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PORT SELECTION USING ANALYTIC HIERARCHY PROCESS WITH PERFECT CONSISTENCY

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ABSTRACT

The Analytic Hierarchy Process is used for port selection, along the East-West trade route from the perspective of a shipping company. Six criteria and eight ports are identified. The hierarchy of the problem is constructed and pair-wise comparisons of the elements of each level are made using a nine-point Likert scale. A questionnaire was designed to suit to a newly proposed Analytic Hierarchy Process procedure which contributed to reducing the number of pairwise comparisons and establishing perfect consistency of all matrices. The current results show that cargo volume and port infrastructure are the most important criteria, thus reflecting the dynamic nature of the container shipping market and addressing the need for continuous monitoring of the changes that take place and for corresponding flexible port management plans capable of accommodating the consequences of such changes in order to keep their market share. Based on these criteria the ports were ranked.

KEYWORDS: *Port Selection, Shipping Companies, The Analytic Hierarchy Process, Perfect Consistency*

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1. INTRODUCTION

In most ports studies, the main performance indicator used for port activity is the annual throughput, e.g. Song and Yeo (2004); Alonso and Bofarull (2007) and Cheon, et al. (2010).World container port throughput was well over 63 million TEUs in the year 2000, increased up to 88 million TEUs in 2005, grew to 115 million TEUs in 2010, reached135 million TEUs by 2015 and achieved 145 million TEUs in 2017 (UNCTAD, 2017). Global container trade has grown by 4.3% in 2017, up from 3.4% in 2016, and further gradual improvement in container trade growth to 4.6% is expected in 2018 (Clark sons Research, 2017).

In consequence, shipping companies demand higher terminal performance, better quality of service and lower prices (Wang and Cullinane, 2006). On the other hand, considering the new trends and technologies of the global trading systems, the ports are obliged to meet the ship operator’s requirements in order to retain a competitive advantage (Ha, 2003). The quality of services has become a major factor affecting the customer’s selection of terminals and ports, especially main hubs, to be used. However, port selection is a Multi-Criteria Decision Making (MCDM) process; a lot of criteria, with different weights, contribute to this process.

Container shipping routes can be divided into three main groups: East-West trade, North-South trade and intra -regional trade. UNCTAD(2016) highlighted the share percentage of the world trade, which indicated that the East West trade route is the main market in the global transshipment system, with a 42% market share, followed by the intra regional trade and the North-South trade, which accounted for 40% and 18%, respectively. Therefore, this research focuses on the port selection process of container ports in the East-West trade route market using the Analytic Hierarchy Process (AHP) model. The research analyses and assesses the selection criteria in the defined market for the 15-year period between 2000 and 2015, and is limited to the large and medium-sized container ports, with throughput greater than 1,000,000 TEUs in 2015.The remainder of the paper is structured as follows. Section 2reviews and analyses the literature based on the various types of studies on port selection, Section 3 illustrates the methodology and techniques used, Section 4discusses weight age of criteria, Section 5prioritises and ranks ports, Section 6 concludes the paper and suggests recommendations to the parties involved in this industry and for future work.

2. LITERATURE REVIEW

Most studies on the port selection confirmed that there are several players that could be decisive in port selection processes, with shipping lines the most important player at all (Bichou and Gray, 2004; Ding, 2007; Chang, et al. 2008 and Tongzon, 2009). Since shipping lines need to select ports of call to deliver and tranship containers and extend their logistics services, port selection criteria have to be identified and decisions have to be made accordingly. Table (1) gives a summary of pertinent port selection criteria literature reviewed from 2000 to 2017 and reveals a considerable range of criteria of different importance, which are hard to include in a single study. For shipping companies, the most important criteria are seen to be port cost, location, cargo volume, infrastructure, quality of services and efficiency and performance, with most of the investigations using a narrow range of criteria. Also, the review demonstrates that research on port selection has focused on specific markets such as the Far East, Chinese and Korean container ports, as well as European and US container ports. It also reveals a low research thrust in the East West trade route, although trade along this route is mainly containerized cargoes. Table (1) also shows that important criteria differ with the development and growth of containerization, some criteria have lost importance, e.g. internal transportation rate, port management and frequency of ship visits, while others have been recently become more important, e.g. cargo volume and Electronic information and technology.

3. RESEARCH METHODOLOGY

The current research examines how liner shipping companies can use AHP in choosing ports in the East West trade route. To meet this objective, a methodology based on quantitative analysis of available data for a period of 15 years, between 2000 and 2015, will be considered. As a first step, secondary data are collected and key port selection criteria are identified with consideration of shipping line perspective. Also, eight representative ports along the East West trade route will be selected as case ports. Then, primary data are composed using a questionnaire which is designed and distributed to targeted groups with the aim to empirically examine shipping lines choice behavior on the East West trade route. In the third step, examining and processing the data collected from the questionnaire, participants will be conducted to rank the alternative ports considered.

Table 1: Port Selection Criteria Literature Reviewed from 2000 to 2017

Author (s)	Year	Area of Study	Criteria																			
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Gonzatez and Gaulda	2000	Brazil		√				√		√				√								
Malchow and Kanifani	2001	USA			√				√		√	√										

Table 1: Contd.,

Tongzon	2002		√						√	√				√								
Tiwari, et al.	2003	China			√			√	√		√									√		
Nir, et al.	2003	Taiwan	√	√					√		√											
Ha	2003	Korea	√	√	√					√			√			√	√					
Lirn, et al.	2004	Taiwan		√	√			√									√					
Song and Yeo	2004	China	√	√	√	√		√		√												
Blonigen and Wilson	2006	USA		√	√							√										
Ng	2006	Europe	√		√					√												
De Langen	2007	Austria		√						√												
Acosta, et al.	2007	Algeciras				√	√	√														
Wiegmans, et al.	2008	Europe	√	√	√					√			√		√		√	√				
Chang, et al.	2008	Intra-Asia		√		√								√				√	√	√		
Grosso and Monteiro	2008	Genoa		√			√							√		√				√		
Tongzon,	2009	Asia		√	√			√	√	√									√	√		
Aronietis, et al	2010	Europe		√				√				√			√			√				
Grosso and Monteiro	2011	Med. ports		√			√							√	√	√	√					
Wang	2012	East Asia		√										√	√		√					
Donatus and Onweg	2013	Nigeria						√	√			√								√		
Saeed and Aaby	2013	Europe					√						√		√							
Sayareh et al.	2014	Persian Gulf	√	√	√			√						√		√	√			√	√	√
Caldeirinha, and Felicio	2014	Europe		√	√		√	√		√				√						√		
Zarei	2015	Iran						√		√							√		√			
Dyck and Ismael	2015	West Africa		√	√	√		√						√						√		√
Zabihi, et al.	2016	Iran		√	√									√	√					√		
Ayanthi, et al.	2016	Sri Lanka		√	√									√						√	√	
Hales, et al.	2017					√		√						√						√		
Kutin, et al.	2017	Asia			√			√						√								

A: Time in port - **B:** Port cost - **C:** Port location - **D:** Cargo volume - **E:** Port logistics and activities – **F:** Port infrastructure G**:** Frequency of ship visits - **H:** Quality of service - **I:** Number of available routes - **J:** Internal transportation rate – **K:** Value added services - **L:** Port performance and productivity **- M:** Port hinterland connection - **N:** Electronic information and technology – **O:** Port management and administration - **P:** Port reliability – **Q:** Port reputation **R:** Port efficiency – **S:** Port security - **T:** Political stability

3.1. Selection of Criteria

The literature review revealed a considerable range of criteria affecting the decision of port choice. After refinery, the current research adopts the following criteria: port finance (C_1); port location (C_2); cargo volume (C_3); port infrastructure (C_4); port efficiency and performance (C_5) and application of new technology (C_6).

Port finance generally impacts supply chain cost (Dyck and Ismael, 2015), whereas strategic port location provides efficient transportation through the supply chain (Aaby, 2012). Handling more cargoes means more preferable port from the viewpoint of users (Song and Yeo, 2004). Port infrastructure affects the level of service ports provide to users and has a crucial role to play in increasing port throughput and reducing port congestion. Port efficiency and performance directly influence the efficiency of shipping companies and other port users (Tongzon and Ganesalingam, 1994; Wang, 2012). New technology, including cargo handling information, cargo tracing information and port management information system and communication systems control the movement of vessels and reduce waiting time in port and maritime accidents (Acosta, et al., 2007).

3.2. Selection of Alternatives

As has been mentioned earlier, the current research will consider eight ports along the East West trade route, which are ranked among the world's top 50 ports in terms of container throughput per annum (Clark sons Research, 2017).

These are: Shanghai (A_1), Singapore (A_2), Jebel Ali (A_3), Port Said East (A_4), Algeciras (A_5), Hamburg (A_6), Antwerp (A_7) and New York (A_8),each having a throughput equal to or greater than a million TEUs in 2016. The selection of these ports is based on dividing the route into four segments: Asia, Middle East, Western Europe and East Coast of America. From each segment, a number of representative ports, between 1 and 3, are chosen; within each segment, distance between ports was also taken into account for better coverage.

3.3. Decision Making with Analytic Hierarchy Process

Since it was first introduced by Saaty (1980), the AHP has been acknowledged as a powerful and direct tool to support decision makers. At AHP, a goal should be set up for decision making; then the criteria are singled out and several alternatives are identified. Data are derived by using a set of pairwise comparisons to obtain the weights of importance of the criteria, and the priorities of the alternatives in terms of each individual criterion. The main advantage of AHP is the structuring of the problem, where the decision problem is disassembled into its smallest elements and the importance of each criterion becomes clear, which can then be analyzed independently. A limitation of AHP is that the number of pairwise comparisons requested can be very high; the more criteria and alternatives are included, the more pair -wise comparisons need to be made. In addition, the method has an artificial limitation due to the use of the nine-point scale of Table (2). The total or final priorities of alternatives are synthesized by means of a grouping procedure, where a new pairwise comparison matrix for the group is constructed aggregating the individual judgements by means of the weighted geometric mean to obtain the total or final priorities of the alternatives.

Table 2: Pair Wise Comparison Scale of Importance (Saaty, 1980)

Intensity of Relative Importance	Definition
9	Extreme importance
8	Demonstrated to extreme importance
7	Demonstrated importance
6	Strong to demonstrated importance
5	Essential or strong importance
4	Moderate to strong importance
3	Moderate importance
2	Equal to moderate importance
1	Equal importance

The outcome of this aggregation is a normalized vector of the overall priorities of the alternatives. Accordingly, the alternatives are ranked and the most appropriate decisions can be taken. The following equations constitute part of the above outlined procedure:

Sum of the elements $a_{ij}$of the j^{th} column in a pairwise comparison matrix is :

$$\Phi_j = \sum_{i=1}^{n} a_{ij,} \; i,j = 1,2,\ldots\ldots,n_, \tag{1}$$

where n is the number of criteria or alternatives.

The geometric mean of thei^{th} row is given by:

$$w_i^* = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \tag{2}$$

The weights w_i are obtained by normalizing $w_i^*$with respect to their sum:

$$w_i = \frac{w_i^*}{\sum_{i=1}^{n} w_i^*} \tag{3}$$

3.3.1. Consistency of Pair Wise Comparison Matrices

The consistency check is an important part of AHP in order to verify the consistency of data. This technique encompasses the calculation of a suitable Consistency Index (CI) given by:

$$\text{CI} = \frac{\lambda \max - n}{n-1}, \tag{4}$$

where λ_{max} is the highest eigenvalue given by multiplying the row vector ($\boldsymbol{\Phi}$) of Eq. (1) By the column vector ($\boldsymbol{w}$) of Eq. (3), that is:

$$\lambda_{max} = \boldsymbol{\Phi}.\boldsymbol{w} = \Phi_1 w_1 + \Phi_2 w_2 + \cdots + \Phi_n w_n \tag{5}$$

When the pairwise comparison matrices are completely consistent, the priority vector is given by the right eigenvector ($\boldsymbol{w}$) corresponding to the highest eigenvalue (λ_{max}). The final consistency ratio (CR) is calculated as the ratio of the consistency index (CI) and the random consistency index (RI) given in Table (3), to conclude whether the evaluations are sufficiently consistent, i.e.

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \tag{6}$$

Saaty (1980) argued that the inconsistency should not be higher than 10%. CR > 10% means that the consistency of the pairwise comparisons is insufficient.

Table 3: Random Consistency Index RI (Saaty, 1980)

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

3.3.2. Treatment of Inconsistency and AHP Limitations

With AHP, a substantial number of pairwise comparisons N need to be completed, as given by the equation:

$$N = \frac{n}{2}(n-1) + n\left[\frac{m}{2}(m-1)\right], \tag{7}$$

where m is the number of alternatives and n the number of criteria.

This approach has the disadvantage that the number of pairwise comparisons to be made may become very large, as it depends on values of m and n.In the current research, where 6 criteria and 8 alternatives are considered, each and every expert participant has to make183 pairwise comparisons. This high number of comparisons can quickly become overwhelming to the expert and comparisons may be entered with a small relaxing time in order to speed up the process. Therefore, it is proposed herein to enter fewer comparisons only, which can be well evaluated, and to deduce the remaining entries using the property:

$$a_{ij} = a_{ik} * a_{kj} = {}^{a_{kj}}/_{a_{ki}}, i = 1, 2, \dots, n\,; j = 1, 2, \dots, m\,; k = 1, 2, \dots, n \; or \; m \tag{8}$$

By doing so, the number of entries N^* requested from each expert will be reduced to:

$$N^* = (n-1) + n(m-1) \tag{9}$$

For $n = 6$ and $m = 8$, $N^* = 47$ comparisons only, which represent about 30% of the initial number of comparisons, N = 183.Table (4) comperes the numbers of pair wise comparisons using the original AHP procedure and the procedure proposed in the current research.

Table 4: Comparing Number of Pair Wise Comparisons in Original and Proposed Procedures

m \ n	1	2	3	4	5	6	m \ n	1	2	3	4	5	6
1	0	1	3	6	10	15	**1**	0	1	2	3	4	5
2	1	3	6	10	15	21	**2**	1	3	5	7	9	11
3	3	7	12	18	25	33	**3**	2	5	8	11	14	17
4	6	13	21	30	40	51	**4**	3	7	11	15	19	23
5	10	21	33	46	60	75	**5**	4	9	14	19	24	29
6	15	31	48	66	85	105	**6**	5	11	17	23	29	35
7	21	43	66	90	115	141	**7**	6	13	20	27	34	41
8	28	57	87	118	150	**183**	**8**	7	15	23	31	39	**47**
Original AHP procedure, Eq. (7)							Proposed AHP procedure, Eq. (9)						

Reducing the number of comparisons is, in fact, not the main advantage of the proposed procedure, but by comparing the elements of one row (or column) and deducing the remaining entries provides a perfect consistency of judgements and waives the need for the consistency check. This can be further illustrated in the following numerical example.

Suppose that weights of four decision criteria need to be evaluated in terms of pairwise comparisons, and that the following table represents the judgement matrix when the four decision criteria are compared by an expert.

Table 5

Criterion	X_1	X_2	X_3	X_4	w^*	w
X_1	1.000	2.000	4.000	2.000	2.000	0.451
X_2	0.500	1.000	2.000	1.000	1.000	0.225
X_3	0.250	0.500	1.000	4.000	0.841	0.190
X_4	0.500	1.000	0.250	1.000	0.595	0.134
Total	**2.250**	**4.500**	**7.250**	**8.000**	**4.436**	**1.000**

To accomplish this step, one has to estimate the right principal eigenvector of the above matrix, the elements of which are approximated by using the geometric mean of each row. Next, the numbers are normalized using Eq. (3). Hence, for the previous matrix the corresponding priority vector is: [0.451, 0.225, 0.190, and 0.134], as shown in the above table. To check consistency, Eq. (5) is used to estimate λmax = 4.476. Then, the (CI) value of 0.159 is calculated using Eq. (4) and the consistency ratio (CR) = 0.176 is obtained from Eq. (6), using a random consistency index RI = 0.9, as extracted from Table (3).Since the CR value is greater than 10%, it is therefore confirmed that the judgements provided in the above table are inconsistent. To get around this fundamental problem, the current research proposes to ask the experts to fill only one row (or column), say the first row, i.e. (a_{1j}), j = *1, 2,.., n*, where n is the number of elements to be pairwise compared. The remaining elements of the matrix will be evaluated using Eq. (8) with K = 1. The following is the modified judgement matrix so obtained.

Table 6

Criterion	X_1	X_2	X_3	X_4	w^*	w
X_1	1.000	2.000	4.000	2.000	2.000	0.444
X_2	0.500	1.000	2.000	1.000	1.000	0.222

Table 6: Contd.,						
X_3	0.250	0.500	1.000	0.500	0.500	0.111
X_4	0.500	1.000	2.000	1.000	1.000	0.222
Total	**2.250**	**4.500**	**9.000**	**4.500**	**4.500**	**1.000**

When the consistency test is applied to the latter judgment matrix, it can be verified thatλmax = 4.000, CI = CR = 0.0, that is perfect consistency is established.

3.4. Questionnaire Survey

A questionnaire was designed to suit the proposed approach and distributed to target groups, mainly from liner shipping companies and ports. Out of the 50 experts contacted, 45 responses were obtained, 6 of which were waived (due to incomplete or wrong data), thus reducing the accepted responses to 39, equivalent of 78% response rate. This response rate was believed to provide enough data for the problem of port selection using the AHP model, which is primarily a subjective method that does not necessarily require a large sample of participants (Cheng and Li, 2002). In the open literature, many investigations were based on a smaller number of respondents. For instance, Chang, et al. (2002) invited 9 experts to undertake a survey; Ha (2003) received a 63% response rate; Nir, et al. (2003) had a rate of 30.5%; Lirn, et al. (2004) received 18 valid replies; Ng (2006) returned questionnaires were 19; Wong and Li (2008) received 10 valid replies; Tongzon (2009) achieved a response rate of 24%; Saeed and Aaby (2013) received 27 qualified replies; Wang et al. (2014) had a response rate of 24.2%; Caldeirinha, et al. (2015) had a rate of valid answers of13.3% and Zabihi (2016) collected only 5 responses.

4. WEIGHT OF CRITERIA

Table (5) lists aggregated pairwise comparisons of the criteria with respect to goal, i.e. port selection. The entries in the cells of the first row represent the geometric mean values of the corresponding entries provided by the 39 experts. Recourse was made to geometric means to preserve the reciprocating property:

$$a_{ij}a_{ji} = 1 \tag{10}$$

The rest of the entries were calculated according to Eq. (8), with $k = 1$. Based on these values, the criteria were weighted following the procedure outlined earlier and the results are also listed in Table (5) and depicted in Figure (1).

Table 7: Pair Wise Comparisons of Criteria with Respect to Port Selection

Criterion	C_1	C_2	C_3	C_4	C_5	C_6	w^*	w
C_1	1.000	2.885	0.287	0.348	0.488	0.834	0.700	0.091
C_2	0.347	1.000	0.100	0.121	0.169	0.289	0.243	0.032
C_3	3.480	10.039	1.000	1.210	1.699	2.900	2.435	0.318
C_4	2.875	8.294	0.826	1.000	1.404	2.396	2.012	0.263
C_5	2.048	5.909	0.589	0.712	1.000	1.707	1.433	0.187
C_6	1.200	3.461	0.345	0.417	0.586	1.000	0.839	0.110
Sum	**10.949**	**31.588**	**3.147**	**3.808**	**5.346**	**9.126**	**7.661**	**1.000**

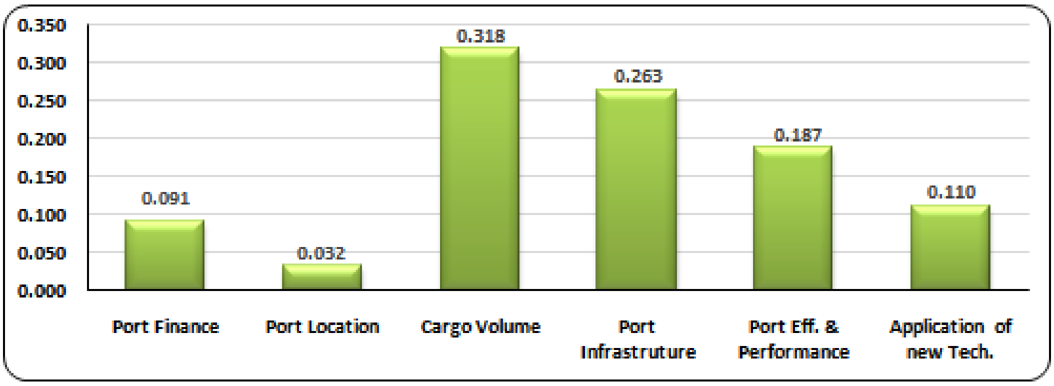

Figure 1: Ranking of Criteria with Respect to Port Selection

It is obvious that cargo volume ranks the highest with a weight of 0.32, which means that port users find parts that handle more cargo preferable. The second most important criterion is port infrastructure with a weight of 0.26. This is important because port users rely on promised load and unload times in order to move cargo effectively and reduce port congestion; this is particularly so in ports which handle more cargo volume. Moreover, the better infrastructure of a port the higher its level of selection will be, as the former affects the level of service ports provide to users. Port efficiency and performance, which can be reflected in the turnaround time of ships, cargo dwelling time and freight rates charged by shipping companies ranked third with a weight of 0.19. This indicates that ports which suffer from long ship turnaround times may have reduced marketability to shipping lines, probably because of congestion and consequent unbalance in the scale of the port to the amount of cargo it handles. It also indicates that ports which provide quick access to berths on ship arrival and a quick ship turnaround time, allowing ships to spend very little time in port, reduce their overall operating costs and increase frequency of ship calls.

This is in agreement with Tongzon (2009) argument that more frequency of ship visits lowers transportation costs by allowing more competition among carriers and attracts more users by providing them with more choices. Accordingly, the higher the quality of service provided to port users, the higher the attractiveness of the port will be, which directly influences the efficiency of shipping companies and other port users.

It is worthy to mention at this point that efficient port facilitates transportation of goods lowers the cost of maritime transportation and improves the quality of customer service. Therefore, many ports on the East West trade route have put a great deal of effort into the elements of facility and services, so as to enhance and sustain a certain level of competitiveness against competing ports. The fourth most important criterion is the application of new technology with a weight of 0.11, as new technology can promote coordination and lower cost. Information flow, cash flow and cargo flow are three key elements in this regard, since they enable large logistics operators to keep their management, efficient (Notteboom and Rodrigue, 2005). Therefore, many ports need to improve their service quality, notably by improving the quantity and quality of information flows and data availability. Application of new technology should be paying attention if both ports and shipping lines aim to have their business extended to logistics services and satisfy customers' requirements.

Surprisingly, port finance ranked fifth with a weight of 0.09, although many survey results conclude that it is a leading selection criterion, e.g. Ha (2003); Lirn, et al. (2004); De Langen (2007); Tongzon (2009); Grosso and Monteiro (2011) and Ayanthi, et al. (2016). This can be attributed to the fact that when shipping companies are more involved in logistics chains, they do not perceive port dues and handling charges as an important factor but focus on cost minimization of the whole logistics chain. More surprisingly, port location is the least important criterion in the current investigation with a weight of 0.03, although the location of the port along major shipping trade routes and from its main hinterland market determines its attractiveness (Dyck,et al. 2015). Moreover, port location is mostly critical from a port operator's perspective at the stage of planning or acquiring terminals. This implies that port location is not just a geographical coordinate, which helps a shipping company find the shortest or most economical way to the destination, but is perceived as a node of importance with better logistic convenience. This particular result needs further confirmation.

It is worthy to mention that the 6x6 pairwise comparison matrix of criteria given in Table (5) is perfectly consistent, since λmax = 6, as may be confirmed using Eq. (5), thus yielding CI = CR = 0 (cf. Eqs. 4 and 6). Similarly, all pairwise comparison matrices obtained in this work are perfectly consistent, due to the proposed procedure outlined earlier.

OVERALL PRIORITIES AND RANKING OF PORTS

After evaluating the weights of individual criteria with respect to port selection and the priorities of alternatives with respect to each criterion, the decision matrix was constructed, as given by Table (6). Then, overall priority of each alternative was calculated, and the alternative ports were ranked accordingly, as shown in Figure (2).

Table 8: Decision Matrix

C / Alt / W	C_1	C_2	C_3	C_4	C_5	C_6	Overall Priority	Rank
	0.091	**0.032**	**0.318**	**0.263**	**0.187**	**0.110**		
A_1	0.235	0.100	0.255	0.199	0.189	0.138	0.208	**1**
A_2	0.176	0.281	0.124	0.204	0.169	0.230	0.175	**2**
A_3	0.193	0.103	0.158	0.182	0.142	0.173	0.165	**3**
A_4	0.048	0.176	0.045	0.054	0.046	0.038	0.051	**8**
A_5	0.065	0.131	0.058	0.060	0.066	0.052	0.062	**7**
A_6	0.099	0.079	0.091	0.141	0.154	0.139	0.122	**5**
A_7	0.107	0.086	0.175	0.094	0.140	0.130	0.133	**4**
A_8	0.076	0.044	0.092	0.066	0.094	0.101	0.084	**6**

Shanghai was ranked first, followed by Singapore and Jebel Ail. These three ports performed well with respect to all the criteria taken into account in the measurement framework. Moreover, they have the most established market accessibility because these ports have long been hub ports and are well known for their worldwide connectivity. Antwerp and Hamburg were respectively ranked fourth and fifth, slightly behind the above three ports, although they are known to be major players in the intra-European trade.

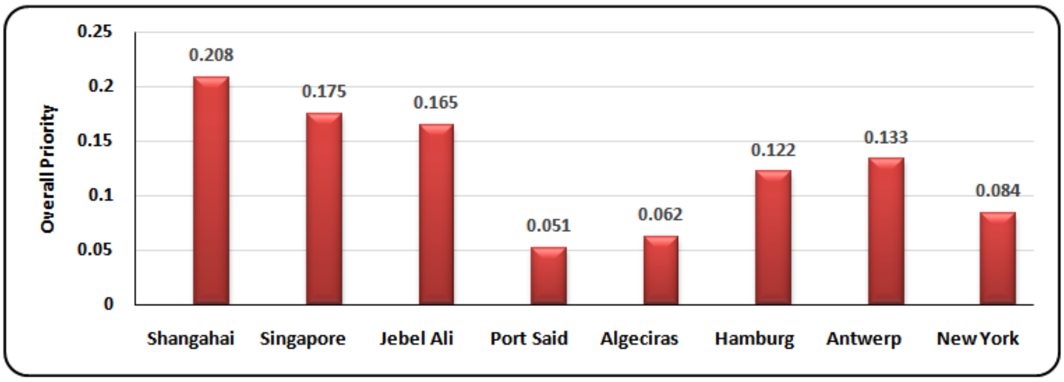

Figure 2: Ranking of Alternative Ports with Respect to the Criteria

Although container throughput of the port of Algeciras places it at the top of the chart in the Mediterranean region (Lloyd's List, 2017), it occupied the sixth position, probably due to port taxes and disability to accommodate mega ships. New York port took the seventh position because only vessels of maximum 8,500 TEUs could call the port due to the Bayonne Bridge's former air draft restrictions. Moreover, the vast majority of cargo handled in New York stays within 25 miles off the port (Lloyd's List, 2017). In addition, the expansion of the Panama Canal has allowed an increase in vessel size to transit the waterway up to a maximum of around 14,000 TEUs, thus reducing the number of calls for New York (Lloyd's List, 2017). This situation may be even worse with the deployment of the mega ships, as shipping companies prefer to deploy a single large vessel on that route instead of two smaller vessels.

Port Said East held the last position, probably because the Suez Canal route was affected by carriers choosing to take the long way through the Cape of Good Hope as a result of falling oil prices and bunker costs. The consequent increased consumption of fuel is compensated by not having to pay transit fees for Suez Canal (Lloyd's List, 2017). Other technical, political and operational issues have also contributed to this problem, such as Canal convoy system and consequent long transit and waiting time, as well as political instabilities in the region. It is anticipated, however, that the development program the Egyptian government is currently pursuing will increase the traffic through the Canal from an average of 49 ships daily to 97. In addition to the second Suez Canal, which was opened in 2016, the program includes the creation of an industrial hub in adjacent areas, the development of five new sea ports, a technology valley, and a center for supplies and logistics (UNCTAD, 2016).

CONCLUSIONS

AHP weight age of the criteria with respect to port selection shows that, according to order of importance, cargo volume ranks the highest. The second most important criterion is port infrastructure, whereas port efficiency and performance ranked third, the application of new technology fourth, port finance fifth and port location sixth. This indicates that, when shipping companies are more involved in logistics chains, port finance and port location lose importance and companies focus on cost minimization of the whole logistics chain. Moreover, a reliable movement of cargo is more important for shipping companies than the cost of port users. The data analysis also revealed that the port of Shanghai followed by the ports of Singapore and Jebel Ali is the leading ports, which indicates that they are the most preferred ports along the East West trade route from a shipping company perspective.The main contribution of this research is the treatment proposed to overcome the inconsistency problem associated with AHP. It is proposed herein to make fewer comparisons only, which can be well evaluated, and to deduce the remaining entries. By doing so, the number of entries requested from each expert will be reduced significantly, thus saving time and effort of the experts, especially when the problem investigated involves a large number of criteria and alternatives. The results of the current research, communicate to port managers and terminal operators the need to systematically monitor and understand the criteria affecting shipping companies port choice and to respond to changes that take place in the containerization market through flexible management plans, in order to increase or even maintain their market share and profits.

This research may be a starting point for further studies in the field of port selection by applying the proposed procedure which produces consistent pairwise matrices and enables to increase the number of criteria and ports without additional burden on participating experts. In effect, the scope of the study widens and the chances of generalizing the results obtained increases. The further future research could also consider other MCDM models, crisp and/or fuzzy.

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