Evaluating Ship Selection Criteria for Maritime Transportation

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Abstract—Nowadays, with the growth of international merchandise trade, the role of the maritime transportation becomes crucial. Selecting the most suitable ship, in order to transport the cargo from an origin port to a destination port, among multiple alternatives is a complex decision process due to the presence of multiple and conflicting criteria. This paper proposes a decision approach based on Decision Making Trial and Evaluation Laboratory (DEMATEL) methodology to determine influential ship selection criteria in maritime transportation industry. Real-world data will be used to illustrate the application of the proposed approach.

Index Terms—maritime supply chain management, ship selection, DEMATEL, criteria weighting

I. INTRODUCTION

In today’s globalized world, maritime transportation becomes one of the most important industries with its immense share in the global trade. As the efficiency of the transportation influences directly the growth of the world economy [1], quantitative techniques to manage better maritime transport activities have received increasing attention. Selecting the most suitable sea carrier, in order to transfer a cargo between two seaports, among multiple alternatives is a complex decision process due to the presence of multiple and conflicting criteria.

This paper proposes a decision approach based on Decision Making Trial and Evaluation Laboratory (DEMATEL) methodology to determine influential ship selection criteria in maritime transportation industry. The rest of the paper is organized as follows. The following section outlines the DEMATEL method. Section III defines the criteria used for ship selection. In Section IV, the application of the proposed approach with real data is presented. Conclusion and directions for further research are provided in Section V.

II. DEMATEL METHOD

The decision making trial and evaluation laboratory (DEMATEL) method [2] is developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 [3]. The DEMATEL method enables the decision maker to visualize influences between criteria and it computes their importance weights. The steps of the method can be summarized as follows [3]-[5]:

Obtain the initial direct influence matrix A. The decision-maker is asked to indicate the direct influence that he believes each factor i exerts on each factor j of the others, as indicated by ai,j, using an integer scale [3].

The integer scale is generally going from “0” to “4” where “0” represents “no influence,” and “4” represents “extreme strong influence”.

In case of there are multiple respondents, the direct matrix A can be obtained by computing the average matrix.

Calculate the normalized initial direct influence matrix D. The normalized initial direct influence matrix can be obtained by normalizing the average matrix.

Calculate the total relation matrix. The total relation matrix T is defined as $T = D(I-D)^{-1}$, where I is the identity matrix.

Define r and c be n x 1 and 1 x n vectors representing the sum of rows and sum of columns of the total relation matrix T, respectively. Suppose ri be the sum of ith row in matrix T, then ri shows both direct and indirect effects given by factor i to the other factors. If ci denotes the sum of jth column in matrix T, then cj shows both direct and indirect effects by factor j from the other factors [5].

When j = i, the sum (ri + ci) is regarded as the degree of importance for factor i in the entire system [5,6].

In addition, the difference (ri - ci) represents the net effect that factor i contributes to the system. Specifically, if (ri - ci)is positive, factor i is a net causer, and when (ri - ci) is negative, factor i is a net receiver [5].

Set up a threshold value, which is determined by the decision makers, to obtain the network relationship map which explains the structural relations among criteria [5].

III. SHIP SELECTION CRITERIA
Selecting the most suitable water carrier, in order to transfer a cargo between two seaports, is considered as one of the most important decisions for a successful supply chain management system. With its need to trade-off multiple criteria, ship selection is a complex multi-criteria decision making (MCDM) problem.

The complexity of the evaluation process is due to the presence of many conflicting criteria and the existence of subjectivity in the human decision making process [7]. In general, experienced decision makers subjectively prioritize selection criteria and make quick decisions. These ad-hoc decisions are not always reliable and consistent [7]. Multi-criteria decision making approaches can be used in order to obtain an effective decision for a ship evaluation and selection problem which is characterized by the availability of various alternatives and the presence of multiple and conflicting decision criteria [7].

In this paper, in order to define ship selection criteria, a literature survey is conducted. The criteria used in previous research papers concerning operational reliability assessment of maritime transportation system [8], maritime risk assessment [9-10], and ship evaluation and selection [7, 11] are listed and reformulated by two ship broker experts. The ten ship selection criteria obtained as a result of this work are listed in Table I.

In order to determine critical criteria in selecting a sea carrier, DEMATEL method described in previous section in employed. Two experienced ship brokers are asked separately to indicate the influence that they believes each criterion i exerts on each criterion j of the others, using an integer scale ranging from 0 to 4 represented in Table II.

The initial direct influence matrix, represented in Table III and Table IV, is obtained by computing the average of the influence matrices which are deducted from pairwise comparisons made by two experts.

The initial direct matrix is normalized and the total relation matrix is calculated.

This case study aims at determining and prioritizing criteria used in the selection process of an appropriate ship among candidate ships.

IV. APPLICATION

This case study aims at determining and prioritizing criteria used in the selection process of an appropriate ship among candidate ships.
As seen in Table VIII, the net causer criteria are flag (C5), year of construction (C6), duration of detentions (C7), gross tonnage (C9), and speed of the ship (C10).

The net receiver criteria are cost (C1), the due date of the payment (C2), delivery time (C3), the reputation of the shipping company (C4), and class (C8).

| C1   | Net receiver |
| C2   | Net receiver |
| C3   | Net receiver |
| C4   | Net receiver |
| C5   | Net causer   |
| C6   | Net causer   |
| C7   | Net causer   |
| C8   | Net receiver |
| C9   | Net causer   |
| C10  | Net causer   |

Reducing the number of criteria taken into account in the decision process enables the ship brokers to focus more on the key criteria. Based on a threshold value of 0.08, eight criteria (cost (C1), delivery time (C3), reputation of the company (C4), flag (C5), year of construction (C6), duration of detentions (C7), class (C8), gross tonnage (C9)) are determined. The importance weights for eight criteria are renormalized as shown in Table X.
According to the Table X, the most important criterion is the reputation of the company (C4). The duration of detentions (C7), the classification organization (C8), the cost (C1), and the age of the ship (C6) are the other critical factors.

### V. CONCLUSION

Selecting the most suitable sea carrier, in order to transfer a cargo between two seaports, among multiples alternatives, is considered as one of the most important decisions for a successful supply chain management system. The selection of an appropriate ship is a complex decision process due to the presence of multiple and conflicting criteria.

In this paper, a decision approach based DEMATEL methodology to determine influential ship selection criteria in maritime transportation industry, is presented. The DEMATEL method enables the decision maker to visualize influences between criteria and it computes their importance weights. Future research will focus on developing MCDM approaches to ship selection problem, using the criteria obtained in this study.

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### REFERENCES


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