Marine Policy 135 (2022) 104866

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Port competitiveness: Do container terminal operators and liner shipping companies see eye to eye?

Sedat Baştuğ [a], Hercules Haralambides [b,*], Soner Esmer [a], Enes Eminoğlu [c]

[a] Iskenderun Technical University, Barbaros Hayrettin Naval Architecture and Maritime Faculty, Merkez Kampus, 31200 Iskenderun, Hatay, Turkey - Dokuz Eylul University, Maritime Faculty, Buca, İzmir, Turkey
[b] Université Paris 1 - Panthéon-Sorbonne and Dalian Maritime University, China
[c] Department of Marine Transportation Engineering, Institute of Graduate Studies, Iskenderun Technical University, Merkez Kampus, 31200 Iskenderun, Hatay, Turkey

ARTICLE INFO

Keywords:
Port competitiveness
Liner shipping
Ports
Fuzzy analytic hierarchy process
Port location
Operational efficiency

ABSTRACT

Most of the literature on port choice has focused mostly on the views of carriers (and indirectly of cargo owners). We venture here to discover whether the choice criteria used by carriers are in line with what the ports themselves consider as important for their competitiveness. We undertake a 20-year-long literature search in peer-reviewed journals to identify the *competitiveness criteria* of both carriers and terminal operators. To that end, survey methods and (*Fuzzy*) Analytic Hierarchy Process (FAHP) are employed. Our findings establish that the factors port operators consider important for the competitiveness of their port are not necessarily of equal importance for shipping companies when selecting a port. This is our main contribution to the academic literature. For port operators, the most important criterion for competitiveness is port location, followed by service level, port tariffs, and port facilities. In contrast, the most important criterion for carriers is (port) *operational efficiency*. The least important criteria for both groups of actors are the institutional framework of the port and its ownership status, respectively. Opposite to earlier research, our innovation here is in confronting ports and carriers with each other's priorities. In competitive markets, such knowledge ought to influence decisions and the added value of this research is in the benefits of a 'better mutual understanding': when demand (carriers) and supply (ports) understand each other better, the result is a more pareto-efficient economic system, not only for the two players but for the greater society by and large.

1. Introduction

The competitiveness of ports has received its fair share of attention in the scientific literature, perhaps more than many other sectors of the economy. This, because of the crucial role of ports as indispensable *nodes* in fiercely competing global supply chains, as well as of the 'success story' of introducing private capital in ports, accompanied by the consequent institutional reforms.

Factors determining the competitiveness of ports are many and vary over time. Their importance, however, is weighed differently by different stakeholders. This is normal in piecemeal assessments (instead of a systems approach), which often resemble the time-honoured fable of the three blind men trying to assess an elephant. For instance, (port) costs may not be 'declared' of equal importance by all stakeholders, with some of them opting for higher efficiency in port operations, or better access to foreign markets (connectivity and centrality arguments), or better hinterland access. At the end of the day, however, everyone's interest is to minimize their costs, may this be achieved from higher operational efficiency, access to markets or from any of the above.

In the absence of a systems approach in the literature of port competitiveness (a project these authors are working on), the rankings attempted here through the *Fuzzy Analytic Hierarchy Process* (FAHP) methodology take us halfway to our final objective. There is a dual objective here, however, summarized in the paper's implicit questions: Are the criteria used by carriers in selecting a port of call in line with those valued as important by the ports themselves? Do the two actors, ship owners and ports, understand each other well? What is the value of a better 'understanding'? Would ship owners look at the larger picture (generalized costs), over and above their preoccupation with port efficiency? And would ports themselves understand that their (perhaps)

* Corresponding author.
E-mail addresses: sedat.bastug@iste.edu.tr (S. Baştuğ), haralambides@ese.eur.nl (H. Haralambides), soner.esmer@iste.edu.tr (S. Esmer), enes.eminoglu@gmail.com (E. Eminoğlu).

https://doi.org/10.1016/j.marpol.2021.104866
Received 2 August 2021; Received in revised form 28 October 2021; Accepted 3 November 2021
Available online 14 November 2021
0308-597X/

Table 1
Criteria Affecting Port Competitiveness.

No	Criteria from the perspective of liner shipping companies*	Criteria from the perspective of port operators**	Definition	References
1	Port costs	Port prices	Port costs refer to direct port costs, such as port dues, storage and stevedoring, container handling, drayage services, and premiums for peak periods; and indirect costs occurred during lengthy port stays.	[42],[65],[70],[72],[2],[32],[9],[57],[17],[66],[12],[48],[31],[49]
2	Hinterland proximity	–	Hinterland proximity concerns the distance to the main hinterland markets and locations with high container traffic.	[42],[70],[28],[62],[15],[32],[9],[66],[18],[30],[34],[55],[33]
3	Hinterland connectivity	–	Hinterland connectivity regards the time and costs of inland transport networks (e.g., rail and road transport).	[42],[70],[28],[25],[32],[14],[71],[66],[18],[1],[17],[68],[47]
4	Geographical location and accessibility	Port location	Geographical location is broadly defined as the spatial positioning of a port within shipping networks, local markets, local transport infrastructure, distribution centers, urban areas, etc. Accessibility is the capacity of a port to serve larger vessels regardless of weather and tidal conditions. This is influenced by natural factors (e.g., drafts and tidal ranges) and physical infrastructure (e.g., locks and breakwaters).	[42],[72],[32],[56],[15],[2],[64],[9],[30],[48],[34],[55],[33]
5	Port infrastructure	Port facilities	Port infrastructure and facilities are tangible assets needed to service port traffic. They include port equipment, refrigerated storage areas, breakwaters, quay walls, and yard surfaces).	[42],[65],[41],[56],[14],[30],[60],[12],[30],[35]
6	Operational efficiency	Cargo volume	Operational efficiency refers to a port's capacity to use all its assets intensively to provide optimal operational performance (e.g., ship waiting times, ship turnaround time, and cargo	[42],[41],[54],[32],[56],[60],[52],[58]

good fortune of a prime location ought not allow them to rest on their laurels but more needs to be done to attract the ship? As said, our questions are implicit and so are their answers. But by showing that ports and carriers think differently we have covered a lot of ground towards helping them to eventually start thinking similarly.

The paper is organized as follows: The relevant literature around *port competitiveness* is explored first. Next, the Fuzzy AHP process (FAHP) is introduced over container shipping and terminal operators, to discover whether the choice criteria used by carriers are in line with what the ports themselves consider as important for their competitiveness. Finally, our results are presented and discussed, followed by conclusions, the policy ramifications of our research, research limitations, and suggestions on follow up research.

2. Literature review

Generally, competitiveness refers to an organization's ability to deliver and sell its output more effectively than its local and foreign competitors [27]. In our case, a competitive port is one that shippers select more frequently than other available alternatives, thus enabling it to grow and increase its market share [37]. Heaver [24] defines port competitiveness as the capability to achieve comparative advantage through infrastructure development and quality of services. This concept is widely used in the analysis of the strategic decision-making behaviour of container terminal operators.

Many factors affect port competitiveness while its benefits, once there, are enjoyed by all 'stakeholders' and end-users: shippers, port operators, shipping companies, freight forwarders, shipping agents, road hauliers, and logistics operators. Naturally, each of those actors employs their own choice criteria, which often go beyond 'port competitiveness' and into generalized costs and global supply chain optimization.

Research on seaport competitiveness started in the early 1960 s, evolving gradually, and noticeably, towards research on the efficiency and competitiveness of container terminals. Earlier studies [11], [36], [67] on the criteria of port choice have considered navigational distances; proximity to hinterland cities; port tariffs; hinterland connectivity; average waiting time in port; port location; and port infrastructure. In their research, Tongzon and Sawant [57] concluded that port costs and the availability of certain port services are the critical factors in the port choice decision of carriers. Wiegmans et al. [66] found that the most important criteria for deep-sea container carriers were availability of hinterland connections, reasonable tariffs, and proximity to clients (large hinterland). Brooks et al. [6] argued that port competitiveness criteria vary, as do perceptions across port users. For instance, while liner shipping companies regard port costs (in a wider sense) as the most significant criterion, cargo owners instead care more about port location and hinterland connections [1]; i.e., generalized door-to-door costs. Following on this, Notteboom et al. [40] found a rise in competition among neighbouring ports, or what Haralambides [20] has coined 'ports in proximity'. Chang et al. [9] reported that the major determinants of port competitiveness are physical and operational capabilities (i.e., profitability of cargohandling operations, intermodal connections, local cargo volume, feeder connections, number of carriers, and transshipment cargo volumes), the operational performance of shipping lines, port development, port charges, and marketability. From their literature review, Parola et al. [42] found that port costs are the most important competitiveness criterion. However, these costs are not simply port dues and terminal handling charges (THC) of port authorities and terminal operators, but the overall costs incurred by the port user, including, for example, storage, transportation, and indirect costs like prolonged anchorage time in ports [26].

Naturally, infrastructure and port facilities appear to be very significant factors of port competitiveness in most studies, showing also that these factors vary considerably among ports. For instance, De Martino and Morvillo [14] classified port competitiveness criteria into *hard* ones (superstructure, infrastructure, inland logistics platforms, equipment, and geographical location) and *soft* criteria (supplied services, inter-organizational relationships between port stakeholders, communication systems, safety and security).

Operational efficiency has been assessed and measured in several ways, mostly through Data Envelopment Analysis (DEA). Usually, the objective here is to maximize 'port output' -given the port's endowments (inputs)-. This may involve the lowering of ship turnaround times at berth (or port waiting time in general), or increasing cargohandling productivity [42]. Among others, Yang et al. [69] related operational efficiency to port size, arguing that bigger ports are more efficient, due to economies of scale, often resulting in quality infrastructures, storage and cargohandling facilities. Related to port efficiency, is the concept of *service quality*, defined as the port's ability to provide differentiated services to customers, for instance, berthing and cargohandling speeds, reliability, availability, security, non-discriminatory access, and eco-friendliness [27]. Finally, the *reputation* of a port has also a role to play among its customers [4] who, incidentally, appear to care little about port ownership issues [19], [27].

Hales et al. [19] surveyed 28 experts and managers in eight major container ports[1] and tested several criteria using Fuzzy Analytic Hierarchy Process (FAHP). Subsequently, the authors built a hierarchical framework based on two main criteria: volume competitiveness (i.e., what they call competition for new business) and investment competitiveness (i.e., competition to attract new investments) and 10 sub-criteria (port prices, port facilities, cargo volumes, service level, port location, institutional status, reputation, financial resources, and legal framework). For port managers, *port location* was the most important competitiveness criterion. In contrast, analyzing the same variables in the same ports, Song and Yeo [48] found that port costs were the most important criterion for port operators. They suggested, however, that differences may be contextual, since price competition may be the most critical when port users have alternatives, as in the United States and the Far East. On the other hand, in regions with few alternatives, users may regard port location as the most significant criterion. Table 1 summarizes the findings of studies on port competitiveness (criteria).

Only few works, however, have examined port competitiveness also from the perspective of port terminals. The reason we attempt to do this here, jointly with carriers' own considerations of what is important for them in their choice of a port, is twofold: a) port competitiveness, as seen by an experienced global terminal investor and operator, is the single most important factor in their decision to invest in the port; b) understanding one's own competitiveness, as a terminal operator, enables them to improve and offer a better service to their customers (ships and cargo), thus augmenting competitiveness further. Firms -including carriers and terminals- engage in different analytic processes when making a decision, e.g., on which port to call at, in a certain region, or what last-mile infrastructure to finance. The parameters they use for this purpose, and the importance they ascribe to them are contextual. Most of the criteria we have used below are, therefore, different among terminals and carriers, and rankings similar to those of earlier studies, cited above, are not possible. Our innovation here is to confront each of the two players with the priorities and contingencies of the other, in the belief that a better mutual understanding is bound to lead to a more efficient overall system. In a game-theoretic perspective (to be pursued in our future research) knowledge of counterparty's priorities influences the formulation of one's own, towards a stable Pareto-optimality at the end of the game.

[1] Busan (South Korea), Los Angeles/Long Beach (United States), Le Havre (France), Inchon (South Korea), Chennai (India), Mayaguez (Puerto Rico), Melbourne (Australia), and New York/New Jersey (United States).

Table 1 (*continued*)

No	Criteria from the perspective of liner shipping companies*	Criteria from the perspective of port operators**	Definition	References
			handling productivity). Cargo volume refers to the productivity indicator which directly relates to the operational efficiency of the port. Many ports measure their operational efficiency by assessing their annual cargo volumes.	
7	Port service quality	Service level	Port service quality refers to the overall quality of port facilities (e.g., cargo handling and berthing speeds, reliability, service availability, security, non-discriminatory access, and eco-friendliness), and a port's ability to offer distinct services vis à vis its rivals. Service level often refers to the percentage of cargo offloaded or loaded within the port management's agreed time period (variance in agreed time) and the average unloading or loading time.	[27],[43],[42],[70],[28],[57],[17],[12],[48]
8	Maritime connectivity	–	Maritime connectivity refers to the efficiency of shipping networks (e.g., quantity and diversity of served destinations and logistics costs of transport networks).	[42],[56],[32],[1],[60],[39],[47]
10	–	Financial resources	This refers to the strength of a port's financial position, which determines its ability to attract investment capital.	[19,44]
11	Quality/ reputation	Port reputation	Port reputation is the widespread belief among customers that a port has value (e.g., reputation for limited pilfering and cargo damage, reliability, etc.).	[27],[43],[38],[4],[56],[13],[7]
12	–	Legal framework	The legal and regulatory framework is the set of constitutional, legislative, regulatory, jurisprudential, and managerial rules	[19]

(continued on next page)

Table 1 (*continued*)

No	Criteria from the perspective of liner shipping companies*	Criteria from the perspective of port operators**	Definition	References
			that define the autonomy of port management.	
13	Port ownership	Institutional structure	Port ownership refers to different institutional structures governing port management (e.g., public service ports, tool ports, landlord ports, and private sector ports).	[19,27]

Source: Authors.

* Adapted from [42].

** Adapted from [19].

'pivot' in global supply chains, particularly in the context of China's New Maritime Silk Road [23]. Other region-oriented studies involved the East and the Far-East. Two of the studies are literature reviews, while the majority are conceptual studies. Methodologies have included multi criteria decision making (MCDM); logistics regression; and data envelopment analysis. The 'dual perspective', i.e., carriers and terminals together, is attempted here for the first time.

3.2. The AHP Model

Developing the AHP model requires four main steps: data collection; construction of the hierarchical model in the form of a *tree structure* consisting of port competitiveness factors; construction the pair-wise comparison matrices that determine the relative weight of each factor; and evaluation of the weights of the different hierarchies [8]. The last step is based on the FAHP model.

3.2.1. Data Collection

The survey was conducted during March and April 2021. The questionnaire was distributed online to liner shipping companies and port operators. This was followed by telephone calls to the interviewees. These were selected using *judgmental sampling*, whereby interviewees are chosen based on the researcher's knowledge, experience and judgment [51]. Container terminal operators were selected from the Eastern Mediterranean region, while containership operators were selected from among the shipping lines calling at those ports. Possible relationships between terminals and carriers were not taken into account when selecting the criteria of each group. Such relationships, i.e., dedicated terminals (Haralambides et al., 2002) or terminal ownership, are rare in the researched region but wherever they exist they can influence the way the two actors prioritize their criteria.[2]

Forty valid questionnaires were returned by April 2021, corresponding to a response rate of 78%. Of these, 20 were from container terminal operators and 20 from liner shipping companies. Both sets of respondents were key decision-makers in top management roles, having had long experience in the industry (see Table 3), with 31 managers having between 11 and 29 years of experience, and 9 with 7–10 years experience.

3.2.2. Constructing the hierarchical model

First, a one-level hierarchical structure is developed, based on our literature review. Table 4 presents the major port selection criteria identified in the literature, by different researchers and their

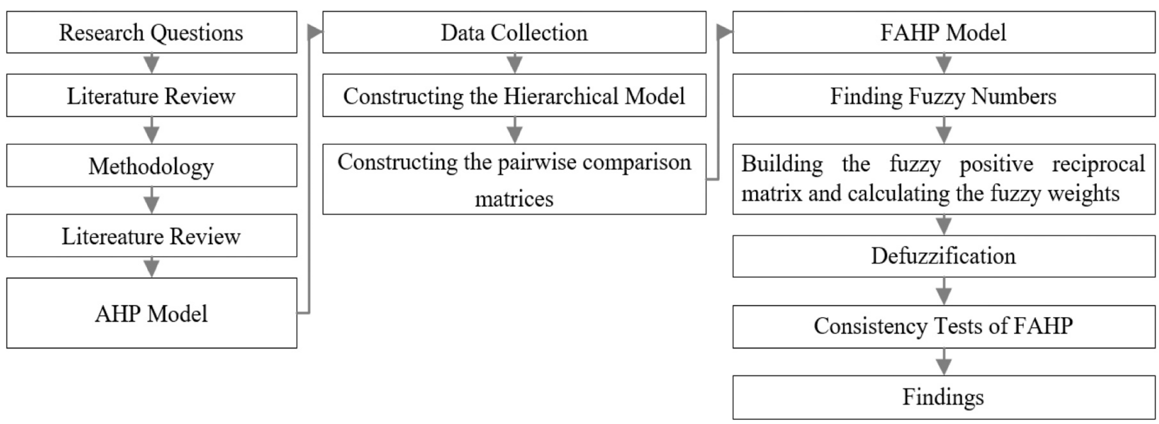

Fig. 1. The Research Design.

3. Methodology

Our methodology consists of a combination of literature review and the pursuant Analytic Hierarchy Process (AHP) modelling. The Fuzzy AHP model uses the pairwise comparison matrices, calculated by AHP. This relationship, between AHP and FAHP, as well as our research design, are illustrated in Fig. 1).

3.1. Literature search on port competitiveness criteria

Through a literature review we identify port competitiveness criteria from the perspective of ocean carriers and terminal operators. Relevant studies from 1985 to 2020 were analysed. Titles, keywords, and abstracts in scientific databases of high-impact journals were searched. The search keywords were: "port competitiveness"; "liner shipping companies"; "shipping lines"; "container shipping companies"; and "port operators". The search was limited to English language publications and transport-related peer-reviewed journals and proceedings. Although online databases have filtering functions, we also undertook manual cross-checking to eliminate mislabelled papers (e.g., labelling a book chapter or conference paper as a research article), irrelevant studies (e.g., historical or navy/defence industry papers), and duplicate sources. The refinement yielded 40 papers, shown in Table 2. High-impact maritime journals dominated this area of research. The focus of many studies is general, opposite to ours which is region-specific. This does not influence either the choice of methodology or our results, while providing insights on a region, the Eastern Mediterranean, considered a

[2] Reserved for future research.

Table 2
Descriptive Information of Studies.

#No	Author (s)	Journal	Published Date	Coverage	Type of Research
1	Brooks	Maritime Policy & Management	1985	Regional	L
2	Slack	Maritime Policy and Management	1985	General	R
3	Marti	Maritime Policy & Management	1990	General	R
4	Strandenes & Marlow	International Journal of Transport Economics	2000	General	R
5	Malchow & Kanafani	Maritime Policy & Management	2001	Regional	R
6	Tiwari et al.	Maritime Economics & Logistics	2003	Regional	R
7	Nir et al.	Maritime Policy & Management	2003	Regional	R
8	Lirn et al.	Maritime Economics & Logistics	2004	General	R
9	Song & Yeo	Maritime Economics & Logistics	2004	Regional	R
10	Malchow & Kanafani	TRE: Logistics and Transportation Review	2004	Regional	R
11	Wood	Maritime Policy & Management	2004	Regional	R
12	De Langen	Maritime Economics & Logistics	2004	Regional	R
13	Cullinane et al.	Maritime Policy & Management	2005	Regional	R
14	Guy & Urli	Maritime Economics & Logistics	2006	Regional	R
15	Ugboma et al.	Maritime Economics & Logistics	2006	Regional	R
16	Acosta et al.	Maritime Policy & Management	2007	Regional	R
17	Lin & Tseng	Maritime Policy & Management	2007	Regional	R
18	Guy & Alix	Journal of Transport Geography	2007	Regional	R
19	Tongzon & Sawant	Applied Economics	2007	General	R
20	De Martino & Morvillo	Maritime Policy & Management	2008	General	C
21	Rountree et al.	Journal of Financial Economics	2008	General	C
22	Wiegmans et al.	Maritime Policy & Management	2008	General	C
23	Chang et al.	Marine Policy	2008	General	R
24	Low et al.	TRA: Policy and Practice	2009	General	R
25	G.-Alonso & S.-Soriano	Maritime Economics & Logistics	2009	Regional	R
26	Anderson et al.	Maritime Economics & Logistics	2009	Regional	R
27	Tongzon	TRE: Logistics and Transportation Review	2009	Regional	R
28	Aronietis et al.	Proceedings of IAME 2010 Conference	2010	Regional	R
29	Onut et al.	Transport Policy	2011	Regional	R
30	Iannone	Maritime Economics & Logistics	2012	Regional	R
31	Yuen et al.	Research in Transportation Economics	2012	General	R
32	Van Asperen & Dekker	Maritime Economics & Logistics	2013	Regional	R
33	Kim	Maritime Economics & Logistics	2014	Regional	R
34	Yeo et al.	TRA: Policy and Practice	2014	General	C
35	Wang et al.	Transport Policy	2014	General	R
36	Nazemzadeh & Vanelslander	Maritime Economics & Logistics	2015	Regional	R
37	Hales et al.	Transportation Journal	2016	General	R
38	Parola et al.	Transport Reviews	2016	General	L
39	Rezaei et al.	Management decision	2019	General	R
40	Kaliszewski et al.	Marine Policy	2020	General	R

TRA: Transportation Research Part A: Policy and Practice.
TRE: Transportation Research Part E: Logistics and Transportation Review.
L: Literature Review, R: Research Paper, C: Conceptual Paper.
Source: Authors.

perspectives. Nine criteria were identified from studies on terminal operators and ten from liner shipping companies. These were coded for further analysis as in Table 4.

3.2.3. Constructing the pair-wise comparison matrices

The survey questionnaire was designed with a nine-point rating scale, inviting respondents to indicate the relative importance they attach to paired criteria.[3] Respondents evaluated seaport competitiveness based on the factors in Table 4, on a nine steps scale (1 = equal importance; 9 = absolute importance). The first part of the questionnaire provided detailed instructions on how to complete the pair-wise comparison scale, together with an explanation of the various factors. This proved important to familiarize respondents with pair-wise comparisons in an AHP survey and minimize inconsistent responses.

3.3. The FAHP model

The *Fuzzy Analytic Hierarchy Process* (FAHP), used here, is a technique for structuring data and for analysing multi-criteria decision-making (MCDM) problems. These regard complex decisions, in problems involving multiple objectives and multiple criteria affecting decisions. The method allows the researcher to employ many quantitative and qualitative criteria, and it has been used widely across different research areas, including port selection, transportation, personnel selection, performance evaluation, and job selection [5,29,31,38,59,61,65,74].

[48]. The AHP survey outcomes are combined with triangular fuzzy numbers (TFN) to produce the FAHP results. The model is analyzed based on the performance evaluation model [50]. This process has four main steps: identification of the fuzzy numbers; building the fuzzy

[3] Paired criteria match the criteria related to port competitiveness with each other. Pairwise comparisons allow researchers to analyze which criteria of port competitiveness are more important for both port operators *and* liner shipping companies.

Table 3
Profile of AHP respondents.

Port operators			Liner shipping companies		
#	Position	Years of experience	#	Position	Years of experience
1	Port Manager	18	21	Operations Manager	12
2	Port Manager	25	22	Operations Manager	29
3	Sales Vice-Manager	15	23	Deputy General Manager	23
4	Operations Director	18	24	Line Operation Director	22
5	Marketing Manager	15	25	Customer Relations Manager	10
6	Customer Service Expert	10	26	Project Manager	7
7	Marketing Manager	8	27	Sales Manager	11
8	Operations Manager	12	28	General Manager	22
9	Yard Operations Supervisor	9	29	General Manager	11
10	Marketing Manager	10	30	Customer Relations Manager	9
11	Port Manager	20	31	Vice-Sales Manager	9
12	Terminal Manager	13	32	Marketing Manager	12
13	Port Manager	8	33	General Manager	15
14	Shift Manager	13	34	Marketing Manager	13
15	Terminal Manager	16	35	General Manager	19
16	Marketing Manager	8	36	Line Operation Director	22
17	Agency Manager	15	37	Deputy General Manager	14
18	Customer Service Representative	12	38	Deputy General Manager	17
19	Terminal Manager	17	39	Operations Manager	8
20	Marketing Manager	16	40	Operations Manager	15

Table 4
Port Selection Criteria and their designations.

Codes	Port operators	Codes	Liner shipping companies
TO1	Port prices	LO1	Port costs
TO2	Port location	LO2	Hinterland proximity
TO3	Port facility	LO3	Hinterland connectivity
TO4	Cargo volume	LO4	Geographical location and accessibility
TO5	Service level	LO5	Port infrastructures
TO6	Financial resources	LO6	Operational efficiency
TO7	Port reputation	LO7	Port service quality
TO8	Legal framework	LO8	Maritime connectivity
TO9	Institutional status	LO9	Quality/reputation
		LO10	Port ownership

positive reciprocal matrix and calculation of the fuzzy weights; defuzzification and, finally, consistency check [31].

Step 1: Fuzzy numbers.

[73] defines a fuzzy set as a class of objects with a continuum of grades of membership, ranging from zero to one. A triangular fuzzy number is represented by three points and denoted as $\widetilde{A} = (l, m, u)$. The parameters l, m, and u define the smallest possible value, the most promising value, and the largest possible value, respectively. To create the *linguistics scale*, it is necessary to create a membership function consisting of the three parameters. A triangular membership function is defined as follows:

Table 5
FAHP Linguistic Scales.

Linguistic variables	The scale of fuzzy number	
	Triangular fuzzy scale	Reciprocal triangular fuzzy scale
Equal importance	(1,1,1)	(1/1, 1/1, 1/1)
Equal to moderate importance	(1,2,3)	(1/3, 1/2, 1/1)
Moderate importance	(2,3,4)	(1/4, 1/3, 1/2)
Moderately to strong importance	(3,4,5)	(1/5, 1/4, 1/3)
Strong importance	(4,5,6)	(1/6, 1/5, 1/4)
Strong to very strong importance	(5,6,7)	(1/7, 1/6, 1/5)
Very strong importance	(6,7,8)	(1/8, 1/7, 1/6)
Very strong to the absolute importance	(7,8,9)	(1/9, 1/8, 1/7)
Absolute importance	(8,9,9)	(1/9, 1/9, 1/8)

Source: Adapted from [3]

$$\mu_{\widetilde{A}}(x) = \begin{cases} (x-l)(m-l), 1 \le x \le m \\ (u-x)(u-m), m < x < u \\ 0, \textit{otherwise} \end{cases}$$

Step 2: Building the fuzzy positive reciprocal matrix and calculating the fuzzy weights.

Data from the 40 valid questionnaires were used to create fuzzy pairwise comparison matrices. In our case, the dimensions of the fuzzy positive reciprocal matrix are 9 × 9 for port operators and 10 × 10 for liner shipping companies. These are subsequently converted into a fuzzy positive reciprocal matrix using the geometric mean approach (the approach is the preferred group preference aggregation in AHP literature; see [50]).

The fuzzy comparison matrix is described, while each membership function (scale of fuzzy numbers), for the port choice criteria, of both sides (port operators and shipping companies) is derived using the [50] fuzzy performance evaluation model. The triangular fuzzy scales for decision-makers judgment are presented in Table 5. The nine-step scale used in the questionnaire consists of *linguistic variables*, i.e., whose values are words or sentences in a natural or artificial language.

Tables 6 and 7 present the aggregated decision matrices, calculated using the geometric mean method for decision judgments.

Step 3: Defuzzification.

Defuzzification is basically the conversion of triangular fuzzy numbers (l, m, u) into one logic value called "*crisp number*" [46]. Defuzzification was applied to determine whether port operators and shipping companies differed significantly in their judgments on port selection criteria. For this, a crisp number is required to check the consistency ratio of the comparison. We use the Best Non Fuzzy performance (BNP) method for crisp values, and for the final ranking of alternatives [50]. The optimum criterion of port competitiveness for each player is thus derived.

Step 4: Consistency Tests of FAHP.

The consistency test is a crucial step because a lack of consistency in comparisons may be evidence that the respondents did not understand the differences in the available choices, or were unable to evaluate correctly the relative importance of the factors compared [31]. Since there are nine dimensions for port operators and ten for liner shipping companies, the Random Consistency Index (RI) was 1.45 for n = 9 and 1.49 for n = 10. RI calculates the logical consistency of the results, indicating whether all statements are true [45]. Therefore, the Consistency Ratio (CR) were calculated, as 0.0362 for port operators, and 0.0542 for liner shipping companies respectively. In the AHP analysis, consistency tests are necessary for each matrix, and if the test is not

Table 6
Aggregated fuzzy judgemental matrix (port operators).

	TO1	TO2	TO3	TO4	TO5	TO6	TO7	TO8	TO9
TO1	(1.00, 1.00, 1.00)	(0.53, 0.63, 0.77)	(0.82, 1.10, 1.43)	(1.32, 1.69, 2.13)	(1.01, 1.28, 1.59)	(2.05, 2.62, 3.16)	(1.49, 1.90, 2.32)	(1.09, 1.31, 1.58)	(2.17, 2.72, 3.25)
TO2	(1.30, 1.60, 1.88)	(1.00, 1.00, 1.00)	(2.59, 3.38, 4.10)	(1.47, 1.95, 2.45)	(1.35, 1.72, 2.12)	(3.48, 4.66, 5.76)	(2.23, 2.83, 3.38)	(1.32, 1.64, 2.00)	(3.02, 3.84, 4.66)
TO3	(0.70, 0.91, 1.21)	(0.24, 0.30, 0.39)	(1.00, 1.00, 1.00)	(1.57, 2.05, 2.51)	(0.43, 0.53, 0.69)	(2.58, 3.36, 4.13)	(1.64, 2.10, 2.55)	(1.06, 1.40, 1.74)	(1.69, 2.29, 3.03)
TO4	(0.47, 0.59, 0.76)	(0.41, 0.51, 0.68)	(0.40, 0.49, 0.64)	(1.00, 1.00, 1.00)	(0.32, 0.40, 0.52)	(0.91, 1.17, 1.46)	(0.80, 1.00, 1.22)	(1.05, 1.28, 1.58)	(1.19, 1.54, 1.92)
TO5	(0.63, 0.78, 0.99)	(0.47, 0.58, 0.74)	(1.45, 1.89, 2.32)	(1.93, 2.52, 3.08)	(1.00, 1.00, 1.00)	(2.09, 2.64, 3.16)	(1.64, 2.07, 2.48)	(1.30, 1.84, 2.58)	(1.82, 2.36, 2.95)
TO6	(0.32, 0.38, 0.49)	(0.17, 0.21, 0.29)	(0.24, 0.30, 0.39)	(0.68, 0.85, 1.10)	(0.32, 0.38, 0.48)	(1.00, 1.00, 1.00)	(0.64, 0.84, 1.09)	(0.94, 1.15, 1.45)	(0.86, 1.09, 1.31)
TO7	(0.43, 0.53, 0.67)	(0.30, 0.35, 0.45)	(0.39, 0.48, 0.61)	(0.82, 1.00, 1.25)	(0.40, 0.48, 0.61)	(0.92, 1.20, 1.57)	(1.00, 1.00, 1.00)	(1.32, 1.60, 1.94)	(1.64, 2.09, 2.63)
TO8	(0.63, 0.76, 0.92)	(0.50, 0.61, 0.76)	(0.57, 0.72, 0.94)	(0.63, 0.78, 0.95)	(0.39, 0.54, 0.77)	(0.69, 0.87, 1.06)	(0.52, 0.62, 0.76)	(1.00, 1.00, 1.00)	(2.39, 2.89, 3.37)
TO9	(0.31, 0.37, 0.46)	(0.21, 0.26, 0.33)	(0.33, 0.44, 0.59)	(0.52, 0.65, 0.84)	(0.34, 0.42, 0.55)	(0.76, 0.92, 1.16)	(0.38, 0.48, 0.61)	(0.30, 0.35, 0.42)	(1.00, 1.00, 1.00)

Table 7
Aggregated fuzzy judgmental matrix (liner shipping companies).

	LO1	*LO2*	*LO3*	*LO4*	*LO5*	*LO6*	*LO7*	*LO8*	*LO9*	*LO10*
LO1	(1.00, 1.00, 1.00)	(0.47, 0.64, 0.90)	(0.40, 0.50, 0.66)	(0.42, 0.53, 0.70)	(0.43, 0.56, 0.77)	(0.43, 0.56, 0.73)	(0.58, 0.76, 0.97)	(1.37, 1.82, 2.35)	(2.28, 2.90, 3.45)	(2.86, 3.68, 4.40)
LO2	(1.11, 1.56, 2.11)	(1.00, 1.00, 1.00)	(0.66, 0.81, 1.07)	(0.45, 0.58, 0.78)	(0.58, 0.79, 1.08)	(0.39, 0.52, 0.73)	(0.46, 0.60, 0.82)	(2.71, 3.49, 4.20)	(1.82, 2.44, 3.06)	(2.08, 2.75, 3.40)
LO3	(1.52, 2.01, 2.52)	(0.94, 1.23, 1.52)	(1.00, 1.00, 1.00)	(0.58, 0.71, 0.91)	(2.08, 0.52, 0.69)	(0.40, 0.49, 0.64)	(0.41, 0.52, 0.69)	(1.39, 1.85, 2.29)	(1.32, 1.74, 2.17)	(1.86, 2.51, 3.15)
LO4	(1.43, 1.89, 2.36)	(1.27, 1.73, 2.22)	(1.10, 1.41, 1.72)	(1.00, 1.00, 1.00)	(0.78, 1.03, 1.36)	(0.97, 1.29, 1.68)	(0.75, 1.01, 1.28)	(2.28, 2.92, 3.47)	(0.84, 0.98, 1.17)	(1.01, 1.38, 1.97)
LO5	(1.29, 1.78, 2.34)	(0.93, 1.26, 1.71)	(1.46, 1.94, 2.45)	(0.74, 0.97, 1.28)	(1.00, 1.00, 1.00)	(0.38, 0.49, 0.66)	(0.42, 0.57, 0.79)	(0.83, 1.17, 1.65)	(1.08, 1.43, 1.89)	(2.02, 2.78, 3.45)
LO6	(1.37, 1.79, 2.30)	(1.37, 1.94, 2.55)	(1.56, 2.03, 2.50)	(0.59, 0.78, 1.04)	(1.52, 2.02, 2.61)	(1.00, 1.00, 1.00)	(1.57, 1.91, 2.21)	(2.85, 3.64, 4.35)	(2.16, 2.77, 3.39)	(2.80, 3.72, 4.65)
LO7	(1.04, 1.32, 1.72)	(1.21, 1.66, 2.19)	(1.44, 1.93, 2.44)	(0.78, 0.99, 1.33)	(1.26, 1.76, 2.40)	(0.45, 0.52, 0.64)	(1.00, 1.00, 1.00)	(2.46, 3.08, 3.82)	(2.48, 3.20, 3.84)	(2.58, 3.49, 4.41)
LO8	(0.43, 0.55, 0.73)	(0.24, 0.29, 0.37)	(0.44, 0.54, 0.72)	(0.29, 0.34, 0.44)	(0.60, 0.86, 1.21)	(0.23, 0.28, 0.35)	(0.26, 0.32, 0.41)	(1.00, 1.00, 1.00)	(0.53, 0.70, 0.94)	(1.21, 1.57, 1.89)
LO9	(0.29, 0.34, 0.44)	(0.33, 0.41, 0.55)	(0.46, 0.57, 0.75)	(0.86, 1.02, 1.19)	(0.53, 0.70, 0.93)	(0.29, 0.36, 0.46)	(0.26, 0.31, 0.40)	(1.06, 1.43, 1.90)	(1.00, 1.00, 1.00)	(2.28, 2.95, 3.60)
LO10	(0.23, 0.27, 0.35)	(0.29, 0.36, 0.48)	(0.32, 0.40, 0.54)	(0.51, 0.72, 0.99)	(0.29, 0.36, 0.50)	(0.22, 0.27, 0.36)	(0.23, 0.29, 0.39)	(0.53, 0.64, 0.82)	(0.28, 0.34, 0.44)	(1.00, 1.00, 1.00)

sufficient (e.g., 0.01 in Saaty's consistency validation), the corresponding part of the survey (or the whole survey) must be repeated. If the CR values are close to 0.1, this is an indication that respondents are more confident in their answers. This also affirms that the developed pair-wise comparison matrix is consistent and acceptable [45]. Our results indicate that the matrix of port operators is more 'confident' than the matrix of liner shipping companies. Tables 6 and 7 show that the aggregate matrix, based on the average of all respondents, is consistent. Next, the calculation of the priority of each criterion is used, for the calculation of the priority of each alternative. The individual pair-wise matrix of all respondents, for the alternatives under each criterion, is calculated and they are found consistent.

4. Findings

Table 8 lists all criteria for both port operators and liner shipping companies. For port operators, the most important criterion was *port location*, followed by *service level*, *port tariffs*, and *port facilities*. In contrast, the most important criterion for line operators was *operational efficiency*, followed by *port service quality*, *geographical location and accessibility*, and *port infrastructure*. The least important criteria for the two sets of respondents were *institutional status* and *port ownership*, respectively.

Table 9 presents the calculated fuzzy weights of the criteria of both actors. Values are listed in descending order from most important to least important.

5. Concluding discussion, policy ramifications, and limitations of research

Most of the port competitiveness literature has focused on port users [9,27,42,56,57,72], and rarely on port operators [19]. In contrast, this study has identified port selection criteria for both sets of economic agents, based on case-study data drawn from the Eastern Mediterranean, Turkey in particular.

Our findings suggest that the factors port operators consider important for the competitiveness of their port are not necessarily in line with those used by shipping companies when selecting a port. Interestingly, but not unexpectedly, *port location* is considered as the most important criterion by port operators. This, often, allows ports to sit back and rest on their laurels, thus neglecting improvements in *operational efficiency*, which is what carriers mostly value. A better understanding of each other's priorities has therefore been one of the objectives of this paper. This finding is consistent with Tongzon and Heng [58], who argue that carriers are preoccupied with operational efficiency more than any other port user. Validating our results further,

Table 8
Fuzzy Weights.

Port operators			Liner shipping companies		
Criteria	Fuzzy Weight	BNP	Criteria	Fuzzy Weight	BNP
TO1	(0.0961, 0.1436, 0.2129)	0.151	LO1	(0.0561, 0.0886, 0.1395)	0.095
TO2	(0.1481, 0.2248, 0.3299)	0.234	LO2	(0.0652, 0.1049, 0.1674)	0.113
TO3	(0.0806, 0.1230, 0.1877)	0.130	LO3	(0.0722, 0.0967, 0.1499)	0.106
TO4	(0.0538, 0.0799, 0.1218)	0.030	LO4	(0.0784, 0.1252, 0.1934)	0.132
TO5	(0.1013, 0.1545, 0.2326)	0.163	LO5	(0.0656, 0.1078, 0.1733)	0.116
TO6	(0.0397, 0.0585, 0.0897)	0.063	LO6	(0.1110, 0.1771, 0.2702)	0.118
TO7	(0.0560, 0.0820, 0.1244)	0.087	LO7	(0.0933, 0.1482, 0.2300)	0.157
TO8	(0.0570, 0.0844, 0.1265)	0.089	LO8	(0.0321, 0.0498, 0.0786)	0.054
TO9	(0.0336, 0.0493, 0.0755)	0.053	LO9	(0.0413, 0.0634, 0.0988)	0.068
			LO10	(0.0248, 0.0382, 0.0614)	0.041
Sum		1,0000	Sum		1,0000
CR		0,0362	CR		0,0542

Table 9
Respondent group comparisons.

Port operators		Rank	Liner shipping companies	
Criteria	Weight		Weight	Criteria
Port location	23.4%	1	18.6%	Operational efficiency
Service level	16.3%	2	15.7%	Port service quality
Port price	15.1%	3	13.2%	Geographical location and acc.
Port facility	13.0%	4	11.6%	Port infrastructures
Legal framework	8.9%	5	11.3%	Hinterland proximity
Port reputation	8.7%	6	10.6%	Hinterland connectivity
Cargo volume	8.5%	7	9.5%	Port costs
Financial resources	6.3%	8	6.8%	Quality/reputation
Institutional structure	5.3%	9	5.4%	Maritime connectivity
		10	4.1%	Port ownership

Wahyuni et al. [63] and Low et al. [32] also argue that operational efficiency is the most important factor in port competitiveness.

It might be opportune at this concluding part of the paper to mention that the issue of *port efficiency* has been analyzed more than sufficiently in the port economics literature, although one might argue that, in today's competition between global supply chains, to talk about the importance of port efficiency is to talk about the obvious. This said, one aspect of port efficiency which has not yet been sufficiently researched, and it ought to, concerns the fact that efficient ports generate themselves new cargo demand and trade. Moreover, efficient ports attract shipping companies, and these too generate new demand, trade and prosperity. As we have argued earlier (Haralambides, 2019), shipping and ports are both facilitators *and* promoters of trade and welfare.

Container shipping, in particular, is undergoing rapid and radical change. The apparently incessant growth in containership sizes, coupled with the (joint) control of tonnage by few powerful shipping alliances, pose new demands on ports for continuous improvement in their efficiency and productivity (for an extensive overview of the impacts these shipping trends have on modern port management, readers are directed to [22]). Ports, keen themselves to maintain and enhance their competitiveness, understand these developments very well and our research, maybe in a small measure, has contributed to this *understanding*. But the challenges facing modern ports, as a result of developments in container shipping, do not end here and we might be amiss not to continue this discourse for yet a while, below, always interested in the value of a better understanding between ports and their users.

Carrier demands of having their increasingly larger ships turned around in the same time as the smaller ones before, and do this within tightly fixed time-windows, present new challenges to ports. In short, these challenges include the allocation of more and bigger ship-to-shore (StS) cranes to work the ship; minimization of terminal movements and rehandles; handling congestion at the gate and surrounding city areas, and more.

In many instances, carriers demand *performance guarantees* and, often, non-performance (e.g., delays) penalties can be quite stiff. In the event of delays, the ship could even sail without waiting for cargo operations to be completed, something known as "cut and go". Demands for performance guarantees are becoming increasingly popular among carriers, given that, often, port performance statistics offered to them are limited to net crane or berth productivity only, without including breakdowns, idle times, hatch cover movements, lunch breaks, etc., or such important port productivity aspects as availability of pilots and tugs, and 'waiting time to berth'.

A point should be made here regarding developments in StS cranes. The lengthwise increase of the size of ships has reached its limits (currently 400 m). Further increases are possible only by increasing the width (beam) of the vessel, i.e., her number of rows (currently 24, or 61 m). This however approaches 'worryingly' the maximum outreach of the current generation of StSs installed around the world, and the addition of one more row on ships would render them useless and in need for replacement.[4]

Our findings on the importance of port location, also for carriers (with regard to port competitiveness), are also confirmed by Parola et al., [42]. From the carrier's point of view, port location is equivalent to minimization of voyage costs (deviations) and in this regard 'port centrality' is a factor of equal importance to 'port connectivity'. Naturally, 'location' and 'centrality' are far more important for transshipment hubs than gateways, where the usually higher port tariffs of domestic captive cargo would justify the deviation. From a 'hinterland perspective', location is also a top priority for shippers and forwarders, interested, naturally, to minimize overland transport costs, thus choosing among the regional alternatives the port closer to them, provided the latter also fulfills certain additional conditions [38]. For the cargo owner, *port connectivity* is also important, in terms of access to foreign markets where their products could be sold. Similar, obviously, are the considerations of port management on the importance of port location, given every port's existential preoccupation with expanding its captive hinterland as much as possible, particularly in an era of fuzzy and intertwined hinterlands as a result of regional port competition.

Song and Yeo [48] examined similar variables to Hales et al. [19], but their findings differ from US-based research, [16], which finds that port costs are the most significant factor for port operators. Such differences could also be contextual, however, since there are more container port alternatives in the United States and the Far East, something that intensifies price competition, vis à vis the importance of *location* in regions with few port alternatives, as in our case. One might also need to repeat, while closing this paper, what we already stressed in our introduction: such differences, if not such *conflicting* results, are not uncommon in piecemeal analyses, vis à vis systems approaches, or structural modelling. As a naïve example, *costs* are the most important consideration for everyone, ports, carriers and cargo owners alike. But lower costs can be the result of efficiency, centrality, connectivity, hinterland access and more. In the case of our example of the Eastern Mediterranean, Turkey in the specific, price competition is negligible and regulated port charges are comparatively low. Non-price

[4] Rotterdam World Gateway (RWG) is already receiving the world's largest StSs, of outreach of 26 rows, i.e., suitable for ships of 30,000 TEU.

competition is thus the way to compete, and *service level* becomes the second most important criterion for port operators. Ports have become agile as a result, offering feedering advantages to regional mega-ports and mega-carriers, in terms of low costs, flexibility, and proximity to hinterlands and local markets.

Our innovation, and contribution to the literature, has more policy ramifications, briefly summarized here. Our overriding objective has been to facilitate a better understanding amongst ports and their users. We pursued this by confronting each player with the priorities and contingencies of the other and the importance they ascribe to them. The underlying *driver* of this approach was that better mutual understanding leads to better decisions, towards a pareto-optimum equilibrium that maximizes social welfare. A port is a complex organization and, often, information necessary in decision-making is notoriously absent. At the danger of using an oversimplified example, carriers may not know the availability of infrastructure (e.g., berths) and nautical-technical services prior to arrival, and ports my not know the latest stowage-planning of the ship and thus the demands this creates on cargohandling operations.

Hopefully, our findings could provide a valuable comparative benchmarking tool regarding the port competitiveness criteria of liner shipping companies and port operators. Future research could attempt to formalize our approach through game-theoretic modelling of actor interactions, dealing also with the limitation of our research, that is, with the possible business links of the two actors in the case of dedicated terminals or port ownerships by carriers. Finally, in view of contextual specificities, more regional applications would definitely add value.

References

[1] M. Acosta, D. Coronado, M. Mar Cerban, Port competitiveness in container traffic from an internal point of view: the experience of the Port of Algeciras Bay, Marit. Policy Manag. 34 (5) (2007) 501–520.
[2] C.M. Anderson, J.J. Opaluch, T.A. Grigalunas, The demand for import services at US container ports, Marit. Econ. Logist. 11 (2) (2009) 156–185.
[3] K.P. Anagnostopoulos, M. Gratziou, A.P. Vavatsikos, Using the fuzzy analytic hierarchy process for selecting wastewater facilities at prefecture level, Eur. Water 19 (20) (2007) 15–24.
[4] Aronietis, R., Van de Voorde, E., Vanelslander, T.2010, July. Port competitiveness determinants of selected European ports in the containerized cargo market. In Proceedings of IAME 2010 Conference. (Lisbon).
[5] G. Balci, I.B. Cetin, S. Esmer, An evaluation of competition and selection criteria between dry bulk terminals in Izmir, J. Transp. Geogr. 69 (2018) 294–304.
[6] M.R. Brooks, T. Schellinck, A.A. Pallis, A systematic approach for evaluating port effectiveness, Marit. Policy Manag. 38 (3) (2011) 315–334.
[7] Mary R. Brooks, An alternative theoretical approach to the evaluation of liner shipping Part II. Choice criteria, Marit. Policy Manag. 12 (2) (1985) 145–155.
[8] D.Y. Chang, Applications of the extent analysis on fuzzy AHP, Eur. J. Oper. Res. 95 (1996) 649–655.
[9] Y.T. Chang, S.Y. Lee, J.L. Tongzon, Port selection factors by shipping lines: different perspectives between trunk liners and feeder service providers, Mar. Policy 32 (6) (2008) 877–885.
[11] F.M. Collison, North to Alaska: marketing in the Pacific Northwest–Central Alaska linear trade, Marit. Policy Manag. 11 (2) (1984) 99–112.
[12] K. Cullinane, Y. Teng, T.F. Wang, Port competition between Shanghai and Ningbo, Marit. Policy Manag. 32 (4) (2005) 331–346.
[13] De Langen, P. W, Governance in seaport clusters, Marit. Econ. Logist. 6 (2) (2004) 141–156.
[14] M. De Martino, A. Morvillo, Activities, resources, and inter-organizational relationships: Key factors in port competitiveness, Marit. Policy Manag. 35 (6) (2008) 571–589.
[15] L. Garcia-Alonso, J. Sanchez-Soriano, Port selection from a hinterland perspective, Marit. Econ. Logist. 11 (3) (2009) 260–269.
[16] Grigalunas, T., M. Luo, S. Trandafir, C. Anderson, S. Kwon. (2004). "Issues in Container Transportation in the Northeast: Background, Framework, Illustrative Results and Future Directions." Report of URITC Project No. 536185, University of Rhode Island Transportation Center.
[17] E. Guy, B. Urli, Port selection and multicriteria analysis: an application to the Montreal-New York alternative, Marit. Econ. Logist. 8 (2) (2006) 169–186.
[18] E. Guy, Y. Alix, A successful upriver port? container shipping in Montreal, J. Transp. Geogr. 15 (1) (2007) 46–55.
[19] D. Hales, J.S. Lee Lam, Y.T. Chang, The balanced theory of port competitiveness, Transp. J. 55 (2) (2016) 168–189.
[20] H.E. Haralambides, Competition, excess capacity and the pricing of port infrastructure, Marit. Econ. Logist. Former. Int. J. Marit. Econ. 4 (2002) 323–347.
[22] H.E. Haralambides, Gigantism in container shipping, ports, and global logistics: a time-lapse into the future, Marit. Econ. Logist. 21 (1) (2019) 1–60.
[23] HE Haralambides, Olaf Merk, The Belt and Road Initiative: Impacts on Global Maritime trade flows'. International Transport Forum Discussion Papers, OECD Publishing, Paris, 2020. No. 2020/02.
[24] T.D. Heaver, The implications of increased competition among ports for port policy and management, Marit. Policy Manag. 22 (2) (1995) 125–133.
[25] F. Iannone, A model optimizing the port-hinterland logistics of containers: the case of the Campania region in Southern Italy, Marit. Econ. Logist. 14 (1) (2012) 33–72.
[26] J. Jiang, L.H. Lee, E.P. Chew, C.C. Gan, Port connectivity study: an analysis framework from a global container liner shipping network perspective, Transp. Res. Part E: Logist. Transp. Rev. 73 (2015) 47–64.
[27] A. Kaliszewski, A. Kozłowski, J. Dąbrowski, H. Klimek, Key factors of container port competitiveness: a global shipping lines perspective, Mar. Policy 117 (2020), 103896.
[28] J.Y. Kim, Port user typology and representations of port choice behavior: a Q-methodological study, Marit. Econ. Logist. 16 (2) (2014) 165–187.
[29] K.X. Li, K.C. Lin, M. Jin, K.F. Yuen, Z. Yang, Y. Xiao, Impact of the belt and road initiative on commercial maritime power, Transp. Res. Part A: Policy Pract. 135 (2020) 160–167.
[30] L.C. Lin, C.C. Tseng, Operational performance evaluation of major container ports in the Asia-Pacific region, Marit. Policy Manag. 34 (6) (2007) 535–551.
[31] T.C. Lirn, H.A. Thanopoulou, M.J. Beynon, A.K.C. Beresford, An application of AHP on transshipment port selection: a global perspective, Marit. Econ. Logist. 6 (1) (2004) 70–91.
[32] J.M. Low, S.W. Lam, L.C. Tang, Assessment of hub status among Asian ports from a network perspective, Transp. Res. Part A: Policy Pract. 43 (6) (2009) 593–606.
[33] M. Malchow, A. Kanafani, A disaggregate analysis of factors influencing port selection, Marit. Policy Manag. 28 (3) (2001) 265–277.
[34] M.B. Malchow, A. Kanafani, A disaggregate analysis of port selection, Transp. Res. Part E: Logist. Transp. Rev. 40 (4) (2004) 317–337.
[35] B.E. Marti, Geography and the cruise ship port selection process, Marit. Policy Manag. 17 (3) (1990) 157–164.
[36] R.J. McCalla, Canadian container ports: how have they fared? How will they do? Marit. Policy Manag. 21 (3) (1994) 207–217.
[37] Merk, O.2013. The competitiveness of global port-cities: synthesis report.
[38] M. Nazemzadeh, T. Vanelslander, The container transport system: selection criteria and business attractiveness for North-European ports, Marit. Econ. Logist. 17 (2) (2015) 221–245.
[39] A.S. Nir, K. Lin, G.S. Liang, Port choice behavior from the perspective of the shipper, Marit. Policy Manag. 30 (2) (2003) 165–173.
[40] T. Nottebottom, C. Ducruet, P.W. de Langen (Eds.), Ports in proximity: Competition and coordination among adjacent seaports, Ashgate, Aldershot, 2009.
[41] S. Onut, U.R. Tuzkaya, E. Torun, Selecting container port via a fuzzy ANP-based approach: A case study in the Marmara Region, Turkey, Transp. Policy 18 (1) (2011) 182–193.
[42] F. Parola, M. Risitano, M. Ferretti, E. Panetti, The drivers of port competitiveness: a critical review, Transp. Rev. 37 (1) (2016) 116–138.
[43] Rezaei, J., van Wulfften Palthe, L., Tavasszy, L., Wiegmans, B., & van der Laan, F. (2019). Port performance measurement in the context of port choice: an MCDA approach. Management decision.
[44] B. Rountree, J.P. Weston, G. Allayannis, Do investors value smooth performance? J. Financ. Econ. 90 (3) (2008) 237–251.
[45] R.W. Saaty, The analytic hierarchy process—what it is and how it is used, Math. Model. 9 (3–5) (1987) 161–176.
[46] Sangaiah, A.K., Gao, X.Z., & Abraham, A. (Eds.). (2016). Handbook of Research on Fuzzy and Rough Set Theory in Organizational Decision Making. IGI Global.
[47] B. Slack, Containerization, inter-port competition, and port selection, Marit. Policy Manag. 12 (4) (1985) 293–303.
[48] D.W. Song, K.T. Yeo, A competitive analysis of Chinese container ports using the analytic hierarchy process, Marit. Econ. Logist. 6 (1) (2004) 34–52.
[49] S.P. Strandenes, P.B. Marlow, Port pricing and competitiveness in short sea shipping, Int. J. Transp. Econ. 27 (3) (2000) 315–334.
[50] C.C. Sun, A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods, Expert Syst. Appl. 37 (12) (2010) 7745–7754.
[51] Taherdoost, H.2016. Sampling methods in research methodology; how to choose a sampling technique for research. How to Choose a Sampling Technique for Research (April 10, 2016).
[52] W.K. Talley, Port performance: an economics perspective, Res. Transp. Econ. 17 (2006) 499–516.
[54] L.C. Tang, J.M. Low, S.W. Lam, Understanding port choice behavior—a network perspective, Netw. Spat. Econ. 11 (1) (2011) 65–82.
[55] P. Tiwari, H. Itoh, M. Doi, Shippers' port and carrier selection behavior in China: a discrete choice analysis, Marit. Econ. Logist. 5 (1) (2003) 23–39.
[56] J.L. Tongzon, Port choice and freight forwarders, Transp. Res. Part E: Logist. Transp. Rev. 45 (1) (2009) 186–195.
[57] J.L. Tongzon, L. Sawant, Port choice in a competitive environment: From the shipping lines' perspective, Appl. Econ. 39 (4) (2007) 477–492.
[58] J. Tongzon, W. Heng, Port privatization, efficiency, and competitiveness: some empirical evidence from container ports (terminals), Transp. Res. Part A Policy Pract. 39 (5) (2005) 405–424.
[59] P.H. Tseng, K. Cullinane, Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model, Marit. Policy Manag. 45 (4) (2018) 422–438, 2018.
[60] C. Ugboma, O. Ugboma, I.C. Ogwude, An analytic hierarchy process (AHP) approach to port selection decisions – empirical evidence from Nigerian ports, Marit. Econ. Logist. 8 (3) (2006) 251–266.

[61] O.S. Vaidya, S. Kumar, Analytic hierarchy process: an overview of applications, Eur. J. Oper. Res. 169 (1) (2006) 1–29.
[62] E. Van Asperen, R. Dekker, Centrality, flexibility and floating stocks: A quantitative evaluation of port-of-entry choices, Marit. Econ. Logist. 15 (1) (2013) 72–100.
[63] Wahyuni, S., Taufik, A.A., & Hui, F.K. P. (2020). Exploring key variables of port competitiveness: evidence from Indonesian ports. Competitiveness Review: An International Business Journal.
[64] Y. Wang, K. Cullinane, Measuring container port accessibility: an application of the Principal Eigenvector Method (PEM), Marit. Econ. Logist. 10 (1) (2008) 75–89.
[65] Y. Wang, G.T. Yeo, A.K. Ng, Choosing optimal bunkering ports for liner shipping companies: a hybrid Fuzzy-Delphi–TOPSIS approach, Transp. Policy 35 (2014) 358–365.
[66] B.W. Wiegmans, A.V.D. Hoest, T.E. Notteboom, Port and terminal selection by deep-sea container operators, Marit. Policy Manag. 35 (6) (2008) 517–534.
[67] M.C. Willingale, The port-routing behavior of short-sea ship operators; theory and practice, Marit. Policy Manag. 8 (2) (1981) 109–120.
[68] G. Wood, Tanzanian coastal and inland ports and shipping: crises and policy options, Marit. Policy Manag. 31 (2) (2004) 157–171.
[69] H. Yang, K. Lin, O.R. Kennedy, B. Ruth, Sea-port operational efficiency: an evaluation of five Asian ports using stochastic frontier production function model, J. Serv. Sci. Manag. 4 (03) (2011) 391–399.
[70] G.T. Yeo, A.K. Ng, P.T.W. Lee, Z. Yang, Modeling port choice in an uncertain environment, Marit. Policy Manag. 41 (3) (2014) 251–267.
[71] G.T. Yeo, M. Roe, J. Dinwoodie, Evaluating the competitiveness of container ports in Korea and China, Transp. Res. Part A Policy Pract. 42 (6) (2008) 910–921.
[72] C.L.A. Yuen, A. Zhang, W. Cheung, Port competitiveness from the users' perspective: an analysis of major container ports in China and its neighboring countries, Res. Transp. Econ. 35 (1) (2012) 34–40.
[73] L.A. Zadeh, "Fuzzy Sets." (doi:), Inf. Control 8 (3) (1965) 338–353, https://doi.org/10.1016/S0019-9958(65)90241-X.
[74] X. Zhang, J.S.L. Lam, A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: a case of maritime organizations, Marit. Policy Manag. 46 (7) (2019) 781–799, 2019.