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A novel quantitative approach to the choice of transshipment container port in the Eastern Mediterranean basin

Doğu Akdeniz havzasında aktarma konteyner limanı seçimine yeni bir niceliksel yaklaşım

Türk Denizcilik ve Deniz Bilimleri Dergisi

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ABSTRACT

In container transportation by sea, it is crucial to define the transshipment design. Liner operators aim not only to reduce operational costs but also to maximize customer satisfaction. Therefore, selecting a transshipment hub port becomes paramount for achieving efficient transshipment capabilities. The study aims to propose an alternative approach to determine the best transshipment hub port for a northbound container ship entering the Eastern Mediterranean basin through the Suez Channel. The proposed model evaluates the container ports with a novel quantitative method. The choice criteria were weighted with the AHP (Analytic Hierarchy Process) method and numerical data acquired with various scientific methods regarding each criterion was used to rank the alternatives based on TOPSIS (Technique for Order Preference by Similarity to Ideal Solutions). Additionally, to generate data and utilize it as a criterion a cross-sectional efficiency snapshot regarding the evaluated container ports was also taken using the bootstrap DEA (Data Envelopment Analysis). Thus, as a decision-maker, the line operator can determine the transshipment port quickly using an easily applicable method upon determining the port calls and the schedules. The findings imply that connectivity is the most important criterion for transshipment hub port choice for containerized goods. The location was also considered important for this choice, but to improve transshipment function, the proper way may be to draw beneficial strategies on maritime connectivity. Conversely, capital investments such as superstructure improvement were found to be less critical for an attractive transshipment hub.

Keywords: Transportation, Port, Container, Transshipment, AHP, TOPSIS.

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ÖZET

Deniz yoluyla konteyner taşımacılığında aktarma tasarımının tanımlanması büyük önem taşımaktadır. Düzenli hat operatörleri sadece operasyonel maliyetleri azaltmak değil, aynı zamanda müşteri memnuniyetini de en üst düzeye çıkarmak istemektedir. Bu nedenle, verimli aktarma yeteneğinin kazanılmasında aktarma merkezi limanı seçimi problemi ön plana çıkmaktadır. Bu çalışma, Süveyş Kanalı üzerinden Doğu Akdeniz havzasına giren kuzey yönlü bir konteyner gemisi için en iyi aktarma merkezi limanını belirlemek amacıyla alternatif bir yaklaşım uygulamayı amaçlamaktadır. Önerilen model, konteyner limanlarını yeni bir niceliksel yöntemle değerlendirmektedir. Seçim kriterleri AHP (Analitik Hiyerarşi Süreci) yöntemi ile ağırlıklandırılmış ve her bir kritere ilişkin çeşitli bilimsel yöntemlerle elde edilen sayısal veriler kullanılarak alternatiflerin TOPSIS'e (İdeal Çözüme Benzerliğe Göre Tercih Sıralaması Yöntemi) göre sıralanması sağlanmıştır. Veri oluşturmak ve bunu bir kriter olarak kullanmak için, önyüklemeli DEA (Veri Zarflama Analizi) kullanılarak değerlendirilen konteyner limanlarına ilişkin bir kesitsel verimlilik anlık görüntüsü de alınmıştır. Böylece karar verici olarak hat operatörü, liman uğraklarını ve tarifelerini belirleyerek, kolay uygulanabilir bir yöntem kullanarak aktarma limanını hızlı bir şekilde belirleyebilir. Bulgular, konteynerle taşınan mallar için aktarma merkezi limanı seçiminde bağlantının en önemli kriter olduğunu göstermektedir. Bu seçim için konumun da önemli olduğu değerlendirildi, ancak aktarma işlevini geliştirmek için doğru yol, deniz bağlantısı konusunda faydalı stratejiler belirlemek olabilir. Öte yandan üstyapının iyileştirilmesi gibi sermaye yatırımlarının cazip bir aktarma merkezi için daha az önemli olduğu görüldü.

Anahtar sözcükler: Ulaşım, Liman, Konteynır, Aktarma, AHP, TOPSIS.

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1. INTRODUCTION

The rapid growth of international trade imposes maritime transportation as a crucial subject. Affecting by this growth, the regular liner shipping industry has become more complex to adapt to strategic alliances and the larger ships and fleet sizes associated with the alliances (Kavirathna, 2018). With the end of the critical supply chain disruptions in the last few years, the relative decline in international sea freight rates for container cargo in the second half of 2022 is notable (UNCTAD, 2023). However, high transportation costs remain a key concern. As a result, the line operators are in a more competitive environment for their cost and pricing strategies. A container line operator manages a fleet of ships deployed on shipping lines consisting of a series of ports to carry containers between ports at a regular service interval. Due to the increasing demand for container shipping, they are deploying large oceangoing ships carrying between hub ports to benefit from economies of scale (Meng and Wang, 2011). Thus, a new route pendulum is defined from transshipment ports to the final destination. In this regard, transit port selection becomes crucial for a container line operator. Since container ports are critical nodes for the supply chain, deciding the most suitable transshipment port can help increase efficiency and reduce costs for the line operators.

Container ports in the East Mediterranean are playing a significant role between Europe, Asia and North Africa. These container ports link these continents, acting as strategic nodes facilitating intercontinental cargo carriage (Moschovou and Kapetanakis, 2023). Container handling in this region has dramatically increased in recent years (Notteboom *et al.*, 2023). To access the Mediterranean via the Asian route, there are several alternatives other than Port Said port at the northern exit of the Suez Canal to unload the transit cargo on a mother ship using the Suez route. However, each of these alternatives has its own set of and advantages. Therefore, making the right decision can be considered a multi-criteria decision problem.

No scientific study has been found that examines the preferability of container ports in the Eastern Mediterranean in terms of transit cargo handling demand using multi-criteria decision-making techniques based on quantitative methods. Therefore, it is thought that there is a gap in the literature. Hence, this study aims to address the selection of suitable ports for unloading transit cargo in the Eastern Mediterranean using multi-criteria decision-making techniques. Criterion weights were obtained using AHP (Analytic Hierarchy Process) with expert opinion, and the ranking of the alternative container ports was made using TOPSIS (Technique for Order Preference by Similarity to Ideal Solutions) with quantitative data.

In the second section of the study, the literature was reviewed. In the third section, the approaches used were summarized. While the fourth section includes the findings and discussion, the last section contains the results and limitations of the research.

2. LITERATURE REVIEW

Goal, motivation and strategy lead the practitioner to various kinds of examining the port selection criteria. In this context, there have been three main perspectives to be considered in the maritime supply chain. First is the freight forwarder, second are the shippers and the third is the line operators (Georgoulas *et al*., 2023). Line operators are generally affected by distinctive port features such as the port's throughput, infrastructure, and connectivity, even if on a different level (Mulder and Dekker 2017). Therefore, a visionary container port may need to assess the potential and actual demand for transit cargo based on many features. Recent literature on these features regarding the choice of transshipment container port varies partially. Because the choice of transshipment port is quite complex and requires extra effort to be figured out considering relevant rational issues. In this context, Brian (1985) argues that the line operators are influenced by cost more than infrastructure and other relevant features of the ports. In contrast, the geographical or the infrastructural features may play a crucial role in the selection process. For instance, Sternberg (2000) states that the Gioia Tauro port in the mid-Mediterranean region is a significant container transshipment port. This distinctive transshipment port had converted substantially in terms of its function from an iron ore port to a container port by 1998 thanks to its superior geographical location, connectivity, operational efficiency and continuous investment in infrastructure and facilities. While Ernst (2001) argues that the increase in transit freight potential is due to an increase in service frequency, transportation and the establishment of intermodal alliances. According to Mary (2000), in addition to distance or operational efficiency, transit time, service frequency, and equipment necessity also affect the choice. The literature reveals that various criteria have been addressed in previous studies. It is thought that diversity may arise from the perspective that evaluates the criteria. Nevertheless, it can be said that in most studies, criteria such as cost, connectivity and location come to the fore.

On the other side, there are also methodological advancements in port selection in the literature. Georgoulas *et al*. (2023) proposed an AHP-based decision support system that enables practitioners' decision-making based on their subjective experience and within realistic time constraints. Chou (2007) ranked the three Taiwanese container ports in terms of their futures related to the transshipment function using a novel canonical representation of multiplication operation on three fuzzy numbers to define the importance of criteria. For a higher transshipment demand, the volume and the cost of handled containers are followed by efficiency, infrastructure and location. Baştuğ *et al*. (2022) examine whether the choice criteria prioritized by line operators align with what the ports themselves consider as crucial for their regional competitiveness. This topic is quite interesting especially for Mediterranean basin. Because the liner operators are working in a dynamic environment that may affect their port selection choices substantially and the port costs may be a secondary consideration. The findings are interesting because they imply that the point of view of port operators does not coincide with the point of view of line operators and that line operators may prioritize different criteria in port selection. According to the findings, the most important criteria of competitiveness for port operators are the location of the port, service level, pricing and superstructure, whereas the

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most important criterion for carriers is operational efficiency. In line with Baştuğ *et al.* (2022), Cruz *et al.* (2013) applied the Analytical Hierarchy Process (AHP) in their study, and they observed that the main factors of port competitiveness from the perspective of port customers are quite different from the service provider. They found that according to ocean freight carriers, the main factor that stands out in competitiveness is vessel turnaround time, followed by intermodality, equipment and infrastructure, distance to the hinterland and depth. Even not in port selection, some studies integrating AHP and TOPSIS methods to assess selection problems in other fields (Xiangda *et al.*, 2023; Haktanır and Kahraman, 2024).

3. METHODOLOGY

3.1. AHP

This study adopts the AHP developed by Saaty (1980) to determine criteria priorities for the defined problem. AHP consists of both subjective interpretations and objective evaluations of the decision-makers. In this sense, it allows the decision-makers to model the goal, alternatives, criteria, and their inter-relationships in a hierarchical structure. It can be expressed that the crucial advantage of this method is to allow the preferences, and intuition, in a logical and structured way. Since the mid-1980s, this method has become more popular due to the development of group decision support systems. On the other hand, the hierarchical structure of AHP may not be suitable to model the complexities of certain scenarios, especially in contexts that are broader or different in terms of industry and culture, due to the lack of flexibility in the structure to consider specific characteristics of actual scenarios (Munier & Hontoria, 2021). Even though there are some discussions about the AHP methodology and its application in the relevant literature, its intuitive nature and mathematical rigor have made it one of the most widely used decision-making techniques worldwide (Mu and Pereira-Rojas, 2018).

Expert opinions were used to define the priorities of the transshipment port alternatives according to a set of criteria, 10 experts on port management and maritime transportation filled out a questionnaire regarding possible criteria weights. While determining the experts, their in-depth knowledge of the port's infrastructure and superstructure and the factors affecting customer preferences were taken into account. The profiles of the experts are summarized in Table 1.

Table 1. The profile of experts

Interviewee	Job	Rank	Expertise
Expert 1	Academician	Professor	Port management
Expert 2	Academician	Assistant Professor	Maritime Transportation
Expert 3	Academician	Associate Professor	Port management
Expert 4	Academician	Associate Professor	Port management
Expert 5	Academician	Lecturer, PhD	Port management
Expert 6	Academician	Lecturer, PhD	Maritime Transportation
Expert 7	Academician	Lecturer, MD	Maritime Transportation
Expert 8	Academician	Research Assistant, PhD	Port management
Expert 9	Freight Forwarder	Sales Manager	Maritime Transportation
Expert 10	Logistician	Managing Director	Maritime Transportation

The implementation of the proposed AHP on transshipment port selection problem is summarized as follows.

Defining the goal: AHP is applied to solve a problem or achieve a defined purpose in a situation or case. In the application, the goal needs to be defined clearly and can be understood by all participants.

Constructing pair wise comparison matrices:

With AHP, one can determine the priorities of each factor by pair wise comparison between the main and sub-factors (if any) to measure the marginal relationship of the criteria with the goal. Due to such complexity, Saaty (2008) suggests

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identifying all criteria affecting the decision and grouping those with common characteristics among the factors in question. After all the factors affecting the decision are brought into a hierarchical structure, the participants' priorities regarding the factors and alternatives are determined by pair wise comparison. Pairwise comparisons consist of matrices in which alternatives are compared, initially considering the main factors, then the sub-factors in each main factor, and finally all factors.

Expert opinion is used to determine the importance levels of factors and alternatives. For this, the score scale between "1" and "9" suggested by Saaty (1990), is used. If the decision-maker thinks that either factors or alternatives have equal importance, the decision-maker marks as "1" among the relevant factors and alternatives. If the decision-maker argues that one of the two alternatives is more important or preferable than the other, he assigns a score of 9 to that factor or alternative. On a 1–9-point scale, each rating implies the degree of importance or favorability. In this way, factor sets are standardized. Importance scale proposed by Saaty (1990) is given in Table 2.

Table 2. Saaty's scale of relative importance (Saaty, 1990)

Intensity of importance	Definition	Explanation
1	Equal importance	Equal contribution to the goal
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgments	Intermediate values

The given points by each expert to each comparison are placed in matrices. To represent all participants through an average value, the geometric mean of each value group is taken. The geometric mean is consistent with the meaning of both judgments and priorities in AHP. In the matrix created for each level in the hierarchy, the priority value for pair wise comparison is written as it is, while the diagonal value is written inverted (1/value).

Calculation of priorities of factors for each level: After the comparison matrices are constructed, row averages are obtained by normalization. Thus, the row average for each factor indicates the priority of decision-makers regarding each factor. This process continues by making a pair wise comparison of factors, making a pair wise comparison of sub-factors, and comparing alternatives for each factor. Normalization and the definition of normality vector used are given in Equation (1) and Equation (2), respectively.

Normalization:

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} aij} \tag{1}$$

Definition of Normality Vector:

$$w_i = \frac{\sum_{j=1}^{n} Cij}{n} \tag{2}$$

Checking consistency:

The criterion weights obtained for the factors and alternatives should be consistent. The AHP method can determine whether experts give consistent answers to the questionnaire. Saaty (1990) suggested calculating the consistency ratio index (CI) with the values in the comparison matrices. If the obtained consistency ratio (CR) is less than 0.1, it can be said that the scores assigned are internally consistent. Otherwise, the

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responses provided should be reassessed. The equations (3) and (4) are as follows, regarding the calculation of consistency ratio.

$$CI = \frac{\lambda_{max} - n}{(n-1)} \quad (3)$$

$$CR = \frac{CI}{RI} \quad (4)$$

λ_{max} is the largest eigenvalue of each matrix. CI is the deviation of λ_{max} from n. RI (Randomness Index) is the randomly calculated correction rate for matrices of various sizes.

3.2. TOPSIS

To compare the alternatives according to the weighted criteria, TOPSIS method were used. One valid reason to prefer this MCDM technique is to pave the way for the actual quantitative data directly to be utilized. TOPSIS (Technique for Order Preference by Similarity to An Ideal Solution) is one of the well-known Multi Criteria Decision Making (MCDM) methods developed by Hwang and Yoon (1981). In this approach, while maximizing the benefit, the solution is expected to be closest to the positive ideal solution and furthest from the negative ideal solution. When making decisions among alternatives, the closest alternative to the positive ideal solution and the furthest alternative from the negative ideal solution is chosen as the best one.

The TOPSIS approach is performed in seven steps. In step 1, the decision matrix consists of the n criteria and m alternatives. The decision matrix is also called the initial matrix, as shown in Table 3.

Table 3. Initial matrix

$$\begin{bmatrix} x_{11} & & x_{12} & \cdots & x_{1n} \\ & \vdots & \vdots & & \vdots \\ x_{m1} & & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

In step 2, the decision matrix is normalized. Data obtained using different scales are made comparable using normalization process. In this step, each element in the matrix is normalized by dividing by its column total. Each column of the normalized matrix sums to 1. In step 3, The sum of each row of the normalized matrix is averaged by dividing by the size of the matrix. These values are the importance weights calculated for each criterion. These weights form the priority vector. The weighted criteria values (w_{ij}) are multiplied by each normalized matrix element (r_{ij}). In step 4, the positive and negative ideal solution values are calculated. For the ideal solution, the highest and lowest values in each column are selected among the values obtained in the previous step. For the beneficial criteria, the highest value is prioritized and for the cost criterion the lowest value is prioritized. In following Equation (5) and Equation (6), A^+ represents the best alternative, A^- is the worst one.

$$A^+ = \{(maxV_{ij} | j \in J), \ (minV_{ij} | j \in J'^C)\} \qquad i = 1, 2, 3, \ldots., m \quad (5)$$

$$A^- = \{(minV_{ij} | j \in J), \ (maxV_{ij} | j \in J'^C)\} \qquad i = 1, 2, 3, \ldots., m \quad (6)$$

In step 5, the separation measures are calculated. The deviation of the alternatives from the positive and negative ideal solutions is calculated with the Euclidian distance function. Positive ideal separation (S_i^*) and negative ideal separation (S_i^-) are calculated as shown in Equation (7) and Equation (8), respectively. In this case, J represents the benefit, J^*represents the cost criterion. Obtained pairs of S_i^* and S_i^- values should be equal to the number of alternatives.

$$(S_i^*) = \sqrt{\Sigma(v_{ij} - v_{j^*})^2} \qquad i = 1, 2, 3, \ldots, m \quad (7)$$

$$(S_i^-) = \sqrt{\Sigma(v_{ij} - v_{j^-})^2} \qquad i = 1, 2, 3, \ldots, m \quad (8)$$

In step 6, the relative priority is calculated according to the ideal solution. The proximity of the alternatives to the ideal solution C_i^* is determined by using ideal and negative ideal separation measures as shown in Equation (9).

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The value used for this is the share of the negative discrimination measure in the total separation measure. Proximity to the ideal solution;

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-}; \qquad 0 \leq C_i^* \leq 1 \qquad (9)$$

In the final step, alternatives are ranked according to the relative proximity values. Thus, by sorting the C_i^* values from large to small, the closest one to the ideal solution is determined as the best alternative.

Hierarchical model for best transshipment port selection:

This study examines the transit port selection criteria and the best choice of container ports for Far East-Europe line operators in the Eastern Mediterranean after the Suez Canal passage. For this purpose, a four-level AHP model consisting of goal, criteria, sub-criteria and alternatives was created based on expert opinions because of the current literature as summarized in Table 4.

Table 4. Current literature which benefited for criteria selection

Study	Criteria	Study	Criteria
Georgoulas *et al*., 2023	Seaport facilities and equipment Depth Connectivity Vessel time at port Proximity to import/export area	Chou, 2007	Port location Hinterland economy Port physical Port efficiency Cost

Based on the existing literature, the criteria identified by brainstorming were scored by experts in the field with a questionnaire compatible with the AHP methodology. Pairwise comparison values obtained with Super Decisions 3.2 computer software were analyzed, and the priority values and order of main and sub-criteria affecting the line operators' transit container port selections were determined.

Constructing a hierarchical structure is routine for AHP to deal with a complex problem or achieve a goal. In a hierarchical structure, the goal, criteria, and alternatives are organized from top to bottom. This hierarchical structure allows the multidimensional decision-making process to be systematically reduced. Thus, decision-makers benefit from the inter-relationships of the components between hierarchical tiers to facilitate the comparison to be performed in the next stage. In this step, the criteria are compared among themselves. Defining the hierarchical structure paves the way for the second step to determine the criteria importance with a pairwise comparison. Proposed hierarchical structure for the port choice for container transshipment problem is illustrated in Figure 1.

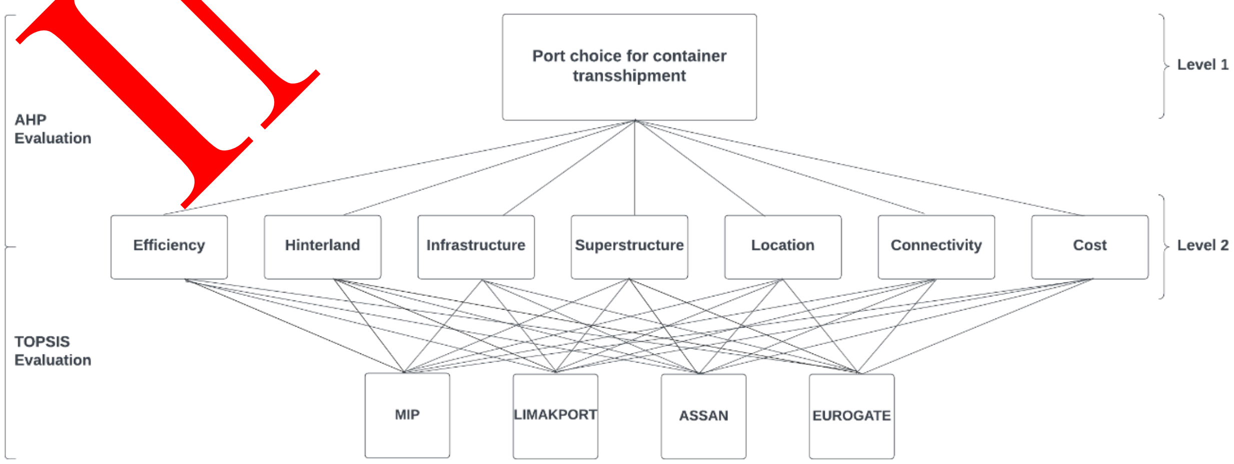

Figure 1. Hierarchical model of port choice for container transshipment

The final decision is reached by determining the relative importance of the alternatives. For this purpose, priority values for the alternatives are obtained by multiplying the priority values of the alternatives for the main factors with the priority values for the main factors. The alternative with the highest priority value is considered the most preferable or most important alternative. The binary comparisons between alternatives are performed with quantitative data.

The alternatives:

MIP (Mersin International Port) is connected by rail and land transportation to Turkey's industrialized cities and neighboring countries. It is one of the crucial container ports in the Mediterranean, with its transit and hinterland connections with the Middle East and the Black Sea. MIP is Turkey's largest port in terms of annual output and its existing backyard (MIP, 2023). This multi-purpose port draws attention to its efficient output levels as highlighted in relevant research (Ateş, 2010; Ateş and Esmer, 2011; Merk and Bagis, 2013; Akyar and Çetin, 2019).

Following substantial investments as part of the privatization process, starting from January 2012, pier structures, storage areas, traffic lanes, port inward and outward passage lines were overhauled, warehouses and all buildings that have completed their economic life were demolished and rebuilt, and new shore and yard cranes were supplied for port operations. In addition, dredging was carried out in the port, allowing ships with a draft of up to 14.50 - 15.00 meters to berth. As a result of the investments, Iskenderun port has become a modern and developed port. The port carries out its services as Limak İskenderun International Port Management Inc (LIMAK PORT, 2023).

ASSAN PORT was put into service at the end of 2010. Assan Port is the first container terminal serving modern container ships in the Gulf of İskenderun, as of its opening date, has become a crucial alternative for the subject hinterland. It has an annual capacity of 250,000 TEU and aims to reach a capacity of 400,000 TEU with new investments. In addition to providing an advantage for companies in the Eastern Mediterranean, Southeastern Anatolia and the south of Central Anatolia in terms of its geographical location, it is a close alternative container terminal opening to the west for Northern Iraq (ASSAN PORT, 2023).

The Port of Limassol is the main port on the Island of Cyprus. EUROGATE took over operations of the container port in January 2017 (EUROGATE, 2023). This port draws attention with its distinctive geographic location and successful managerial strategies.

The criteria:

The literature review and expert opinion were utilized to select criteria —and determine the importance levels using the AHP approach. As a result, the main criteria affecting line operators' transit cargo port selection are efficiency, hinterland, infrastructure, superstructure, location, connectivity and cost with a two-level AHP model of 10 experts. Pairwise comparisons of the criteria were performed with TOPSIS based on quantitative data as summarized in Table 1 and 4.

Maritime connectivity:

Globalized production, trade, communication and finance depend on connectivity which refers to the opportunities for individuals, businesses, and nations to establish connections. Improved liner shipping connectivity can help reduce trade costs and has a direct, positive bearing on trade volumes (UNCTAD, 2017). Therefore, this critical feature of a container port is included to the model as a main criterion. By the end of 2022, Port liner connectivity index (PLCI) calculated by UNCTAD (2023) are as shown in Table 5.

Table 5. Port liner connectivity scores (UNCTAD, 2023)

Terminal	PLCI
MIP	41.59
LIMAK	28.54
ASSAN	28.54
EUROGATE	10.96

Efficiency:

For a container port, efficiency can be defined as the ratio of the inputs required to carry out handling and related activities to the handling and linked services achieved (Farrell, 1958; Charnes *et al*., 1978). It is considered that the ratio of physical equipment and infrastructure inputs used for handling the output is technical

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efficiency and bootstrap efficiency scores are estimated using the procedure of Simar and Wilson (1998) to prevent bias due to the small sample size ($n = 16, replication = 200$). To measure the technical efficiency of the examined terminals, the data gathered for the years between 2019 and 2022 from TURKLIM (2020, 2021, 2022, 2023) and official websites of the terminals. The descriptive statistics of the variables used in the frontier-based bootstrap DEA efficiency model are summarized in Table 6.

Table 6. Descriptive statistics of the input/output variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Output					
Throughput (TEU)	6	771,692.813	748,837.002	177,661.000	2,097,349.000
Inputs					
Terminal area (Ha)	6	217.063	350.783	22.500	920.000
Berth length (m)	6	1,625.500	1,109.883	680.000	3,370.000
Channel / Berth depth (m)	6	16.650	1.404	15.800	19.000
Handling equipment (pcs)	6	8.188	5.753	4.000	18.000

The efficiency analysis was performed with R "Benchmarking" community contributed package. The estimated efficiency levels are shown in Table 7. According to the results, while MIP is the relatively the most efficient terminal, ASSAN is the least in East Mediterranean basin. The relative efficiency levels of LIMAK and EUROGATE were estimated as 0.87 and 0.75.

Table 7. Bootstrapped efficiency scores

Variable	Mean	Std. Dev.	Min	Max
MIP	0.889	0.017	0.867	0.904
LIMAK	0.870	0.092	0.734	0.939
ASSAN	0.499	0.074	0.400	0.560
EUROGATE	0.749	0.026	0.716	0.778
Average	0.752	0.170	0.400	0.939

Hinterland:

Seaports serve the hinterland with rail and land transportation. In this sense, for a container port, the hinterland can be defined as the related economic area (Atak and Esmer, 2021). Bucak and Esmer (2019) emphasized that accessibility to the hinterlands should be optimized. They stated that there are many studies on this subject in the literature. Therefore, it is considered that hinterland accessibility, economic level and size can affect customer preferences, as they are the factors that relate to the service network and size of the port. GDP (Gross Domestic Product) per capita in US dollars was used as a proxy of the hinterland size. GDP per capita as of the end of 2022 of Mersin, Hatay and Limassol are 8278 $, 6785 $ and 32093 $, respectively.

Infrastructure:

The approach channel, breakwater and port entrance, seabed and docks of a container port are considered the infrastructure of that port. Maneuvering restrictions, improper quay shape, and insufficient berth length regarding the time and difficulty of berthing and unberthing operations may affect the choice of container line operators. Deeper terminals, longer berth spaces and large turning circles are considered critical elements of a transshipment terminal. Principal component analysis was performed to calculate a component that presents a proxy of the total infrastructural ability of the container ports based on different scale features. Table 8 summarizes the infrastructural features of the alternative terminals and the normalized infrastructure score as of the end of 2022.

Table 8. Infrastructural features of the terminals

Terminal	Terminal area (Ha)	Total berth length (m)	Maximum berth depth (m)	Normalized PCA score
MIP	124	3,370	15.8	3.62
LIMAK	27	1,652	15.8	1.52
ASSAN	22.5	680	19	0
EUROGATE	34	800	16	1.11

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Superstructure:
The number of the equipment that performs the handling mechanically can also be a factor that will affect customer choice. The quantity of the shore crane that performs the handling work may cause interruption in operation process. Therefore, it is considered as an influential factor in the customer's choice of products. Table 9 summarizes the infrastructural features of the alternative terminals as of the end of 2022.

Table 9. Superstructure of the terminals

Terminal	Handling equipment (pcs)
MIP	18
LIMAK	6
ASSAN	4
EUROGATE	5

Location:
It is thought that the location of the container port can be crucial in a line operator's choice. As the liner services are organized according to a pre-fixed schedule, optimized vessel speed and possible port congestions are undesirable situations, and distance and number of calls are complex issues that vary with the port location. Therefore, the location of a container port is considered as main and sub-criteria in the model. Distance to main trade routes, geographic location and the status for a regional competitive environment may be crucial in terms of being a distinctive transshipment container port. The shortest distances to the Asia-Europe main route are given in Table 10. Accordingly, Limassol EUROGATE terminal is the most advantageous terminal in terms of the distance to the main route.

Table 10. Distance to the main route (Port Said)

Alternative	Distance (km)	Distance (nautical miles)
MIP	659.03	355.79
LIMAK	696.26	375.89
ASSAN	703.52	379.81
LIMASSOL	380.80	205.58

Cost:
Like every commercial enterprise operated for profit, liner operators operate ships to make a profit. Therefore, it is thought that port fees and handling tariffs may also be effective in the selection criteria of line operators. The transshipment costs gathered from official websites of the alternatives based on the beginning of 2023 prices are given in Table 11. The average price for each terminal is calculated using the following Equation (5).

$$AverageTransCost_{DMU_i} = AritmeticMean(Price_{TEU,FULL}; Price_{TEU,EMPTY}) + AritmeticMean(Price_{FEU,FULL}; Price_{FEU,EMPTY}) \quad (5)$$

Table 11. Transshipment costs[1] based on 2023 prices.

Terminal	Condition	TEU ($)	FEU ($)	Average Cost ($)
MIP	Full	115	115	97.500
	Empty	80	80	
LIMAK	Full	110	110	90.000
	Empty	70	70	
ASSAN	Full	110	160	117.500
	Empty	100	100	
LIMASSOL	Full	164.77	164.77	123.605
	Empty	82.44	82.44	

4. FINDINGS AND DISCUSSIONS

Criterion weights were determined based on questionaries filled out by ten expert academicians in the field. To determine the criteria priorities, questionnaires were utilized on a scale of 1-9 grade, as suggested by Saaty, to use in pairwise comparisons of criteria (Saaty, 2003).

[1] The transshipment of the container using the storage yard.

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SuperDecisions 3.2 computer software was used to calculate AHP formulations based on pairwise comparisons. The geometric means of the criteria weights obtained from the AHP approach are shown in Table 12.

Table 12. AHP pairwise comparison matrix for the criteria priorities

Criteria	Efficiency	Hinterland	Infrastructure	Superstructure	Location	Connectivity	Cost
Efficiency	**1**	4.75	0.45	2.73	0.59	0.59	0.97
Hinterland	0.21	**1**	0.48	0.56	0.303	0.20	0.51
Infrastructure	2.24	2.07	**1**	2.18	0.29	0.48	0.99
Superstructure	0.37	1.77	0.46	**1**	0.26	0.29	0.35
Location	1.71	3.30	3.48	3.86	**1**	1.17	2.22
Connectivity	3.30	5.02	2.07	3.46	0.85	**1**	1.98
Cost	3.48	1.97	1.00	2.86	0.45	0.50	**1**

The importance levels acting as the weights for the pairwise comparisons to be made are given in Table 13. In addition, as shown in Table 11, consistency ratio (CR) is calculated as 6% (0.06220) This value is smaller than 0.1. Therefore, in this case, it can be said that a consistent criteria evaluation was carried out by the experts. From the perspectives of the experts, the findings state that connectivity (PLCI) is the most important criterion for the choice of the transshipment port. Location, cost and efficiency follow the connectivity in terms of importance, respectively. Location can be a crucial feature for a hub port. But in this context, it is necessary to examine why connectivity is slightly more important than location. Regardless of the location, limited maritime customer diversity may limit the demand for transit cargo handling. The least important criterion is defined as superstructure. It can be considered as reasonable. Recently, the most common marketing tactic has arisen as the gigantism of the terminal superstructure in social media and brochures. The port managers can feel safe while expressing themselves in this way. However, it seems a worse strategy to attract customers according to these findings. In alignment with Chou (2007) who stated that, for a higher transshipment demand, the volume and the cost of handled containers are followed by efficiency, infrastructure and location. To aim to be a competitive hub port, East Mediterranean container ports need to be more connected with their neighbors and customers as well as considering their location. In this sense, a better consequence of the higher connectivity could be triggered by a closer location to the main routes. Determining the distance to positive and negative ideal solution, ranking of the alternatives and determined via TOPSIS method and given in Table 14. The calculation steps are omitted, but tabulated in Appendices section (Appendix II, III, IV, V).

Table 13. Weights of the criteria and consistency level

Criteria	Weight (%)
Efficiency	13.430
Hinterland	4.845
Infrastructure	9.891
Superstructure	5.755
Location	23.680
Connectivity	26.038
Cost	16.361
CI/RI	**0.062**

The results based on actual quantitative data are shown in Table 14. The results suggest that the most preferable transshipment hub alternative is MIP located in Mersin. This finding is consistent with real-life observations. Because MIP is Turkey's largest port in terms of annual output and its existing backyard (MIP, 2023).

Table 14. Rank of alternatives

Alternative	S_i+	S_i-	Score	Rank
MIP	0.05307	0.176131	0.76845	1
LIMAKPORT	0.10814	0.096070	0.47044	2
ASSANPORT	0.13782	0.078453	0.36274	3
EUROGATE	0.16116	0.070403	0.30403	4

In East Mediterranean, the handling outputs are beneficial to evaluate the consistency of the results. According to TURKLIM (Port Operators Association of Turkey) sector report (2023), highest amounts of transit cargo have been recorded in MIP by the years of 2019-2022 as shown in Table 15.

Table 15. Transit cargo handling amount of the Turkish competitors (TURKLIM, 2023)

Alternative	2019	2020	2021	2022
MIP	480.977	429.070	456.225	437.064
LIMAKPORT	15.252	21.195	24.698	30.359
ASSANPORT	9.854	5.789	8.622	10.711

5. CONCLUSION

In this study, Transshipment port selection problem of a container line operator was evaluated. The criteria were assessed by experts and the alternatives were ranked according to quantitative methods by using the actual numeric data. It is found that this hybrid method can be utilized by the line operators to decide the best transshipment port thanks to the method's easy applicability and consistency.

According to the findings, the most important criterion for the most preferable transshipment hub port is connectivity. Therefore, the Eastern Mediterranean container ports should evaluate connectivity-based strategies to achieve better transshipment levels besides export and import handling activities.

In this context, utilizing digital technologies in ports can change the customers' perspective on the port. Because digital technologies result in an altered perspective of seaport service quality. Since seaport service quality is not prescribed and strictly defined, the importance of digitalization should be considered, which includes redefining the seaport service quality factors. The development of the port's customer profile may also bring about a gradual increase in maritime connectivity. In addition, bilateral agreements with carriers and line operators can play a critical role in the newly established regular lines to provide bilateral connectivity between ports. Finally, since the location should not be ignored in transit port selection if a port can not constitute an alternative to competitive rivals with its locational features, the managers should review their infrastructure and equipment investment strategies in this context.

In future studies, it will be beneficial to consider more criteria to make a better pairwise comparison. Thus, it would be useful for the container line operators to evaluate in a more complex environment. Moreover, the criteria can be decomposed to the sub-criteria and use alternative MCDM methods for the evaluation of the alternatives.

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AUTHORSHIP CONTRIBUTION STATEMENT

Volkan EFECAN: Conceptualization, Methodology, Validation, Formal Analysis, Resources, Writing- Original Draft, Writing-Review and Editing, Data Curation, Software, Visualization, Supervision.

CONFLICT OF INTERESTS

The author declares that for this article there is no actual, potential or perceived conflict of interests.

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