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CONTEMPORARY TRENDS IN SHIPPING: A RELATION ANALYSIS BY FUZZY DEMATEL METHOD

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Abstract:
Developing and changing world trade brings many innovations in different sectors according as in maritime industry. Several problems arise while maritime industry is trying to accommodate itself to these developments due to its conservative structure. The purpose of this study is to reveal problems stem from recent trends in maritime and to evaluate relationship between related problems. Criteria that are evaluated by the experts have been analysed by Fuzzy DEMATEL (Decision Making Trial and Evaluation Laboratory) method. As a result of the analysis, the affecting factors of the established model and more sensitive factors to other criteria have been revealed.

Key words:
Maritime Industry, Recent Trends, Fuzzy DEMATEL, Future Problems.

INTRODUCTION

It is effortlessly avowable that significance of the shipping in the transfer of goods on global routes is clear. Such that, international seaborne trade has got to 10.7 billion of tonnes in 2017, in comparison to the year of 2009 figure which is 7.8 billion of tonnes [1]. Especially after 2008 global economic crisis, maritime transport has expanded through the strategies which are knowledge based instead of labour or capital motive ones [2]. Demographic changes, handover of the global economic force and newest digital-based technologies are changing the whole globe included maritime industry [3]. Especially with Industry 4.0, digital implications on maritime industry have begun to be visible nowadays. On the other hand, unfortunately, cyber-attacks have come into prominence as a primary security problem. Technologic improvement has also brought along mega ships which have high volume carrying capacity, to the sector. This high capacity ship technology causes fluctuated freight rates, an increasing number of the laid-up vessel, faster operation pressure on ports, etc. Besides, there are developments directly affecting the maritime environment, as well as events indirectly affect the sector such as climate change, deepening political rows, growing infrastructure of the other transport modes, etc. are also exist. This study particularly investigates to what extent recent developments affecting the maritime industry, stimulate each other.

In the previous studies, issues related to recent developments in the maritime industry have been studied frequently. Esmer [4] disclosed the new globalization model in the light of the latest global evolvements and evaluated its 9 basic components what will affect shipping and the ports. Digitalization has also excited the attention of the researchers and studied with its various aspects. Claramunt et al. [5] evaluated recent developments related to the integration, management, analysis, and visualization of objects moving at sea etc. and also suggested some recommendations on maritime forecasting. Nita and Mihailescu [6] also proposed suggestions for effective predictions related to maritime transport by using big data analytics, while Garnier and Napoli [7] were submitting big data analytics as a precaution for the voyage safety and data security. Uta and Silva [8] investigated the working principle of the 'Maritime Domain Awareness' in order to determine whether new developments such as cooperation, data-exchange, integration, intelligence and data mining etc. changed it. Vettor and Soares [9] described the ship weather routing system in consideration of latest developments especially in tracking systems to reach optimum route planning. On the other hand adverse events in the maritime environment such as climate change, security concerns etc. also happen. These concerns have been studied to take precautions and to seek an opportunity from these negative changes. Dinwoodie et al. [10] revealed a framework to specify the management strategy against environmental impact from maritime operations, especially in small ports, which increases as a natural result of globalization in shipping. Gocmen and Yilmaz [11] approached 'Maritime Inventory Routing Problem' while taking into account the recent issues which are environmental concerns and ship hold capacities. Against uncontrollably increasing glacial melting, global decision makers developed an opportunist strategy what is 'Arctic Route' usage and academicians also comply with this idea. Firstly, Stephenson and Smith [12] proposed an 'Arctic Route' which comes to exist as an opportunity against global warming, as China's way of reaching Europe more quickly. Then, this idea has been accepted as a future strategy for global strategy by the authors such as Dawson [13], Drewniak et al. [14], Milakovic [15], and the requirements for this route were determined in their studies. Moreover, Luo and Shin [16] revealed that the focus of the academic researches on ship accidents has changed from naval architecture to human faults as the result of their review on half-centennial maritime accidents literature. Autonomous vessels with the characteristic that minimizing man impact, could be a solution for reducing ship accidents. Route optimization, cost efficiency, traffic control, accident minimization that autonomous ships will bring to transportation, is clear but Sharp and Fanam [17] consider the status of the seafarers against this new technology. Burke and Clott [18] are interesting challenges faced in and implications for applying training pattern to train mariners while taking into consideration that knowledge technologies usage in ship and port operations becomes widespread. In the light of the recent developments, maritime environment and its drivers have been changed. Helling and Poister [19] proposed a research agenda in the 2000s for US ports taking into considerations the then developments such as containerization, intermodalism, and increasing scale etc. Nowadays it is being studied in China and its maritime policies qua driver of the product flow globally. So To and Lee [20] investigated motivations of China's unprecedented economic growth in the maritime economy and forecasted that it will sustain near future and coastal tourism efficiency of the China will increasingly continue. Lee et al. [21] explored the Belt and Road Initiative (BRI) comprehensively and made general evaluation by concentrating infrastructure based elements of the route. They also revealed the expected impact of the project and reviewed research trends related to BRI. Unlike, in this study, the whole recent developments affecting the maritime industry were collected and relationship analyses of these developments were performed by employing Fuzzy DEMATEL method.

In the section that follows, firstly Fuzzy DEMATEL method and its analysis steps will be explained, secondly problem description, expert selection and application of the proposed method will be expressed. Subsequent to sharing findings of the relationship analyses which contain cause and effect factors, finally, results related to the analyses will be evaluated.

1 RESEARCH METHODOLOGIES

Assessing the most common and significant potential problems stem from recent developments in the maritime industry, fuzzy sets along with the DEMATEL method are primarily-deployed instruments in this study.

1.1 Fuzzy Sets

Developed by Lotfi A. Zadeh in 1965, fuzzy logic which allows evaluating various factors influencing the decision-making processes such as uncertainty and ambiguity. Within this context, the examination of real-life decision-making problematics reveals that less precisely known constraints and uncertain events are conducive to numerous decisions [22]. Translation of linguistic terms into fuzzy numbers is more advantageous rather than blending opinions, ideas or decisions stemming from the expertise of the individuals or groups. Therefore, problems of group decision-making problems ended up with an essential generation of fuzzy numbers to be implemented. A triangular fuzzy number can be phrased as a triplet $\tilde{A}$=(l,m,u) where l, m and u represents lower, medium and upper numbers of the fuzzy which is crisp and real numbers ($x \leq y \leq z$). The membership function of a triangular fuzzy number can be depicted as below.

$$\mu_{\tilde{A}} = \begin{cases} 0, & x < l \\ (x-l)/(m-l), & l \leq x \leq m \\ (u-x)/(u-m), & m \leq x \leq u \\ 0 & x \geq u \end{cases} \tag{1}$$

Figure 1, however, demonstrates a triangular fuzzy number and identifies the ersatz relationship between the linguistic terms and triangular fuzzy numbers. Figure 2 describes fuzzy ratings and their membership function.

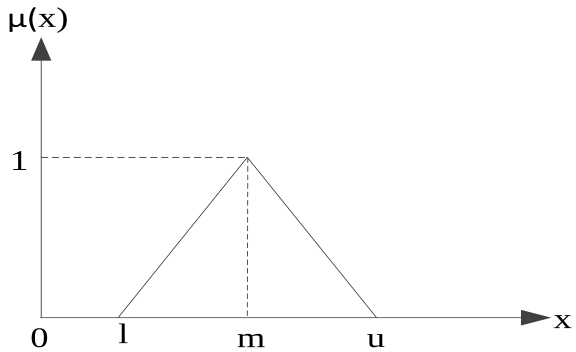

Fig.1 *Triangle Fuzzy Numbers*

***Tab. 1** Ersatz relationship between linguistic terms and fuzzy numbers*

Linguistic terms	Triangular fuzzy numbers
No influence (No)	(0, 0, 0.25)
Very low influence (VL)	(0, 0.25, 0.5)
Low influence (L)	(0.25, 0.5, 0.75)
High influence (H)	(0.5, 0.75, 1)
Very high influence (VH)	(0.75, 1, 1)

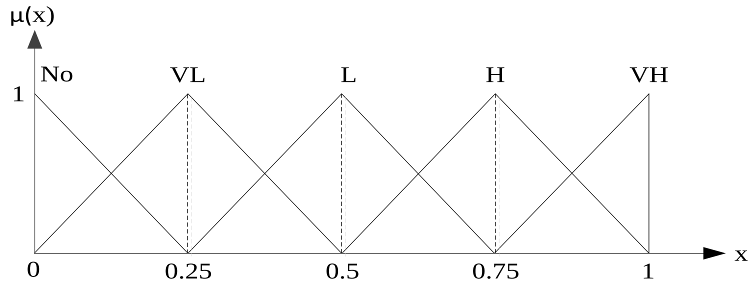

***Fig. 2** Fuzzy Ratings and their Membership Function*

For any two triangular fuzzy numbers A ̃_1=(l_1,m_1,u_1) and A ̃_2=(l_2,m_2,u_2), the following defines the mathematical calculation of the two triangular fuzzy numbers:

The inset process among the triangular fuzzy numbers;

$$\tilde{A}_1 + \tilde{A}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

The removal operation among the triangular fuzzy numbers;

$$\tilde{A}_1 - \tilde{A}_2 = (l_1 - u_2, m_1 - m_2, u_1 - l_2) \quad (3)$$

The multiplication operation among the triangular fuzzy numbers;

$$\tilde{A}_1 \, x \, \tilde{A}_2 = (l_1 x l_2, m_1 x m_2, u_1 x u_2) \quad (4)$$

The arithmetical operation for the triangular fuzzy numbers;

$$k x \tilde{A}_1 = (k x l_1, k x m_1, k x u_1), (k > 0) \quad (5)$$

$$\frac{\tilde{A}_1}{k} = \left(\frac{l_1}{k}, \frac{m_1}{k}, \frac{u_1}{k}\right), (k > 0) \quad (6)$$

Equitation 7 enables obtaining the normalized direct-relation matrix. All diagonal elements are equal to zero, though. By dint of equation 8, we can calculate the total relation matrix (T). Ultimately, r_i and c_j are acquired by means of equations 9 and 10 respectively.

$$D = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \quad (7)$$

$$T = D(1 - D)^{-1} \quad (8)$$

$$r_i = \sum_{1 \le j \le n} t_{ij} \quad (9)$$

$$c_j = \sum_{1 \le i \le n} t_{ij} \quad (10)$$

1.2 Integration of the Methods

This section highlights the way in which fuzzy sets and DEMATEL methods are integrated to carry out the sensitive evaluation. Figure 3 provides a flow diagram of the fuzzy DEMATEL approach. Below is a description of the main steps of the method [23; 24; 25].

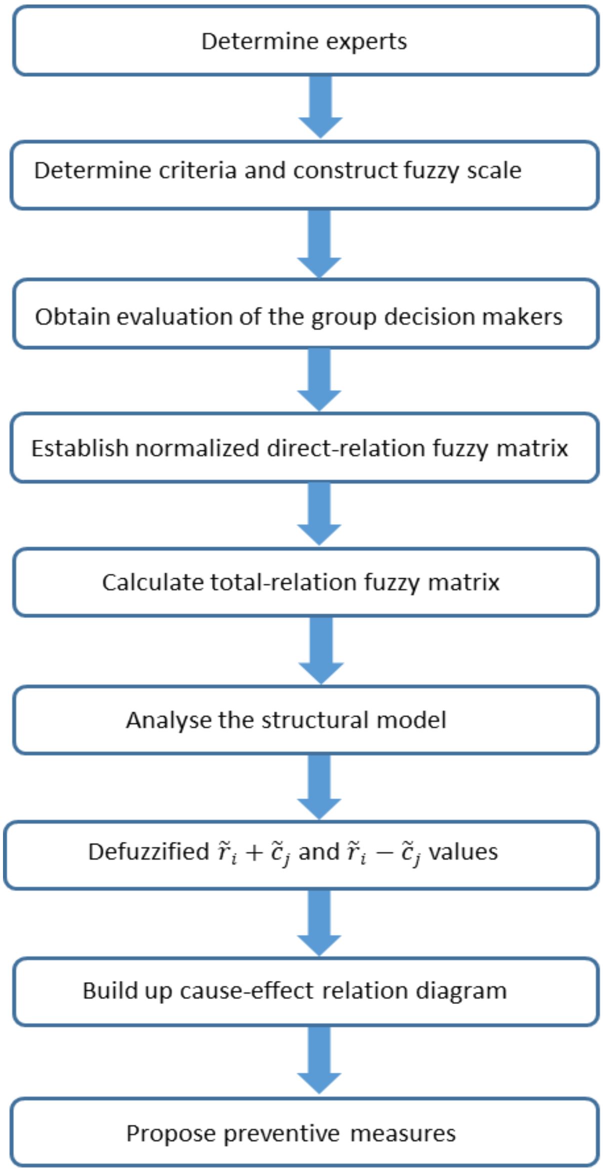

Fig. 3 *Flow Diagram of the Fuzzy DEMATEL Method*
Source: [26].

Step 1- Determine experts: Consultation of the experts with profound knowledge and experience about the problem is helpful in order to obtain coherent assessments.

Step 2-Determine factors and construct fuzzy scale: Substantial factors are detected so that they be analysed and assessed in an appropriate way. Afterwards, linguistic variables apply with five scales (no influence, very low influence, low influence, high influence, and very high influence) owing to the linguistic terms and fuzzy numbers. Hereupon, corresponding triangular fuzzy members are shared.

Step 3: Acquire assessment of the group decision makers: The pairwise comparison is made with regard to linguistics variables. Furthermore, fuzzy assessments become defuzzified and aggregated as a crisp value. Consequently, initial direct-relation fuzzy matrix ($\tilde{E}$) of group decision makers is achieved.

$$\begin{bmatrix} 0 & \cdots & \tilde{E}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{E}_{n1} & \cdots & 0 \end{bmatrix} \tag{11}$$

$$\tilde{e}_{ij} = (l_{ij}, m_{ij}, u_{ij}) \tag{12}$$

Step 4-Demonstrate normalized direct-relation fuzzy matrix: Inside the initial direct-relation matrix, normalized direct-relation fuzzy matrix is built. With the aim of achieving that, firstly, β ̃_i and γ as triangular fuzzy numbers should be taken into consideration. The calculation below is made respectively.

$$\tilde{\beta}_i = \sum \tilde{e}_{ij} = \left(\sum_{j=1}^{n} l_{ij}, \sum_{j=1}^{n} m_{ij}, \sum_{j=1}^{n} u_{ij}\right) \tag{13}$$

$$\gamma = max\left(\sum_{j=1}^{n} u_{ij}\right) \tag{14}$$

Moreover, implementation of the linear scale transformation converts the factors into corresponding scales. The normalized direct-relation fuzzy matrix (F ̃) of group decision makers is displayed as below.

$$\tilde{F} = \begin{bmatrix} \tilde{\tilde{F}}_{11} & \dots & \tilde{F}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{F}_{n1} & \dots & \tilde{F}_{nn} \end{bmatrix} \tag{15}$$

Where $\tilde{f}_{ij} = \frac{\tilde{e}_{ij}}{\gamma} = \left(\frac{\tilde{e}_{ij}}{\gamma}, \frac{\tilde{e}_{ij}}{\gamma}, \frac{\tilde{e}_{ij}}{\gamma}\right)$

Step 5-Calculate total-relation fuzzy matrix: Establishment of the normalized direct-relation fuzzy matrix is followed by a total-relation fuzzy matrix calculation, ensuring that $\lim_{\omega\to\infty} F^{\omega} = 0.$. Then, the crisp case of the total-relation fuzzy matrix is established as follows.

$$\tilde{T} = \lim_{\omega\to\infty}\left(\tilde{F} + \tilde{F}^2 + \cdots + \tilde{F}^{\omega}\right) \tag{16}$$

$$\tilde{T} = \begin{bmatrix} \tilde{t}_{11} & \dots & \tilde{t}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{t}_{n1} & \dots & \tilde{t}_{nn} \end{bmatrix} \tag{17}$$

Where $\tilde{t}_{ij=} = (l''_{ij}, m''_{ij}, u''_{ij})$

$$Matrix\left[l''_{ij}\right] = F_l \; x \; (I - F_l)^{-1} \tag{18}$$

$$Matrix\left[m''_{ij}\right] = F_m \; x \; (I - F_m)^{-1} \tag{19}$$

$$Matrix\left[u''_{ij}\right] = F_u \; x \; (I - F_u)^{-1} \tag{20}$$

Step 6-Analyse the structural model: First, matrix $\tilde{T}$, $\tilde{r}_i + \tilde{c}_j$and then $\tilde{r}_i - \tilde{c}_j$are calculated. In the formula, $\tilde{r}_i$and $\tilde{c}_j$means the sum of the rows and columns of matrix $\tilde{T}$. Hthe owever, $\tilde{r}_i + \tilde{c}_j$ represents the importance of factor i, and $\tilde{r}_i - \tilde{c}_j$ the net effect of factor i.

Step 7- Defuzzify $\tilde{r}_i + \tilde{c}_j$ and $\tilde{r}_i - \tilde{c}_j$: Hereupon, $\tilde{r}_i + \tilde{c}_j$+ and $\tilde{r}_i - \tilde{c}_j$are defuzzified by use of COA (centre of area) defuzzificthe ation technique which was introduced by Ross [27] so as to establish BNP (best non-fuzzy performance) value. For a convex fuzzy number $\tilde{\delta}$, a real number z^* corresponding to its centre of area can be predicthe ted with the help of equation below [28the].

$$z^* = \frac{\int \mu_{\tilde{\delta}}(z) z dz}{\int \mu_{\tilde{\delta}}(z) dz} \tag{21}$$

The BNP value of a fuzzy number $\tilde{G} = (l_{ij}, m_{ij}, u_{ij})$can be set with the given formula.

$$BNP_{ij} = \frac{u_{ij} - l_{ij} + m_{ij} - l_{ij}}{3} + l_{ij} \tag{22}$$

Step 8-Build up cause-effect relation diagram: Finally, the cause and effect relation diagram is depicted by the representation of the dataset of $r_i + c_j$ and $r_i - c_j$. The calculation can be achieved thanks to the step 6 approach.

2 APPLICATION

In this section, relationship analysis of the recent developments in a maritime environment with each other which is applied by Fuzzy DEMATEL method has been described step by step. The 8 new developments that affect the maritime industry have been determined via academic studies and current news from related business websites.

2.1 Problem Description

Over the past decade, several new trends have been occurred in the maritime industry, especially in a technological, politic (legal), economic or climatic sense. It remains unknown whether any development affects other ones and if it affects, to what extent their relationship level. At this point, to know the trigger elements which are the latest negative effective events we approached is of great significance to direct the global focus for taking precautions. Recent problems we approached which are listed in Table 2, contain in itself either unfailing problems from past to present such as 'Fluctuations in Freight Rates' and 'Politic Trade Barriers' or problems stem indirectly from state-of-the-art.

Tab. 2 *Problems Stem From Recent Maritime Trends*

Code	Trend Name
C1	Fluctuations in Freight Rates
C2	Transition to Cost Effective Vehicles
C3	Politic Trade Barriers
C4	Mega Ship Pressure on Ports
C5	Threats of Alternative Modes
C6	Increasing Share of Non-Operating Ships
C7	Cyber-Attack Risk
C8	Climate Effect

2.2 Determining of the Experts

The views of the academicians who study generally contemporary issues related to the maritime industry, on potential threats or problems are crucial due to guide policy makers' focus towards taking precautions. Potential problems intrinsically are qualitative processes and while identifying these risks, it would be more appropriate to consult expert opinion. Moreover, demonstrating quantitatively the experts' qualitative expressions would make potential problems stem from recent trends in shipping more understandable. The fact that entire selected experts are academicians, two of them also worked as a captain for a while and they generally study on contemporary issues makes them competent people in evaluating the relationship between threats and determining the trigger element. In this study, expert opinions of selected academicians who have been interested in contemporary issues in the maritime environment and have at least 10-year experience, have been referred. It has been asked to the selected experts to what extent the relationship of the potential problems for the maritime industry in order to determine trigger one. It seems that the consensus of experts is built to obtain significant findings.

2.3 Application of Proposed Method

Potential problems arisen from latest trends are given in Table 2 and academicians were asked to determine the relationship between problems. Then, selected academicians analyse the relationship between the mentioned problems through the use of fuzzy verbal scale. Accordingly, the initial direct-fuzzy matrix is illustrated in Table 3. Subsequent to determining established initial direct-fuzzy matrix, the normalized direct-relation fuzzy matrix is determined by using equations 13-15 respectively. Table 4 reveals the normalized initial direct-relation fuzzy matrix. Moreover, the total relation fuzzy matrix can be determined with the help of equations 16-20. So, Table 5 shows the total-relation fuzzy matrix. Later on, Table 6 illustrates defuzzified threshold values of T-matrix, Table 7 demonstrates fuzzy values of $\tilde{r}i$, $\tilde{c}j$, $\tilde{r}i + \tilde{c}j$, $\tilde{r}i - \tilde{c}j$ and lastly in the light of above, with the help of equations 21 and 22 the crisp results.

Tab. 3 *The Initial Direct-Relation Fuzzy Matrix*

	C1	**C2**	**C3**	**…**	**C6**	**C7**	**C8**
C1	(0.00 0.00 0.21)	(0.00 0.04 0.25)	(0.54 0.71 0.79)	…	(0,00 0,00 0,21)	(0.25 0.36 0.54)	(0.14 0.21 0.39)
C2	(0.21 0.36 0.54)	(0.00 0.00 0.21)	(0.25 0.36 0.54)	…	(0,11 0,18 0,39)	(0.32 0.39 0.57)	(0.04 0.07 0.29)
C3	(0.00 0.00 0.21)	(0.00 0.04 0.25)	(0.00 0.00 0.21)	…	(0,00 0,04 0,25)	(0.00 0.04 0.25)	(0.14 0.21 0.43)
…	… … …	… … …	… … …	…	… … …	… … …	… … …
C6	(0,54 0,71 0,79)	(0,00 0,04 0,25)	(0,25 0,43 0,57)	…	(0,00 0,00 0,21)	(0,39 0,54 0,64)	(0,00 0,00 0,21)
C7	(0.21 0.29 0.46)	(0.04 0.11 0.32)	(0.39 0.50 0.61)	…	(0,00 0,04 0,25)	(0.00 0.00 0.21)	(0.07 0.14 0.36)
C8	(0.11 0.18 0.36)	(0.07 0.14 0.36)	(0.21 0.32 0.46)	…	(0,07 0,14 0,36)	(0.14 0.21 0.43)	(0.00 0.00 0.21)

Tab. 4 *Normalized Initial Direct-Relation Fuzzy Matrix*

	C1	**C2**	**C3**	**…**	**C6**	**C7**	**C8**
C1	(0.00 0.00 0.04)	(0.00 0.01 0.05)	(0.10 0.13 0.14)	…	(0,00 0,00 0,04)	(0.05 0.06 0.10)	(0.03 0.04 0.07)
C2	(0.04 0.06 0.10)	(0.00 0.00 0.04)	(0.05 0.06 0.10)	…	(0,02 0,03 0,07)	(0.06 0.07 0.10)	(0.01 0.01 0.05)
C3	(0.00 0.00 0.04)	(0.00 0.01 0.05)	(0.00 0.00 0.04)	…	(0,00 0,01 0,05)	(0.00 0.01 0.05)	(0.03 0.04 0.08)
…	… … …	… … …	… … …	…	… … …	… … …	… … …
C6	(0,10 0,13 0,14)	(0,00 0,01 0,05)	(0,05 0,08 0,10)	…	(0,00 0,00 0,04)	(0,07 0,10 0,12)	(0,00 0,00 0,04)
C7	(0.04 0.05 0.08)	(0.01 0.02 0.06)	(0.07 0.09 0.11)	…	(0,00 0,01 0,05)	(0.00 0.00 0.04)	(0.01 0.03 0.06)
C8	(0.02 0.03 0.06)	(0.01 0.03 0.06)	(0.04 0.06 0.08)	…	(0,01 0,03 0,06)	(0.03 0.04 0.08)	(0.00 0.00 0.04)

Tab. 5 *Total–Relation Fuzzy Matrix*

	C1	C2	C3	…	C6	C7	C8
C1	(0.00 0.01 0.22)	(0.00 0.01 0.19)	(0.10 0.15 0.35)	…	(0,00 0,01 0,18)	(0.05 0.07 0.28)	(0.03 0.05 0.23)
C2	(0.05 0.08 0.29)	(0.00 0.01 0.20)	(0.06 0.09 0.33)	…	(0,02 0,04 0,23)	(0.06 0.09 0.31)	(0.01 0.03 0.23)
C3	(0.00 0.01 0.18)	(0.00 0.01 0.16)	(0.00 0.01 0.21)	…	(0,00 0,01 0,16)	(0.00 0.01 0.20)	(0.03 0.04 0.20)
…	… … …	… … …	… … …	…	… … …	… … …	… … …
C6	(0,10 0,14 0,33)	(0,00 0,01 0,20)	(0,06 0,11 0,33)	…	(0,00 0,00 0,19)	(0,08 0,11 0,31)	(0,01 0,01 0,21)
C7	(0.04 0.06 0.26)	(0.01 0.02 0.20)	(0.08 0.11 0.32)	…	(0,00 0,01 0,19)	(0.00 0.01 0.23)	(0.02 0.04 0.22)
C8	(0.02 0.04 0.23)	(0.01 0.03 0.20)	(0.05 0.07 0.28)	…	(0,01 0,03 0,20)	(0.03 0.05 0.25)	(0.00 0.01 0.19)

Tab. 6 *Defuzzified Threshold Values of T-Matrix*

	C1	C2	C3	C4	C5	C6	C7	C8
C1	0,08	0,07	0,20	0,08	0,11	0,06	0,13	0,10
C2	0,14	0,07	0,16	0,13	0,10	0,09	0,15	0,09
C3	0,06	0,06	0,07	0,07	0,07	0,06	0,07	0,09
C4	0,13	0,09	0,13	0,07	0,13	0,09	0,14	0,11
C5	0,07	0,08	0,13	0,07	0,07	0,08	0,09	0,08
C6	0,19	0,07	0,17	0,07	0,11	0,06	0,17	0,08
C7	0,12	0,08	0,17	0,07	0,14	0,07	0,08	0,09
C8	0,10	0,08	0,13	0,06	0,09	0,08	0,11	0,07

Tab. 7 *Fuzzy Values of* $\tilde{r}_i$, $\tilde{c}_j$, $\tilde{r}_i + \tilde{c}_j$, $\tilde{r}_i - \tilde{c}_j$

	r_i	c_j	r_i+c_j	r_i-c_j
C1	(0.22 0.37 3.02)	(0.26 0.42 3.13)	(0.48 0.79 6.14)	(-2.91 -0.05 2.76)
C2	(0.27 0.45 3.25)	(0.06 0.16 2.51)	(0.33 0.61 5.76)	(-2.24 0.28 3.19)
C3	(0.05 0.12 2.39)	(0.42 0.67 3.67)	(0.48 0.79 6.06)	(-3.62 -0.55 1.97)
C4	(0.23 0.41 3.17)	(0.10 0.19 2.54)	(0.33 0.60 5.71)	(-2.31 0.22 3.07)
C5	(0.13 0.23 2.63)	(0.18 0.34 3.02)	(0.30 0.57 5.65)	(-2.89 -0.11 2.46)
C6	(0.27 0.45 3.15)	(0.07 0.16 2.50)	(0.35 0.60 5.65)	(-2.22 0.29 3.08)
C7	(0.20 0.36 3.00)	(0.28 0.45 3.28)	(0.49 0.81 6.29)	(-3.08 -0.09 2.72)
C8	(0.14 0.27 2.78)	(0.14 0.25 2.75)	(0.29 0.52 5.53)	(-2.60 0.02 2.64)

***Tab. 8** Crisp Values of $\tilde{r}_i$, $\tilde{c}_j$, $\tilde{r}_i + \tilde{c}_j$, $\tilde{r}_i - \tilde{c}_j$*

	r_i	c_j	r_i+c_j	r_i-c_j
C1	1.20	1.27	2.47	-0.07
C2	1.32	0.91	2.23	0.41
C3	0.85	1.59	2.44	-0.73
C4	1.27	0.94	2.21	0.33
C5	1.00	1.18	2.17	-0.18
C6	1.29	0.91	2.20	0.38
C7	1.19	1.34	2.53	-0.15
C8	1.07	1.05	2.11	0.02

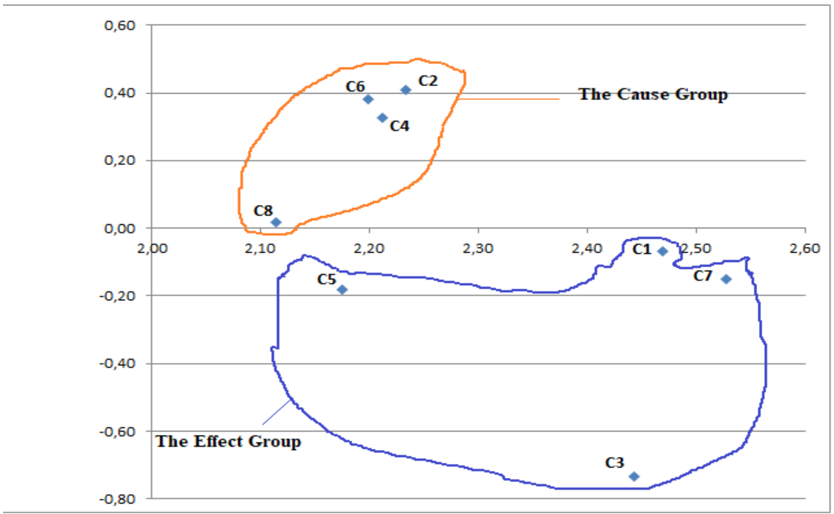

***Fig. 4** Cause-Effect Relation Diagram*

2.4 Findings

As a result of the calculations mentioned above, Cause and Effect Diagram has been exhibited in Figure 4. This diagram revealed the differentiation which problems are involved in 'cause group' or 'effect group'.

2.4.1 Cause Factors

While estimating the most known problems stem from recent trends in shipping, it should be focused on the cause group which contains the most common elements after analysis. Figure 4 shows that C2 (Transition to Cost Effective Vehicles) has the highest r*i*-c*j* score (0.41) in comparison to other elements. Accordingly, C2 has the biggest impact on the whole model. Respectively C6 (Increasing Share of Non-Operating Ships) and C4 (Mega Ship Pressure on Ports) are hard on the heels of C2 in respect of imthe pact on enthe tire process. C6 has the second highest r*i*-c*j* score (0.38) and C4 has become third (0.33) in the r*i*-c*j* score ranking. On the other hand, C8 (Climate Effect) has moderaa te effect on the whole process with its r*i*-c*j* score (0.02).

2.4.2 Effect Factors

The effect factors are known by the definition of the method as factors can easily be affected by other ones. So, analysing the effect group could facilitate to understand the consequences if global problems occur without taking precautions. When examined Figure 4 and Table 8 (see in Appendix I), it is seen that C7 (Cyber-Attack Risk) has the biggest ri+cj score (2.53) between the effect group. This means that cyber security would be the most affected threat by recent trends in the maritime sector according to selected experts. In other respects, C1 (Fluctuations in Freight Rates) runs a close second to C7 with its under-highest ri+cj score (2.47). Similarly, C3 (Politic Trade Barriers) has a close ri+cj score (2.44) with C7. The potential problem for maritime transport which is C5 (Threats of Alternative Modes) falls behind in other effect group factors.

3 CONCLUSIONS

Adapting recent innovations that new developments brought along to itself is considerably challenge for the maritime industry due to its conservative structure. In this study, the latest trends in shipping have been evaluated from a general perspective and a relationship analysis has been conducted between potential problems that may arise due to these trends. Accordingly, 8 critical problems were evaluated by means of expert opinion and analysed by Fuzzy DEMATEL method. In consequence of the analysis, generated crisp values of each problem which represent relationship level with other ones, have been revealed and thus 'cause-effect diagram' has been formed. When examining the results obtained, 'Transition to Cost Effective Vehicles' has come into prominence as a trigger of the model and on the other hand 'Cyber-Attack Risk' has been seen a criterion which is most affected from recent trends in our model. The effects of global warming have become more visible in recent years. This has accelerated the development of emergency action plans against environmental concerns and the introduction of new vehicles in maritime transport, both in the port area and on the sea side, which is the locomotive of the transport sector, one of the leading producers of atmospheric pollution. The pressure to upgrade to the newest vehicles in the short term is forcing shipping which suffers from bottlenecks at times, due to additional investment costs. For this reason, 'Transition to Cost Effective Vehicles' has been given prominence by the selected experts as a trigger element for maritime future. On the other hand, it is expected that the maritime sector will not be indifferent to the digitalizing world and all sector transactions in the short or medium term will be carried out in digital environments in order to facilitate the adaptation of the latest developments. As a result of this expectation, 'Cyber-Attack Risk' has been expressed as an element which is most affected by trends approached in this study. However, when the other criteria are evaluated, it is observed that each of them is a certain extent affecting or affected criterion and this level of interaction is substantial. The problems stem from recent trends discussed in this study reflect a general perspective and these problems form the basis for further researches so long as each of them is enriched with sub-criteria.

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