal to this value are taken, s; Indicates whether the discordance matrix is first or second. If the same area is filled in both matrices, that area is crossed out.

The p value of 0.56 was chosen for the fit matrix. The reason for choosing this value is that it is an average value compared to other values and it was obtained by taking the arithmetic average of the fit matrix. If the result is not found here, it will be passed to the second discordance matrix, and the q value can also be changed. The q value for the first discordance matrix is 0.20, because the arithmetic mean of the first discordance table is taken. Values greater than or equal to 0.56 will be marked in the concordance matrix, and then values less than or equal to 0.20 will be marked in the first discordance matrix. After these markings, the matrices will be placed on top of each other and the boxes where the signs intersect will be crossed out. Table 8 shows the threshold matrix.

Table 8: Threshold Matrix by 1st Discordance Matrix

	Options/ Criteria	1000-3000	3001-5000	5001-7000	7001-9000	>9001
Deadweight Tonnage	1000-3000	-	X	-	-	-
	3001-5000	-	-	-	-	-
	5001-7000	-	X	-	-	-
	7001-9000	-	X	-	-	-
	>9001	-	X	-	X	-

Table 7 is made with inconsistency. X indicates that the option in the column is superior to the option in the row 1. Looking at the threshold matrix made with 1st discordance, there is no tonnage that provides superiority against ships of 3001-5000 dwt. The superiority of 3001-5000 dwt ships over other tonnages in all criteria emerges because of the intense demand of coaster enterprises for ships in this deadweight tonnage. On the other hand, as can be seen from the table 8, ships of 7001-9000 dwt have superiority only to ships of 9001 and over dwt. This was again seen as proof that large tonnage ships are a disadvantage for coaster ship operations. In the arrow representation below, the arrow goes from the dominant to the weaker. In arrow notation, the tip of the arrow indicates the preferred or less preferred deadweight tonnage.

Figure 3: Relationship Between Deadweight Tonnages According to Threshold Matrix by 1st Discordance Matrix

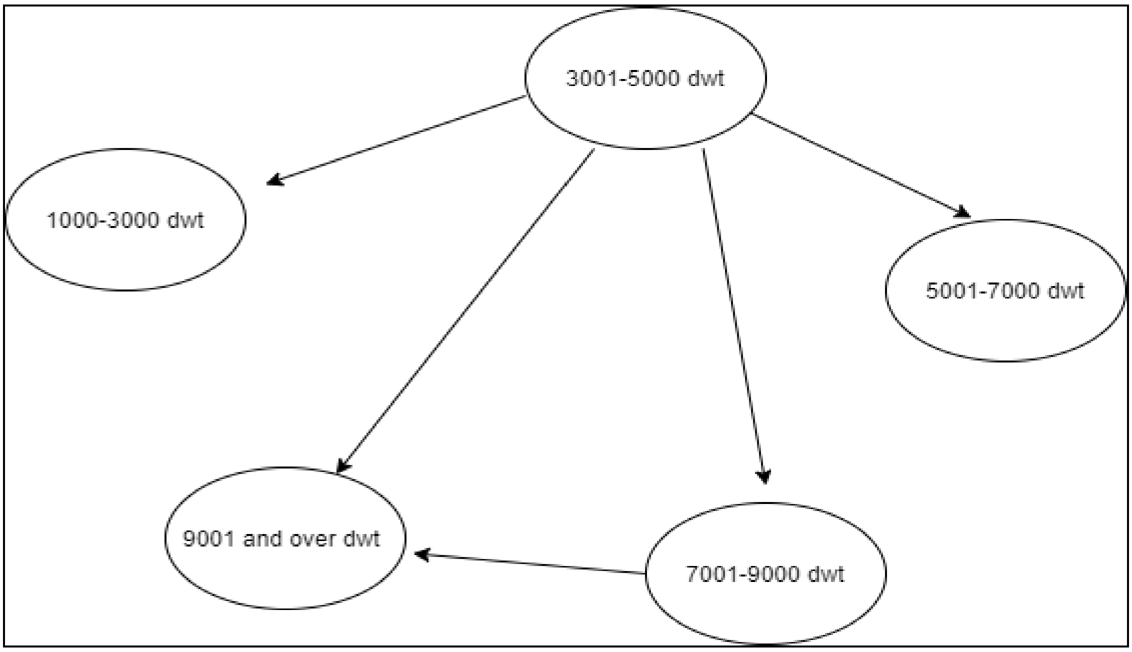

Figure 4: Relationship Between Deadweight Tonnages According to Threshold Matrix by 1st Discordance Matrix

The arrow representation in Figure 3 is made according to the result of the 1st discordance matrix.

Table 9: 2nd Discordance Matrix.

		Deadweight Tonnage				
	Options/ Criteria	1000-3000	3001-5000	5001-7000	7001-9000	>9001
Deadweight Tonnage	1000-3000	-	X	X	-	-
	3001-5000	-	-	-	-	-
	5001-7000	-	X	-	-	-
	7001-9000	-	X	X	-	-
	>9001	-	X	-	X	-

It is made according to the 2nd Discordance matrix in Table 9. The X sign indicates that the option in the column is superior to the option in the row 2. When we look at the result of the threshold matrix table made with discordance, it is seen that the result obtained in the threshold matrix made with the 1st discordance in Table 8, that is, the ships in 3001-5000 dwt are quite superior to the tonnage of other ships. It is seen that the ships in 5001-7000 dwt are more advantageous in Table 8. It is shown more clearly in the arrow notation Figure 4. In arrow representation, the arrow goes from the dominant to the weaker. In arrow notation, the tip of the arrow indicates the preferred or less preferred tonnage.

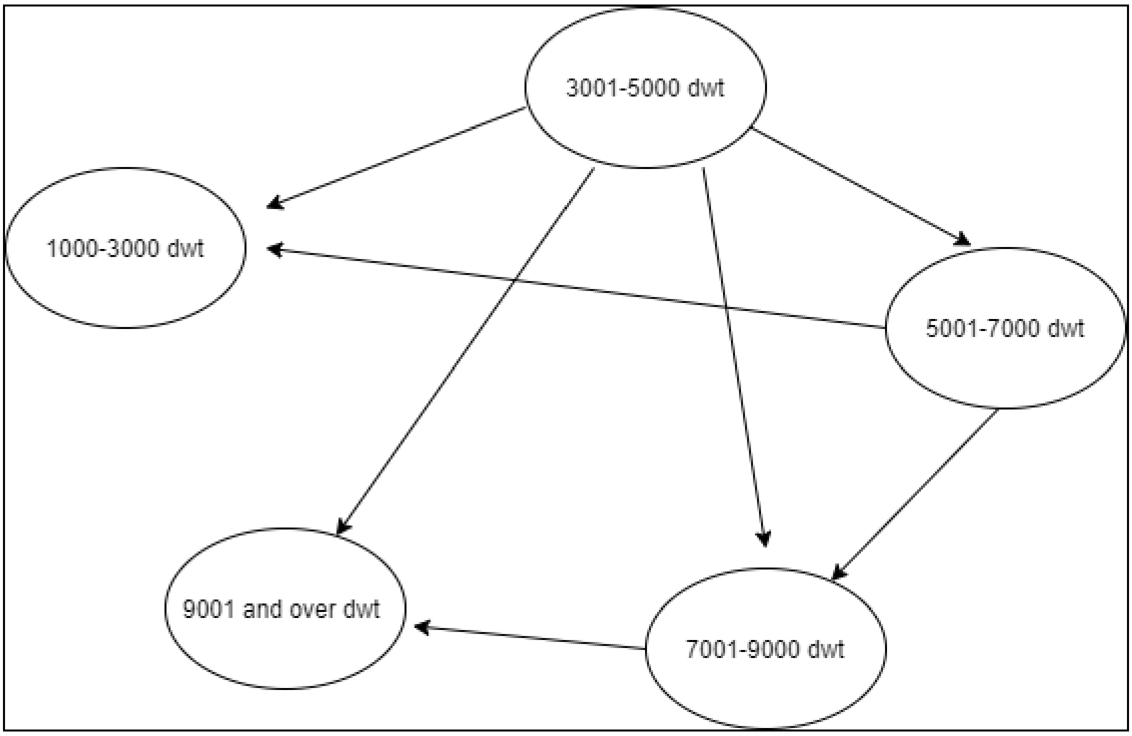

Figure 5: Relationship between Deadweight Tonnages According to Secondary Threshold Matrix by 2nd Discordance Matrix.

CONCLUSION:

In the study named dry cargo coaster ship tonnage determination, modeling was tried to be made on the determination of coaster ship tonnage for maritime companies operating in Turkey. Opinions were received from experts working in leading maritime companies operating in Turkey. The criteria prepared with the data obtained from these views were tried to be analyzed by the electre method. According to the data obtained from the criteria obtained, it has been revealed that the ship owners and operators prefer mostly low tonnage ships in coaster ships in the dry cargo sector in Turkey. When considered in terms of the determined criteria, it is seen that most of the criteria are advantageous for low tonnage ships, but disadvantageous for high tonnage ships.

Freight, which is the first of the criteria, is the most basic criterion that guides ship operations and chartering in maritime trade. Cargo owners, forwarders and brokers give priority to the freight offers given by the ships in their ship preferences. The freight price of a 1000-3000 gross tonnages ship can never be the same as the freight offer of a 3001-5000 gross tonnages ships. Of course, the ship operating costs of ships between 1000-3000 gross tonnages and the ship operating costs of ships between 3001-5000 gross tonnages will be close to each other. However, due to the increase in the amount of cargo carried, there will be differences in the freight prices per ton/m3. Ships between 3001-5000 gross tonnages are advantageous in the freight offer. As the gross tonnage ratio increases, the freight rates decrease and an advantage is gained in the price offers to be submitted. In addition, when considering the amount of cargo, it is known that very high rates, especially in cabotage cargoes, are not supplied to the market. In this case, ships below 9001 gross tonnages are more advantageous.

In terms of port suitability (depth, berth length), it enables low tonnage vessels to be advantageous when entering and exiting ports. Low tonnage ships adapt more easily to the physical structures of ports. Draft problem is the most important criterion for ports, especially for high tonnage ships in berthing and departure operations. Low tonnage vessels can perform berthing and take-off operations quickly at every pier and pier. However, high tonnage ships cannot do berthing and lifting operations at every pier and pier due to their draft. They have to wait for the appropriate docking places to be emptied. In this case, it causes loss of time and money for the ship. In this criterion, high tonnage ships fall into a disadvantageous position and ships between 1000-3000 gross tonnage provide a great advantage.

One of the most important areas in terms of criteria is ship operating costs. Unless there is a huge difference in tonnage between the operating costs of the ships, operating costs close to each other arise. In this case, it reduces the chance of small tonnage ships and makes them disadvantaged compared to other ships. On the other hand, as the operating costs of high tonnage ships will increase and there is an increase in their expenses, there is a decrease in profit rates. In addition, the bunker cost, which is at the beginning of the operating costs of the ships, does not vary greatly between ships with close tonnage. However, due to the closeness of the transportation costs, the profit rate increases with the increase in the cargo carried, and it turns out that the 3001-5000 gross tonnages coaster ships are the most advantageous tonnage range. In terms of all the criteria determined by the experts, it has been revealed in the study that ships between 3001-5000 gross tonnages are the most advantageous tonnage range.

One of the most important expenses in terms of tonnage selection of coaster ships is personnel costs. In the operation of high tonnage ships, a maximum number of personnel is required as per ISM rules. Therefore, the personnel expenses of large tonnage ships are higher than those of small ships. Low tonnage ships, on the other hand, are more advantageous in terms of personnel costs compared to high tonnage ships, Since they require less personnel in terms of operation. Maritime companies give importance to personnel expenses in terms of cost expenses. Personnel expenses on board are calculated not only as the salary of the personnel but also as the sum of other social benefits. Therefore, even 1 personnel difference in ship operation sometimes becomes an important ship cost. In the tonnage selection of coaster ships, ships between 1000-3000 gross tonnage are the first group with the highest disadvantage in terms of personnel expenses. Because although the ships are quite small in size, they have to have a minimum of personnel and the profit rate is the lowest compared to the operating costs in terms of the load they carry. With the change in the length of the ships, there is not much change in the number of personnel. In this case, the personnel numbers of ships between 1000-3000 gross tonnages and ships between 30001-5000 gross tonnages can be almost the same.

It is hoped that the data obtained in this study will be a guide for ship owners and ship operating companies in Turkey for prospective ship purchases or ship charters. The tonnage selection range should be made from ships between 3001-5000 gross tonnages in order for the ships to be selected by the maritime enterprises to be used in the coaster ship sector in Turkey, in order to carry out the most profitable transports. This tonnage range has been found according to the criteria preferred by shipping companies in ship selection and by electre management, which is a scientific research method. Of course, there will be stretches in this ship tonnage range according to the market conditions of maritime companies, fluctuations in ship prices and opportunities. However, in the current market conditions, it has been revealed that it is most efficient to make the tonnage range between 3001-5000 gross tonanges in Turkey's maritime trade conditions. When ship owners and ship operating companies make their choices according to this determined tonnage range while making their ship tonnage preferences, it will ensure that they get the highest profit rate in terms of the operation of the ship and that the ship will make the highest number of voyages. The current market conditions will of course change according to the economic, political and political situations that will occur in the future. However, the criteria that should be emphasized here are the most basic and important criteria, and they are the criteria that will maintain their importance in all kinds of developments and changes. In this respect, it is expected that the data obtained in the study and the determined ship tonnage range will remain largely the same. With the emergence of new criteria depending on the changing market conditions and developing technology in the future, new scientific studies can be carried out on the determination of new tonnage ranges.

Compliance with Ethical Standard

Conflict of Interests: There is no conflict of interest between the authors or any third party individuals or institutions.

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