Journal of ETA Maritime Science

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Analysis of Empty Container Accumulation Problem of Container Ports

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Abstract

In this study, the empty container problem is evaluated by quantification of factors related to empty container accumulation as well as alternative ways that can be followed for solutions. The study is mainly constructed as two parts; the first part is on identifying involving factors by using DEMATEL and the second part deals with alternative solutions by applying TOPSIS method. The main causes affecting empty containers were found as trading imbalance, irregular distribution, delivery time, unbalanced freight charges and inadequate port management. Finally, based on applied Multi Criteria Decision Making approach, this study suggests that empty container problem can be solved by sharing infrastructures and equipment among logistic companies, allocating storage areas for empty containers outside the ports and following robust fast custom regulations.

Keywords: Empty Container, Container Ports, Fuzzy DEMATEL, Fuzzy TOPSIS.

Konteyner Limanlarına Yönelik Boş Konteyner Yığılması Probleminin Analizi

Öz

Bu çalışma ile limanlarda boş konteyner yığılmasına neden olan etkenler tespit edilmiş ve bu soruna ilişkin uygulanabilir, pratik çözüm önerileri sunulmaya çalışılmıştır. Çalışma iki aşamadan oluşmakta olup ilk aşamada konteyner limanlarında yaşanan boş konteyner yığılmasına neden olan kriterler tespit edilmiş ve bu kriterlerin birbirleri ile olan ilişkileri, önem dereceleri bulanık DEMATEL (The Decision Making Trial and Evaluation Laboratory) yöntemi ile değerlendirilmiştir. İkinci aşamada ise bu soruna çözüm getirebilecek olan alternatifler belirlenerek bulanık TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) yöntemi yardımı ile alternatifler arasında sıralama yapılmıştır. Çalışmanın sonuçlarına göre konteyner limanlarında boş konteyner yığılmasına neden olan en önemli faktörlerden bazıları sırasıyla; ticari dengesizlik, düzensiz sevkiyat ve teslimat süreleri, navlun fiyatlarındaki dengesizlikler ve yetersiz liman yönetimleri olarak tespit edilmiştir. Bu soruna çözüm getirebilecek en önemli alternatiflerden bazıları ise; ortak ekipman kullanımı / firmalar arası konteyner havuzu, liman dışı konteyner depolama alanlarının oluşturulması ve gümrük düzenlemeleri olarak tespit edilmiştir.

Anahtar Kelimeler: Boş Konteyner, Konteyner Limanları, Bulanık DEMATEL, Bulanık TOPSIS.

1. Introduction

International maritime trade shows a sharp trend towards containerization and multi- modal logistics. The total volume of international cargo transferred by containers is constantly rising. A new era in maritime logistics started after commencement of the container box in to the international logistics. Containers are much more preferable in logistics compared to classic boxes, bales and packs as they ease the handling operations on shipboard and ports as well as being suitable for multi-modal cargo transfers. Moreover, container usage can diminish port time, handling costs, loss of cargo and time needed for paperwork [1, 2, 3, 4].

The volume of total container traffic steadily increases as global maritime trade market shows growing trends that can be accounted of billions of dollars each year. According to authorities, the total number of containers circulated in the global maritime logistic chain will continue rising for the next five or ten years. Therefore, capacity increase is needed both for the ports and for the oceangoing merchant ships [5, 6, 7, 8]. Another forcing factor for expanding the port capacities is the rising number of the empty containers that should be stored and wait until next shipment [9, 10].

Empty container problem became an issue of high priority in maritime industry. Moreover, the volume of cargo shipped with the containers is also increasing in accordance with related port infrastructures and newly built very large container ships. This problem is also triggered by recently well-received multi-modal transportation model in maritime logistics. Therefore, maritime logistic sector, port authorities and companies seek for a solution in order to overcome the empty container management problem [3, 4, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19].

In terms of container traffic, there should be a balance between imported and exported container counts but unfortunately this balance is not accomplished in every geographic location of the world. Therefore, empty containers needed to be transferred from one node to another in different logistic hubs. The root cause of the empty container accumulation can only be explained by imbalance between importing and exporting countries in world wide scale. For example, in the central regions of the world production markets such as China, a need for empty container is very high and sometimes logistic companies suffer from empty container shortage whereas in some countries empty container become a demanding problem due to imbalance between imported and exported manufactured products [3, 8, 18, 20, 21, 22, 23, 24, 25, 26].

From the managerial perspective, the empty container issue can cause some extra problems stemmed from rising costs and delivery which is potentially harmful for the prestige of the companies and the open market conditions. Therefore, simulating global container traffic and estimation of empty container hot spots is highly important for smooth and effective container logistics [1, 14, 17, 26, 27, 28, 29]. Moreover, the freight charges of the goods transported to some geographic regions with luxury and high living standards is always high then the opposite route which makes difficult to transfer the empty container to their origins. Besides that, the cost of a new container is relatively low thus many logistic companies prefer to buy new containers instead of using the empty ones [11, 12, 19, 22, 29, 30, 31, 32].

Effective and efficient management of the empty containers is one of the major problems in the field of maritime logistics. Deciding on forwarding an empty container from one node to another is a critical strategic approach in terms of maritime operations. The root cause of empty container problem is the imbalance

of the wealth and prosperity among different geographic regions of the world. Furthermore, some geographic regions such as America and Northern Europe are generally covered by importing countries whereas some others such as Far East countries are exporting much more goods than their total imported volume. Therefore, the port efficiency of the former countries is negatively affected by the accumulation of the empty containers [2, 4, 8, 12, 27, 29, 31, 32, 33]. The authorities estimate that these types of ports are not likely to continue their service after introducing a fully equipped and well founded new container ports to the industry because, speed and efficiency are the major two factors that are sought by the customers of the container ports. Thus, for a long term customer satisfaction renovation or rehabilitation of those ports are inevitable to enhance the physical conditions of the ports and extend the container storage area [3, 21, 34]. Undoubtly, the empty container problem is very well recognized by the actors of the maritime logistics and port authorities [13, 23, 35].

Therefore, the issue of the empty container is regarded as a multicriteria decision making problem as there are many factors involved in accumulation of the empty containers and also many alternatives that can be ranked according to expert judgements. It is deterministically correct way to seek the inner relations between involved factors in empty container problem by using fuzzy quantitative evaluations. This is one of the best alternative methodologies to reach a realistic solution in case of multicriteria problems [36, 37, 38, 39, 40].

In this study, the empty container problem is investigated by analyzing involved criteria and alternative solutions based on expert evaluations. Fuzzy DEMATEL and Fuzzy TOPSIS techniques were used in a step wise manner for

determination of the criteria and ranking the alternative solutions.

2. Methodology

Empty container accumulation problem is very well recognized by the port managers, authorities and logistic companies but availability of many criteria that potentially influence the container storage stays an issue of high priority. Empty container accumulation problem in seaport companies has become an issue of high priority and needs to be evaluated by analytical techniques. Therefore, a MCDM approach can be one of the best solutions for deciding and quantitatively evaluating the empty container problem and such problems are successfully eliminated using Fuzyy MCDM techniques in literature [38, 39, 40, 41, 42]. Ideal solution of the problem should take in to account the complex inner relationships among various criteria and finally simplify the problem. Therefore, the reasons of empty container accumulation in ports were determined with the help of available literature and personal interviews carried in different ports. After defining the criteria set, expert evaluations were received to find the relative weights of each criterion. The weight and relations of the criteria were calculated using Fuzzy DEMATEL technique. Finally, ranking of the alternatives was completed by applying Fuzzy TOPSIS (Chen, 2000)[43]. The applied techniques were briefly described in the next sub-sections.

2.1. Fuzzy DEMATEL Technique

The term "DEMATEL" is an abbreviation of "The Decision Making Trial and Evaluation Laboratory" which is first introduced to the literature from Battelle Memorial Institute in Geneva The aim was to solve complex problems following a hierarchical structure. The technique is based on graph theory. The inter relations among factors are also modeled by using

pairwise comparisons and dividing the criteria set to cause and effect groups.

The DEMATEL technique is different from other decision analysis techniques in terms of its several capabilities such as priority determination of the involved factors according to relation type, inter-relations among criteria and the impact of each factor on another one. [42, 44, 45, 46].

Fuzzy DEMATEL technique was first applied by Lotfi A. Zadeh who is accepted as a father of the fuzzy mathematics. Fusing DEMATEL with Fuzzy sets may help to better describe and model the real world problems. The Fuzzy DEMATEL technique is briefly described as follow [42, 46, 47, 48];

A membership function for the Fuzzy set $\tilde{A}$ can be represented by triangular fuzzy numbers as (r, y, z) and written as,

$$\mu\tilde{A}(x)= \begin{cases} 0, & x < 1 \\ \frac{x-r}{y-r}, & r \leq x \leq y \\ \frac{z-x}{z-y}, & y \leq x \leq z \\ 0, & x>z \end{cases}$$

Step 1. Definition of the criteria and deciding on Fuzzy Linguistic Scale:

The first step of the technique requires designing of the fuzzy linguistic scale that is necessary to convert pair wise comparison statements to triangular fuzzy numbers. The values shown in Table 1 can be used as a reference scale;

Table 1. *Linguistic terms and corresponding linguistic values [42, 43, 49]*

Linguistic Terms	Linguistic Values
No influence (0)	(0;0;0.25)
Little influence (1)	(0;0,25;0.50)
Low influence (2)	(0.25;0,50;0.75)
High influence (3)	(0,50;0.75;1)
Strongly influence (4)	(0.75;1;1)

Step 2. In this step, direct-relation matrix is obtained by using pair wise comparisons provided by experts' evaluations. This (nxn) dimension matrix can be written as $\check{K}$ = $[\check{K}_{ij}]_{nxn}$ where $\check{K}_{ij}$ is the weight effect of the criterion "i" on criterion "j".

Step 3. The normalized fuzzy direct-relation matrix $\check{A}$ = $[\check{a}_{ij}]_{nxn}$ is computed according to Eq.1 and Eq.2 in this step.

$$\check{a}_{ij}= \frac{\check{K}}{s} = \left(\frac{r_{ij}}{s}, \frac{y_{ij}}{s}, \frac{z_{ij}}{s} \right) \qquad (1)$$

$$s = max_{1\leq i\leq n}(\textstyle\sum_{j=1}^{n} r_{ij}) \quad s = max_{1\leq i\leq n}(\textstyle\sum_{j=1}^{n} y_{ij})$$
$$s = max_{1\leq i\leq n}(\textstyle\sum_{j=1}^{n} z_{ij}) \qquad (2)$$

Step 4. Fuzzy total-relation matrix is defined as "$\check{T}$" and can be separated to three sub-matrices (A_r, A_y, A_z) and written according to Eq.3 as follow,

$$\check{T} = \check{A}+\overline{A^2}+\overline{A^3}+...= \textstyle\sum_{i=1}^{\infty} \tilde{A}^i=\check{A}\left(I - \tilde{A}\right)^{-1} \quad (3)$$

Where "I" an identity matrix and $\check{T}$ = $[\check{t}_{ij}]_{nxn}$ is total-relation matrix, $\check{t}_{ij}$ = ($\check{t}_{ij,r}$, $\check{t}_{ij,y}$, $\check{t}_{ij,z}$) are the weights attributed by an expert for each criteria, this step is repeated for all sub-matrices separately and finally the results are combined in one matrix.

Step 5. Sending and receiving group criteria are defined in this step. Assuming, the sum of the row "i" is $\tilde{D}_i$ = $\sum_{j=1}^{n} t_{ij}$ and sum of the column "j" is $\tilde{R}_i$ = $\sum_{j=1}^{n} t_{ij}$. The component "$\tilde{D}_i$" is direct and indirect sending function of criterion "i" on other criteria whereas "$\tilde{R}_i$" is a receiving function. Therefore, ($\check{D}$ + $\check{R}$) is the impact level of criterion "i" on both receiving and sending factors and ($\check{D}$ - $\check{R}$) is the net effect of criterion "i" on the decision network. The value of ($\check{D}$ - $\check{R}$) is used to decide if the criterion is sending or receiving considering the all involved criteria.

Step 6. Defuzzification processes has to be applied in order to obtain practical absolute values of the decision problem. There are many defuzzification techniques in literature. In this study arithmetic mean is used as shown in Eq.4 and Eq.5.

$$(\tilde{D}_i + \tilde{R}_i)= \frac{r+y+z}{3} \qquad (4)$$

$$(\tilde{D}_i + \tilde{R}_i) = \frac{r+y+z}{3} \quad (5)$$

According to results of the defuzzification process, a threshold value should be decided and used to choose which criteria will be included in the cause and effect diagram.

Step 7. The final step is on calculating the criteria weights normalized between [0,1] by using Eq.6 and Eq.7.

$$w_i = \sqrt{[(\tilde{D}_i + \tilde{R}_i)]^2 + [(\tilde{D}_i - \tilde{R}_i)]^2} \quad (6)$$

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (7)$$

2.2. Fuzzy TOPSIS Technique

The second technique used for ranking the alternatives of empty container accumulation problem of container ports selection is based on FuzzyTOPSIS methodology [43, 50, 51]. The FuzzyTOPSIS technique has a flexible structure that can deal with both quantitative and qualitative criteria loads. Different from classical TOPSIS, the fuzzy version of the technique is capable of converting verbal variables to the numbers to make a quantitative ranking of the alternatives. This technique was proved to be very successful in group decision making where the intercomparions of the alternatives are necessary [37, 50, 51].

There are many techniques in literature that suggest using of TOPSIS method. In this study the Chen (2000)[43] triangular fuzzy numbers based on vertex range scaling was used. This technique is widely used to ranking the alternatives of fuzzy decision making problems. Application of the technique was explained below.

Fuzzy TOPSIS technique introduced by Chen (2000)[43] is followed in this study. This technique is applied in five steps [42, 50, 51].

Step 1. Fuzzy decision matrix is normalized to [0,1] interval by applying Eq.8 and Eq.9.

$$\tilde{D} = [\widetilde{d_{ij}}]_{mxn} \quad \text{and} \quad \widetilde{d_{ij}} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) (8)$$

$$\tilde{D} = [\widetilde{d_{ij}}]_{mxn} \quad \text{and} \quad \widetilde{d_{ij}} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) (9)$$

In Eq.8 and Eq.9, if "j" is the benefit criterion, then $c_j^* = max_i \, c_{ij}$; and if it is cost criterion then $a_j^- = min_i a_{ij}$

Step 2. As a second step, Criteria weights and normalized fuzzy decision matrix is multiplied to obtain the weighted fuzzy decision matrix as presented in Eq.10.

$$\tilde{K} = [\widetilde{k_{ij}}]_{mxn} \; i=1,2,\dots,m \; j=1,2,\dots,n \; ise \; \widetilde{k_{ij}} = \widetilde{d_{ij}}.\widetilde{w_{ij}} \; (10)$$

Step 3. This step involves calculating the distances, the distance from fuzzy positive ideal solution (A⁺) of each criterion is (m_i^+) and from fuzzy negative ideal solution (A⁻) is (m_i^-). Then, the positive and negative distances can be calculated as shown in Eq.11 and Eq.12.

$$m_i^* = \sum_{j=1}^{n} m\left(\widetilde{k_{ij}}, \widetilde{k_j^*}\right) \quad i = 1, 2, \dots, m \quad (11)$$

$$m_i^- = \sum_{j=1}^{n} m\left(\widetilde{k_{ij}}, \widetilde{k_j^-}\right) \quad i = 1, 2, \dots, m \quad (12)$$

For the "benefit" criteria, A⁺ and A⁻ are calculated by applying Eq.13 and Eq.14

$$A^+ = (k_1^+, k_2^+, \dots, k_n^+) \text{ and } k_j^+ = (1, 1, 1), (13)$$

$$A^- = (k_1^-, k_2^-, \dots, k_n^-) \text{ and } k_j^- = (0, 0, 0), (14)$$

For the "cost" criteria "A⁺" ve "A⁻" are calculated as shown in Eq.15 and Eq.16

$$A^+ = (k_1^+, k_2^+, \dots, k_n^+) \text{ and } k_j^+ = (0, 0, 0) \quad (15)$$

$$A^- = (k_1^-, k_2^-, \dots, k_n^-) \text{ and } k_j^- = (1, 1, 1) \quad (16)$$

Step 4. At this step, proximity coefficient is calculated. The calculation of the coefficient "CC_i" is based on positive and negative distances among criteria and given in Eq.17.

$$CC_i = \frac{m_i}{m_i^+ + m_i^-} \; ; \quad where \; i = 1, 2, \dots, m \; (17)$$

Step 5. Finally, ranking of the alternatives is carried out according to calculated

proximity coefficient beginning from the most effective one.

3. Case Study

Application of the case study on empty container accumulation problem was carried out in four stages. At first stage, criteria, alternatives, fuzzy number type, related fuzzy scales and pairwise comparison matrix results were obtained. Furthermore, the hypotheses on the solution of these problems were determined to identify the alternatives. In the second stage, expert group views were obtained and datasets that included paired comparison matrices were produced. And then third section involved with application of the proposed techniques and completion of calculations. Therefore, obtained data were analyzed with the proposed models and methods. Finally, fourth section, results of the study were analysed and suggestions

on labor turnover in seaport companies were made and included the interpretation of the analysis results and the findings and the presentation of the solution recommendations. The flow diagram of the study is depicted on Figure 1.

3.1. Determine Selection Criteria and Alternatives

In accordance with research model in this study, criteria were decided by reviewing the available literature on empty container accumulation problem. In order to determine the study criteria and alternatives, a detailed literature review (on scientific articles, reports and statistics, current information resources, theses, etc.) was conducted. It was decided that a further field study should be conducted to obtain applicable study results that are adequate to empty container accumulation problem due to the lack of a detailed study
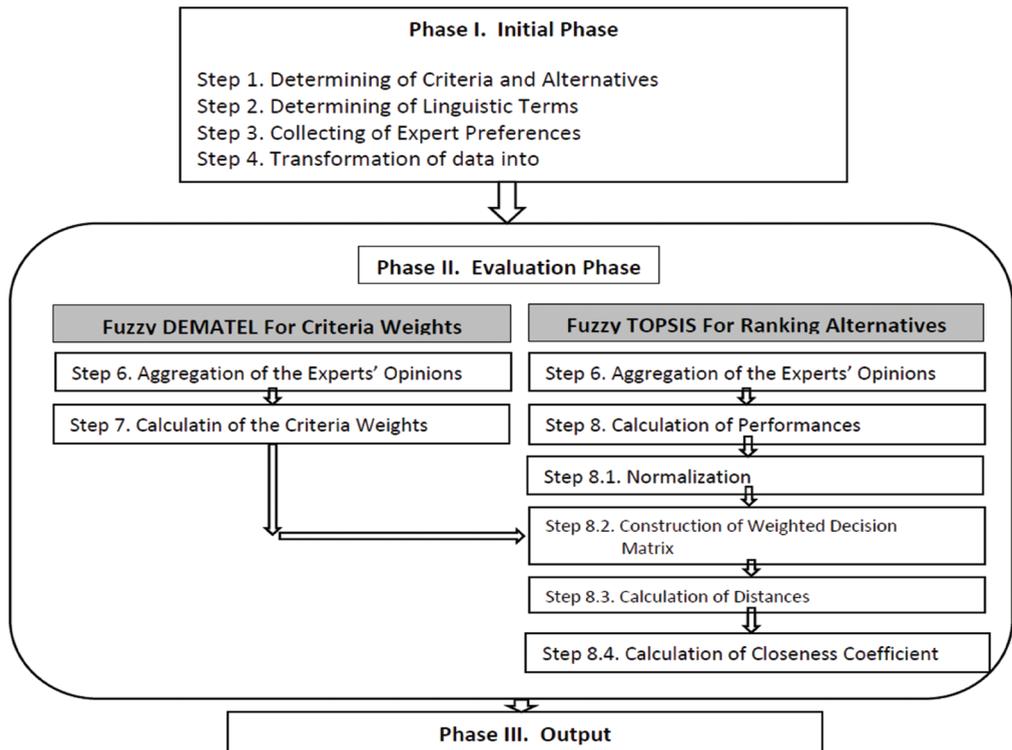

Phase I. Initial Phase

Step 1. Determining of Criteria and Alternatives
Step 2. Determining of Linguistic Terms
Step 3. Collecting of Expert Preferences
Step 4. Transformation of data into

Phase II. Evaluation Phase

Fuzzy DEMATEL For Criteria Weights	**Fuzzy TOPSIS For Ranking Alternatives**
Step 6. Aggregation of the Experts' Opinions	Step 6. Aggregation of the Experts' Opinions
Step 7. Calculatin of the Criteria Weights	Step 8. Calculation of Performances
	Step 8.1. Normalization
	Step 8.2. Construction of Weighted Decision Matrix
	Step 8.3. Calculation of Distances
	Step 8.4. Calculation of Closeness Coefficient

Phase III. Output

Figure 1. Flow Diagram of the Case Study

on the subject. The field study was carried out in two stages. In the first stage, a questionnaire that included open-ended and multiple-choice questions was applied to 37 seaport management officer managers who includes 17 port managers, 13 port operations chiefs and 7 port authorities, in different container ports of large cargo scale in Turkey. In the second stage of the field study, the views of the 24 faculty members in the maritime and logistic department who conducted several studies on the fields of transportation, maritime management and port management were obtained. Collection of data lasted about 3 months. Finally, in order to determine the related criteria and alternatives and 24 faculty members were interviewed. As a result, the large number of data and views obtained in the literature review and field study were organized and the criteria and alternatives presented in Figure 2.

3.2. Determination of Expert Group

A digital questionnaire was designed in order to carry out the pairwise comparisons

evaluations with corresponding expert group that included 17 individuals was selected to determine and evaluate the paired comparison matrices for the study data. The expert group consisted of 9 persons from port managers and 8 persons faculty members from the different maritime faculties departments which are focused on port management research area. Totally 17 experts' opinions were acquired for determining the most effective criteria and sort out the possible alternatives for the empty container accumulation problem in seaports.

3.3. Analysis

Electronic survey forms were designed in order to compare the data presented in Figure 2 and to obtain paired comparison matrices and presented for the scrutiny of the expert group. Each expert was properly completed the pairwise comparison matrix using the linguistic scale. As a step forward, the verbal replies were converted to the triangular fuzzy numbers by previously determined linguistic scale given in Table 1
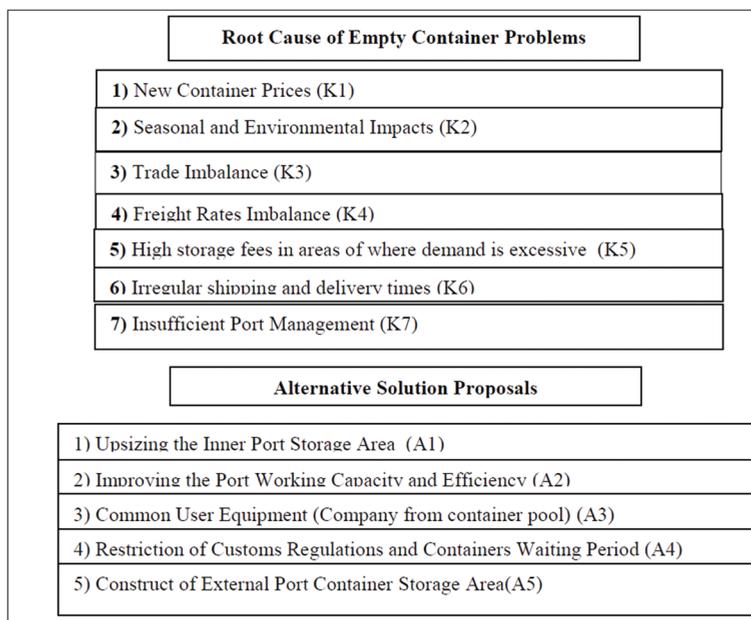

Figure 2. *Criteria and Alternatives Determined for the Study.*

and Table 2. MCDM literature was used to compile the necessary linguistic scales used in this study [43, 51]. Weighted average mean was used to combine all matrices in to a single matrix. Then, a common matrix was obtained by taking the arithmetic mean of 17 matrices in total and the normalized fuzzy direct correlation matrix was calculated with the Equations 1 and 2 and shown in Table 3.

Normalized direct relation matrix fuzzy numbers (A_r , A_y , A_z) were joint by applying Eq.3 to compute the total fuzzy relation matrix "$\check{T}$". To decide on sending and receiving criteria weights, ($\check{D}$ + $\check{R}$) and ($\check{D}$ - $\check{R}$) values were calculated. As a step forward, defuzzification was achieved by applying Eq.4 and Eq.5. Finally, criteria weights were defined according to Eq.6 and Eq.7, the weights were shown in Table 4. A digraph showing causal relations is depicted in Figure 3.

According to Figure 3, factors affecting the empty container accumulation are trade imbalance, irregular logistic and delivery times, freight charge fluctuations and inadequate port management whereas affected factors are new container prices, seasonal and environmental conditions and high storage prices for empty containers.

In order to complete the ranking, the previously determined alternatives, Fuzzy TOPSIS technique was applied. Combined
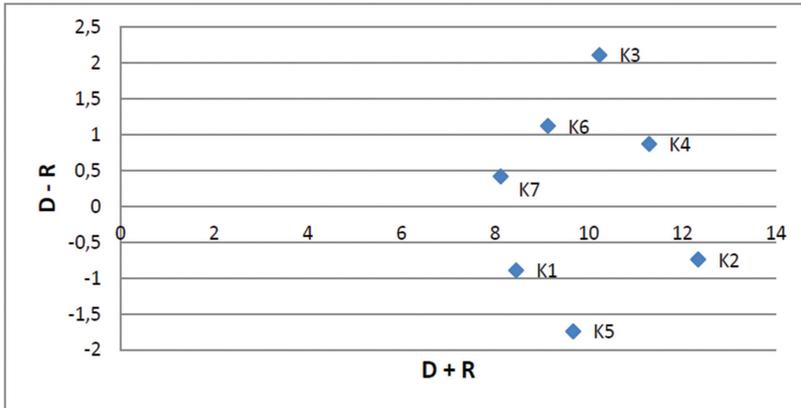
Table 2. *Linguistic Terms and Corresponding Linguistic Values for Alternatives [43, 42, 51]*

Linguistic Terms	Fuzzy Numbers Values
Very Low influence	(0, 0, 3)
Low influence	(0, 2.5, 5)
Medium influence	(2.5, 5, 7.5)
High influence	(5, 7.5, 10)
Very High influence	(7, 10, 10)

Table 3. *Normalized Fuzzy Direct Relation Matrix*

	K1	K2	K3	K4	K5	K6	K7
K1	0;0;0	0,03;0,08;0,11	0,09;0,11;0,14	0,20;0,19;0,18	0,06;0,09;0,12	0,03;0,08;0,11	0,09;0,09;0,12
K2	0,20;0,19;0,17	0;0;0	0,09;0,11;0,14	0;0;0,5	0,03;0,08;0,11	0;0,06;0,11	0,14;0,15;0,17
K3	0,23;0,21;0,18	0,26;0,23;0,18	0;0;0	0,14;0,15;0,17	0,26;0,23;0,18	0,14;0,15;0,17	0;0,04;0,08
K4	0,09;0,09;0,14	0,26;0,23;0,18	0,14;0,15;0,17	0;0;0	0,23;0,21;0,18	0,20;0,19;0,17	0,06;0,09;0,12
K5	0;0;0,5	0,20;0,19;0,17	0,26;0,23;0,18	0;0;0,06	0;0;0	0,14;0,15;0,17	0,03;0,08;0,11
K6	0,17;0,17;0,16	0;0;0	0,17;0,17;0,16	0,17;0,17;0,18	0,09;0,11;0,14	0;0;0	0,06;0,09;0,12
K7	0;0,06;0,09	0,20;0,19;0,18	0,09;0,11;0,14	0,23;0,21;0,18	0;0;0,5	0,09;0,11;0,14	0;0;0

Table 4. *Sum of Influences Given and Received on Each Criterion*

	$\check{D}$ + $\check{R}$	$\check{D}$ - $\check{R}$	($\tilde{D}_i$ + $\tilde{R}_i$)	($\tilde{D}_i$ - $\tilde{R}_i$)	w_i
K1	8,00; 10,02; 14,31	-0,21; -0,63; -0,28	8,45	-0,89	0,165
K2	3,62; 6,30; 11,12	0,43; 0,44; 0,24	12,34	-0,74	0,158
K3	9,60; 11,64; 15,60	-1,13; -0,77; -0,59	10,23	2,11	0,192
K4	5,58; 7,70; 12,30	2,80; 2,62; 2,00	11,29	0,87	0,175
K5	3,62; 6,30; 11,12	-1,76; -1,56; -1,16	9,67	-1,74	0,152
K6	6,69; 9,11; 14,18	0,43; 0,44; 0,24	9,13	1,12	0,184
K7	6,54; 9,09; 13,38	-1,13; -0,77; -0,59	8, 12	0,42	0,171

Figure 3. *A Digraph Showing Causal Relations Among Criteria*

Table 5. *Normalized Fuzzy Decision Matrix.*

	A1			A2			A3			A4			A5		
K1	0,737	0,643	0,444	0,259	0,526	0,357	0,842	0,786	0,667	0,067	0,017	0,159	0,046	0,027	0,056
K2	0,895	0,857	0,778	0,517	0,526	0,357	0,579	0,429	0,111	0,052	0,013	0,098	0,136	0,136	0,129
K3	0,579	0,429	0,111	0,690	0,579	0,429	0,789	0,714	0,556	0,075	0,042	0,105	0,076	0,076	0,076
K4	0,947	0,929	0,889	0,517	0,842	0,786	0,684	0,571	0,333	0,037	0,021	0,069	0,154	0,040	0,324
K5	0,684	0,571	0,333	0,345	0,789	0,714	0,842	0,786	0,667	0,103	0,099	0,110	0,025	0,000	0,086
K6	0,842	0,786	0,667	0,603	0,632	0,500	0,895	0,857	0,778	0,133	0,114	0,114	0,057	0,049	0,075
K7	0,895	0,857	0,778	0,259	0,737	0,643	0,947	0,929	0,889	0,193	0,158	0,171	0,062	0,016	0,123

decision matrix of expert opinions was calculated according to Eq.20 and Eq.21. Table 2. was used to convert linguistic values to triangular fuzzy numbers.

$$\tilde{C}_{ij} = (1/N) \otimes (\tilde{c}_{ij}^1 \oplus \tilde{c}_{ij}^2 \oplus \dots \oplus \tilde{c}_{ij}^N) \qquad (20)$$
$$\tilde{D}_{ij} = (1/N) \otimes (\tilde{d}_{ij}^1 \oplus \tilde{d}_{ij}^2 \oplus \dots \oplus \tilde{d}_{ij}^N) \qquad (21)$$

To obtain weighted decision matrix, normalized fuzzy decision matrix and criteria weights given in Table 4 must be multiplied by applying Eq.10.

Distances (m_i^* ; m_i^-)from ideal positive (A*) and ideal negative (A-) solution for each alternative was computed according to Eq.11, Eq.12 and Eq.13 and the results were given in Table 6. and Table 7. The similarity of each alternative to ideal solution was defined by applying Eq.14, the results shown in Table 8.

Table 6. *Total Distance of Each Alternative from A*.*

Alternatives	Total Distance
A1	4,387
A2	4,654
A3	4,257
A4	4,857
A5	4,562

Table 7. *Total Distance of Each Alternative from A-.*

Alternatives	Total Distance
A1	2,603
A2	2,435
A3	2,687
A4	2,801
A5	2,731

Table 8. *The Ideal Solution to The Similarity of Each Alternative.*

Alternatives	Total distance
A1	0,319
A2	0,332
A3	0,375
A4	0,351
A5	0,364

4. Results and Discussion

Empty container accumulation problem has some negative impacts on international trade and logistic flow of the goods and services. This study pinpoints the cause and effects of empty container accumulation and suggests alternative solutions by following an analytical approach based on multicriteria decision making. As inferred from findings of the study, international trade imbalances, irregular logistics and delivery, freight charge fluctuations and inadequate port management are main factors causing accumulation of the empty containers.

According to Zhang et al. (2017) [8] the global trade fluctuations are the main causes of the accumulation problem of empty containers. The same study suggests that the problem can be solved by better policy of international trade management and establishing a shared container pool. Similarly, Akyüz and Lee (2016) [18] stated that empty container problem is one of the most complex problems facing the global maritime trade and may limit the international container transport logistics in future as there is no stable solution that widely acceptable for the problem. In order to avoid empty container accumulation, the international liner logistic which is mostly causing the problem should be more effective in repositioning and management their containers [4, 29]. Zheng, Sun and Gao (2015)[26] and Belayachi et al. (2017) [29] also suggested better management of the empty container problem by stressing its

importance in terms of international trade logistics.

In accordance with available literature and management of empty container problem recommendations, the current study suggests equipment sharing and establishing empty container pool among logistic companies can be an alternative solution to overcome the problem. Moreover, allocation of additional container storage areas inside and outside of the ports, automatized and enhanced custom services, increasing port handling capacity and productivity would be some other alternatives that can be followed by governing bodies or stakeholders related to empty container accumulation problem.

It can be very difficult and unrealistic to say that proposed alternatives can totally solve the empty container accumulation but raising the awareness among related figures may help to trigger of optimization process by focusing on the problem. Because, the current international trade flow seems to continue in near future. Technologic tools and multicriteria decision making can facilitate the problem by applying analytical techniques or simulations.

It is known that empty container is not only causing high logistic freight charges but also affecting the overall productivity of a port. Therefore, an empty container management plan for every container port is a necessity that can be used in emergency situations for transferring and storage of the empty containers.

Finally, the current study can potentially help to port authorities, port managers and logistic companies when they face with empty container problem as it serves an analytical approach based on fuzzy multicriteria decision making. It is believed that the proposed stepwise approach can be easily followed by related bodies and may guide to container port management strategies by providing a reliable approach to the maritime logistics community.

Therefore, it is proved that Fuzzy DEMATEL and Fuzzy TOPSIS methods can produce reliable solutions in problems that need to evaluate many criteria such as container ports management procedure. Finally, the container port management procedure for empty container accumulation problem is presented in detail to improve the available literature and provide a guide for the maritime logistic sector.

5. Conclusion

In the present study, multi-criteria decision-making methods were used to scrutinize the problems experienced by empty container accumulation problem in the maritime industry in Turkey and their alternative solutions. The objective as to provide decision makers with an ideal, flexible and uncomplicated analysis method using MCDM techniques. In conclusion, it is considered that analytic approaches based on MCDM methods in occupation oriented port management would contribute to an increase in productivity in the long term. Furthermore, the fact that the utilized techniques are effective, realistic and reliable would contribute to the literature by application to different problems in field that require expert opinion, similar to the present study, especially in the maritime industry. It is believed that, the maritime sector could benefit from the quantitative evaluations presented in the current study, which is kept as simple as possible to be understood and applied by all stakeholders involved in the sector. The proposed methodology can be also applied to some other major problems of the maritime sector due to its simplicity and quantification capability. It is considered that the present study would guide future studies by filling the gap in the literature.

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