Arab Academy for Science, Technology and Maritime Transport

The International Maritime and Logistics Conference Marl
Impacts of the Fourth Industrial Revolution on Port City Integration
"World Port Sustainability Program Aspects"
10 – 12 October 2020

Evaluating the competitiveness of North African container ports: An empirical study on the Egyptian and Libyan container ports using FAHP

Author: Dr. Ahmed Ismail
Co-author 1: Dr. Captain Mohi Eldin Elsayeh
Co-author 2: Cap. Abdulla Wanis
Arab Academy for Science, Technology and Maritime Transport

Abstract

The purpose of this paper is to propose a performance measurement framework to assess the level of competitiveness position of the Egyptian and Libyan container ports through evaluating their performance and quality of service provided using FAHP approach and panel data for three consecutive years from 2016 to 2018. The outcomes of this study clearly demonstrates that the Egyptian container ports are more efficient than the Libyans, where were ranked in the first, second, third, fourth, fifth and seventh positions out of ten ports that conducted in this study from both countries. Added to this, using a FAHP as a multi criteria decision making technique/tool actually can help container ports' managers to enhance their ports' competitiveness. Thus, inefficient terminals are continuously focused on increasing the productivity and efficiency by reducing their costs in order to obtain outstanding overall performance. So, to achieve this goal, the stated ports under this study need to use the new and modern technologies and innovations, such as, digitalization and joint collaborative platforms and electronic solutions.

Keywords: **Container port, Competitiveness, Fuzzy Analytic Hierocracy Process (FAHP), The Fourth Industrial Revolution 4.0 I.R.**

1. Introduction

The geographical location of North African states is a backbone for the global powers in pursuit of furthering their economic interests as well as strengthening their regional connectivity at the crossroads of Africa, Asia and Europe. Moreover, North African Arab states, which participated in some of the oldest trade routes in human history, are less globally and regionally involved in recent trade. Further, the routes through the Suez Canal and the Mediterranean have historically been very important as they connect Asia and Europe. In the era of containerization the old Mediterranean ports have changed their traditional roles, and the new ones have introduced relatively new concepts, such as transhipment and port networking, totally changing the commercial map (Schinas et al., 2000).

The Egyptian and Libyan container ports could benefit greatly from their strategic location on the Asia-Europe international trade route (East-West Route) and their expansive hinterland. This route has become the largest containerized trading lane since 2007; this was strongly related to the fact that the main driver of world economic activity has been the robust and sustained growth of China, India and other Asia-Pacific emerging markets (UNCTAD, 2018; UNCTAD, 2019).

Within this context, Libya has the potential to be the gateway to the other African countries that need seaports to trade (Ghashat, 2012). In essence, Libya could be used as an alternative corridor for some of its land-locked neighbours; in 2004, for example, the World Food Programme used Libya as a corridor to provide aid for Darfur refugees via Chad.

So far, port performance is traditionally evaluated by comparing actual and optimum throughputs (measured in tonnage or number of containers handled), while efficiency is a relative concept that means *a level of performance that uses the lowest amount of inputs to create the greatest amount of outputs, and if container ports conduct effective evaluation of their productivity performance to enhance the efficiency of productivity* (Tongzon and Heng, 2005). Thus, efficiency itself is a primary concept in the field of economics and is basically focused on the economic utilization of resources for production (Cullinane and Wang, 2006). On the other hand, efficiency is a relative concept that can only be valued by comparison, and comprises technical efficiency, scale efficiency and allocative efficiency (Lansink et al., 2001).

Monitoring a port's performance in an ever-changing environment is crucial for measuring its efficiency levels as well as its competitiveness (Jimenez et al., 2013). Recently, the efficiency of container ports has become more important since it is one of the key factors of survival in the current competitive business environment in the shipping industry and a way to reduce maritime cost. Moreover, container ports are vital to the efficiency of the whole global logistics chain since they act as the connecting link between different transportation modes in the global logistics chain (Wang et al., 2005; Elsayeh, 2015).

On the other hand, the world facing the fourth industrial revolution (4.0 IR) that will be the result of enormous increase of computing power a smart port concept has become more prominent in the recent years. It considered as a part of the expanding feasibility and applicability of Industry 4.0 IR themes; automation, data analysis, device connectivity, portable working – within traditionally conservative port operations. In this vein, smart port is designed, built and managed to use less space and resources while reducing the environmental impact of operations (Saanen, 2019; Port Technology, 2019). Accordingly, traditional ships to be replaced by smart ships, totally autonomous and unmanned, unmanned but remote controlled from shore station or autonomous but carrying skeleton crew on board as well, and the same scenario to become with container terminals.

2. Literature Review

Efficiency is one of the two most important concepts in measuring performance in container ports namely; productivity and efficiency. Efficiency rather than productivity is the most important concept in measuring performance of container ports. It is an important contributor to a nation's international competitiveness (Elsayeh, 2015). The efficiency of container ports has become more important since it is one of the key factors of survival in the current competitive business environment in the shipping industry and a way to reduce maritime cost. Moreover, container ports are vital to the efficiency of the whole global logistics chain since they act as the connecting link between different transportation modes in the global logistics chain (Wang et al., 2005).

The Analytic Hierarchy Process (AHP) approach has not been utilized by previous studies to assess, evaluate or rank the performance of container ports (Cabała, 2010; Sumi and Kabir, 2010; Elgazzar et al., 2010; Kousalya et al., 2012; Muhisn et al., 2015). AHP is a decision making technique for establishing priorities in multi-criteria decision making (Al-Harbi, 2001). AHP is most widely used technique in decision making due to its promising accuracy, simplicity, ability to handle both qualitative and quantitative criteria or tangible and intangible aspects, also, its ability to measure the consistency of judgment of respondents (Muhisn et al., 2015).

Although, limited scholars have studied the AHP and FAHP for ranking and measuring container port efficiency, none of any previous research used the FAHP technique to rank the Egyptian and Libyan container ports and terminals before 2018. Fundamentally, the studies have been conducted to measure the efficiency of the Egyptian and Libyan container ports and terminals are seldom. In this vein, Gu and Dong (2006) empirically identify the competitiveness of major 20 container ports in Asia by examining factors influencing the perceived competitive edge of each port using the Hierarchical Fuzzy Process, a method embracing human knowledge and/or judgment into a mathematical framework. A survey group of 350 experts was conducted over the period of two months in 2002.

The main findings reveal that Singapore is the most competitive port among the sampled ports. Moreover, the study successfully overcomes the major drawbacks of the AHP which existed in the previous studies, also ranking the world top 20 container ports in Asia, which provides those engaged in port businesses an insight into some aspect of relative competitiveness of those selected ports.

Caldeirinha, et al. (2014) analysed the performance of a port through its characterising factors limiting their study to European ports. The results show that port's operational performance strongly depends on the geographical location and economic characteristics of the region. Moreover, port size has considerable impact on port performance, also affecting infrastructure and maritime services, while Akbarian (2015) presented an original approach for ranking of DEA-efficient DMUs based on the cross efficiency and AHP methods. Using mixed methods was due to the optimal input-output weights obtained by classical DEA are not unique; therefore, the cross efficiency scores depending on these weights are also not unique. The main advantage of this proposed method was its capability of ranking extreme and non-extreme DEA-efficient DMUs

Herrera and Ancor (2016) found that ports that operated in more competitive environments were more efficient. Therefore, the most efficient terminals are able to increase their market share which will increase the competition between terminals in the region, while Ismail and Elgazzar (2018) used Fuzzy Analytics Hierocracy Process (FAHP) to measure, assess, evaluate and benchmark the port efficiency of six container ports in Egypt. The study results clearly showed that East Port Said port has the highest score of the efficiency index at (0.736), while El-Sokhna port comes second, while Damietta port, Port Said and El-Dekheila come at the third, fourth and fifth places respectively. Alexandria port comes at the sixth and last position with the lowest efficiency score at (0.287). This index, however, can be disaggregated in order to identify any criteria that need to improve Egyptian container port system.

Most recently, Ismail and Wanis (2019) evaluated technical efficiency of 6 Egyptian and 4 Libyan ports using DEA-CCR method and panel data in the period between 2012 and 2016. They found that only 2 Libyan ports among stated ports were inefficient over the period of study. Hence, in order to enhance the Egyptian and Libyan port efficiency and their rank globally, large investments in the infrastructure/superstructure are urgently needed.

Saanen (2019) argued that, there are 10 pre-requisites for smart terminals including; (i) connected to the outer world more, (ii) connected to all assets more, (iii) connected to all staff same, (iv) real-time, holistic planning, control and optimization same, (v)real-time measuring of KPI's more, (vi) continuous analysis of performance (KPI's) same, (vii) training and certification of staff more, (viii) capability to learn from the past same, (ix) terminal development based on a 'master plan' more, and (x)a solid cyber security layer in place more. He added, none of the points mentioned will require large investments, or be too complex to implement, but they do require an ability and willingness to change.

Thus, in accordance with the 4.0 IR, Port Technology (2019) strongly recommended that port operators need to ensure all areas of their business continue to operate at high efficiency and that their security is fortified to ward off any potential threats. Moreover, ports need to be smarter; they need to utilize technologies within the context of the Industrial Internet of Things (IIoT), block chain solutions, artificial intelligence (AI) and big data to make sure they are not left behind in an ever-increasingly connected age. They must look at mobile communication technologies that allow them to keep up with the demand and continue to thrive in a relentless and breathless industry.

In short, and in order to achieve research objective, an express review for the previous scholars related to the Libyan, Egyptian container ports efficiency has been conducted. Although, most studies on port performance and efficiency were centered on the advanced and emerging markets in the North America, Europe and North East Asia, measuring of container port efficiency in the South Mediterranean and North Africa is limited/seldom through global academic research network due to data availability and market share of the region which is very low. North African ports, on the other hand, always considered as a part of MENA ports (Almawsheki and Shah, 2015).

3. Methodology

Analytic Hierocracy Process (AHP) *is a decision making technique for establishing priorities in multi-criteria decision making , and categorized as an additive weighting method* (Al-Harbi, 2001), or AHP is a powerful tool for analysis of complex decision problems. AHP is most widely used technique in decision making due to its promising accuracy, simplicity, ability to handle both qualitative and quantitative criteria or tangible and intangible aspects, also, its ability to measure the consistency of judgment of respondents (Muhisn et al., 2015).

The AHP has been widely used to solve Multiple Attribute Decision-Making (MADM) problems. However, the AHP enables the decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple criteria environment in confliction (Cheng et al., 1999).

On the other hand, due to the existence of vagueness and uncertainty in judgments, a crisp, pair-wise comparison with a classical AHP may be unable to accurately represent the decision-makers' ideas (Ayağ, 2005). Even though the discrete scale of AHP has the advantages of simplicity and ease of use, it is not sufficient to take into account the uncertainty associated with the mapping of one's perception to a number. Therefore, fuzzy logic is also introduced into the pair-wise comparison to deal with the deficiency in the classical AHP, referred to as FAHP. In other words, the FAHP, as a version of multi-criteria evaluation, is developed from the AHP, which was introduced by Saaty (1980).

So far, a fuzzy set theory is a powerful tool in dealing with vagueness of human thoughts and expressions in making decisions (Zadeh, 1965). It permits vague information, knowledge and concepts to be used in an exact mathematical manner. Normally, in a fuzzy environment, the assessment grades, such as; linguistic terms for criteria are expressed by fuzzy numbers triangular or trapezoidal fuzzy numbers rather than crisp numbers. Furthermore, the fuzzy set theory can be easily combined with other methods for decision making issues. The most commonly used membership functions in practice are the triangular and trapezoidal due to their simple formulas and computational efficiency (Kaufmann and Gupta, 1988).

The AHP methodology is based on pairwise comparisons of the defined criteria which are used to establish the weight to assess the performance scores for alternatives. In using the AHP, one constructs a hierarchy and then makes judgments on pairs of elements with respect to a controlling element. Ratio scales are derived from these judgments and then produced throughout the structure to select the best alternative. The Limitation of AHP method is that the number of pairwise comparisons requested can be very high, the more factors are included, the more pairwise comparisons need to be made (Osuri, 2014).

In order to calculate the empirical values of these criteria, it is necessary to define ''identifiable or representative attributes'' for each criterion. For this purpose, 3 years panel data from 2016 to 2018 was used to identify and representative evaluation criteria, whose selection procedures are as follows. Five main criteria to measure the container port competitiveness; namely: storage capacity, terminal area, berth length, draught and handling equipment (Cullinane et al., 2005; Cullinane and Wang, 2010; Elsayeh, 2015); as shown in Figure (1).

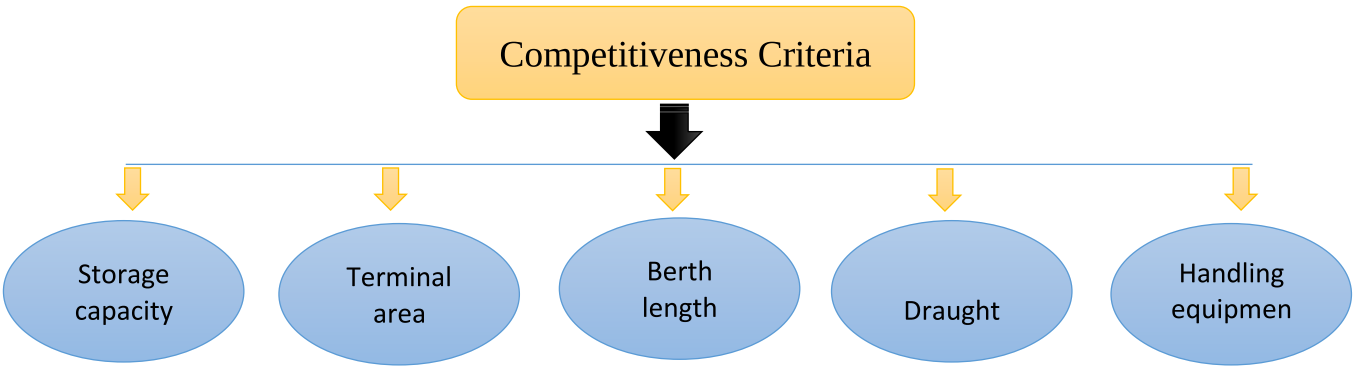

Figure (1) Input variables / competitiveness criteria.

(Source: Authors' own elaboration)

4. The proposed framework

The research on the port selection criteria is, to some extent, biased in light of dimensions examined. As the quality for port services is constantly expected to improve according to the changing business environment, the formerly recognized factors should be re-assessed and new dimensions should be identified and established. As for this purpose, this study proposes a framework to rank port efficiency using FAHP technique based on the following four steps (Ismail and Elgazzar, 2018):

Step one: Identifying the criteria used to evaluate the level of efficiency in a container port

A review of previous studies was conducted to define main criteria reflect the level of container port efficiency. The review concluded with five main criteria to measure the container port efficiency; namely: storage capacity, terminal area, berth length, draught and handling equipment (Tongzon, 2001; Cullinane et al., 2005; Cullinane and Wang, 2010; Elsayeh, 2015).

Step two: Developing a FAHP survey to identify the relative importance of the selected criteria

FAHP survey was developed to determine the relative importance weight of the efficiency criteria in a container port based on a pairwise comparison scale ranging from 1 to 9, where 1 denotes equally important, 3 denotes moderately more important, 5 denotes strongly more important, 7 denotes very strongly more important, 9 denotes extremely important (Al-Harbi, 2001; Muhisn et al., 2015). Table (1) illustrates the survey form to prioritize the criteria of a container port's efficiency.

To determine the relative importance weight (W) of the selected criteria, survey will be distributed to group of experts in the field (port authority, shipping companies, shipping agencies, academic experts and other decision-makers in the field).

Once judgments are entered by the group of experts, the level of consistency of responses will be tested. To verify the consistency of the comparison matrix, consistency index (CI) and consistency ratio (CR) are calculated using Saaty's method (Saaty and Kearns, 1985). For any metrics, if the value of the CR is smaller or equal to 10%, the inconsistency is acceptable; while if the CR is greater than 10%, the pair-wise comparison processes should be repeated until the consistency ratio reaches less than 0.1. An inconsistency level higher than 10% (CR $>$ 0.10) means that the consistency of the pairwise comparisons is insufficient (Saaty, 1980).

Step three: Establish a performance rating scale to evaluate each efficiency criterion

A five-point performance rating scale (very poor, poor, good, very good and excellent) is established based on container ship features to evaluate the five efficiency criteria in order to assess the efficiency of a container port. A performance rate (R) is assigned for each criteria (0.2, 0.4, 0.6, 0.8 or 1), where 0.2 denotes very poor performance, 0.4 denotes poor performance, 0.6 denotes good performance, 0.8 denotes very good performance and 1 denotes excellent performance.

Step four: Calculate the efficiency index of a container port

After determining the performance rate (R) and the relative weight (W) of each criterion, the weighted rate (WR) of each criterion is calculated by multiplying the relative weight of each criterion by its performance rate. Finally, the weighted rates of all criteria are aggregated using a weighted average aggregation method to determine the efficiency index of a container port and rank it compared to indices of other ports.

Table -1 FAHP questionnaire form

With respect to (Port efficiency)	***Importance or preference of one factor over the frame of discernment (Decision Alternatives D.A.'s)***									
	Absolutely more important (9)	**Demonstrably more important (7)**	**Strongly more important (5)**	**Slightly more important (3)**	**Equally important (1)**	**Slightly more important (3)**	**Strongly more important (5)**	**Demonstrably more important (7)**	**Absolutely more important (9)**	
Storage capacity	9	7	5	3	1	3	5	7	9	Terminal area
	9	7	5	3	1	3	5	7	9	Berth length
	9	7	5	3	1	3	5	7	9	Draught
	9	7	5	3	1	3	5	7	9	Handling equipment
Terminal area	9	7	5	3	1	3	5	7	9	Storage capacity
	9	7	5	3	1	3	5	7	9	Berth length
	9	7	5	3	1	3	5	7	9	Draught
	9	7	5	3	1	3	5	7	9	Handling equipment
Berth length	9	7	5	3	1	3	5	7	9	Storage capacity
	9	7	5	3	1	3	5	7	9	Terminal area
	9	7	5	3	1	3	5	7	9	Draught
	9	7	5	3	1	3	5	7	9	Handling equipment
Draught	9	7	5	3	1	3	5	7	9	Storage capacity
	9	7	5	3	1	3	5	7	9	Terminal area
	9	7	5	3	1	3	5	7	9	Berth length
	9	7	5	3	1	3	5	7	9	Handling equipment
Handling equipment	9	7	5	3	1	3	5	7	9	Storage capacity
	9	7	5	3	1	3	5	7	9	Terminal area
	9	7	5	3	1	3	5	7	9	Berth length
	9	7	5	3	1	3	5	7	9	Draught

(Source: Ismail and Elgazzar, 2018)

5. Empirical analysis and discussion

The brief illustrative procedures for applying the proposed method (FAHP) are divided into the following four major steps.

Step one: Identifying the criteria used to evaluate the level of efficiency in the Egyptian and Libyan container ports: five main criteria to measure the container port efficiency; namely "Storage capacity, terminal area, berth length, draught and handling equipment.

Step two: Developing a FAHP survey to rank the selected criteria: the FAHP survey was carried out to determine the relative importance weight (W) of the selected criteria in the Egyptian and Libyan container ports. The survey was conducted with a group of experts and decision-makers in the field; where Egyptian navy respondents 8%, Egyptian Port Authority 33%, shipping companies & shipping agencies 23% and Academic experts 36%; in the field in Egypt were distributed out of them were valid after removing the invalid surveys. The researcher used Microsoft Excel Spreadsheets and Pop Tools add-in (version 3.2; build 5) to analyze the responses on the survey.

Step three: Determining the relative importance weights of the selected criteria: as shown in Table- 2 illustrates the relative importance weights of the five main criteria based on survey response. The results revealed that draught has the highest relative importance weights of the five main variables percent with 32% because draft is a significant factor limiting navigable waterways, especially for large vessels therefore, ports need deeper draft to attract bigger ships.

Table – 2: Relative importance weights of the container port competitiveness criteria

Criteria	Priority	
Storage capacity	17%	3
Terminal area	11%	5
Berth length	11%	4
Draught	32%	1
Handling equipment	29%	2

(Source: Ismail and Elgazzar, 2018)

Handling equipment took the second position with relative importance with 29% because effective handling equipment reduce time in port and increases ships call numbers. Storage capacity took the third position with 17%. Both terminal area and berth length approximately took the fourth position according to the relative importance weight with 11%.

Perform the consistency. Three steps to calculate the Consistency Ratio (CR) as follows:

Calculation of Eigenvalue (λmax)
λmax = 5.090550009. Also, total the five criteria should equal one "0.16808985 + 0.111543798 + 0.114883427 + 0.317953416 + 0.287529509 = 1".

Calculation of Consistency Index (CI). Where CI = λmax - N /N-1 (Mu and Rojas, 2017). CI= 5.090550009 –5 / 5 – 1 = 0.0226375

Calculation of Consistency Ratio (CR). Where CR = CI/RI (Triantaphyllou and Mann, 1995; Dyck and Ismael, 2015). CR= 0.0226375 / 1.12 = 0.020212056.

Accordingly, in order to verify the consistency of responses, CR must be calculated, it found 0.02 which is lower than the maximum accepted Consistency Ratio 0.1. Therefore, our judgments matrix is reasonably consistent so we may continue the process of decision-making using AHP (Elgazzar, 2013). Also, the CI result reflects increase the validity degree of this research, because the result is reliable only when CR value is 0.1 or less, as shown in Table (3).

Table – 3: Consistency test table

EIGENVALUE	CI	RI	CR
5.090550009	0.0226375	1.12	0.020212056

(Source: Ismail and Elgazzar, 2018)

Consistency Index (CI) result reflects increase of the validity degree of this paper, because the result is reliable only when CR value is 0.1 or less, and CR in our results is 0.02. Secondary data are already valid because it collected from published reports.

Step four: Establish a performance rate: a five-point performance rating scale (very poor, poor, good, very good and excellent) is established to evaluate the five main criteria to rank the efficiency of the Egyptian and Libyan container ports. A performance rate used in this paper by using the Triple E container ship which is the maximum container ship that can be handled in some container ports in Egypt. Table 4 shows the aggregated weighted rates of the five main criteria of the Egyptian and Libya container ports.

Table 4: The aggregated weighted rates of the five main criteria

Criteria	Storage capacity			Terminal area			Berth length			Draught			Handling equipment			SUM	Rank
	W	R	WR	W	R	WR	W	R	WR	W	R	WR	W	R	WR		
Alexandria	0.17	0.2	0.034	0.11	0.2	0.022	0.11	0.4	0.044	0.32	0.4	0.128	0.29	0.2	0.06	0.286	**7**
El-Dekheila	0.17	0.4	0.068	0.11	0.4	0.044	0.11	0.6	0.066	0.32	0.2	0.064	0.29	0.4	0.12	0.358	**5**
Damietta	0.17	0.2	0.034	0.11	0.4	0.044	0.11	0.4	0.044	0.32	0.6	0.192	0.29	0.6	0.17	0.488	**3**
East Port Said	0.17	0.8	0.136	0.11	0.8	0.088	0.11	0.8	0.088	0.32	0.6	0.192	0.29	0.8	0.23	0.736	**1**
Port Said	0.17	0.2	0.034	0.11	0.4	0.044	0.11	0.2	0.022	0.32	0.4	0.128	0.29	0.6	0.17	0.402	**4**

El-Sokhna	0.17	0.2	0.034	0.11	0.4	0.044	0.11	0.4	0.044	0.32	0.8	0.256	0.29	0.4	0.12	0.494	**2**
Khoms	0.17	0.4	0.068	0.11	0.2	0.022	0.11	0.6	0.066	0.32	0.2	0.064	0.29	0.2	0.06	0.278	**8**
Tripoli	0.17	0.4	0.068	0.11	0.2	0.022	0.11	0.8	0.088	0.32	0.2	0.064	0.29	0.4	0.12	0.358	**6**
Misurata	0.17	0.2	0.034	0.11	0.2	0.022	0.11	0.8	0.088	0.32	0.2	0.064	0.29	0.2	0.06	0.266	**9**
Tobruck	0.17	0.2	0.034	0.11	0.2	0.022	0.11	0.4	0.044	0.32	0.2	0.064	0.29	0.2	0.06	0.222	**10**

(Source: authors own calculations)

Form the above table, East Port Said port took the first position, El-Sokhna port took the second position, while Damietta port took the third position, Port Said port took the fourth position, El-Dekheila port took the fifth position. Tripoli port from Libya was ranked in the sixth position, while Alexandria port took the seventh position. Khoms port was ranked in the eighth position, while Misurata took the ninth position. Finally Tobruck port was ranked as the last port in this study in terms of technical efficiency. Thus, using these outcomes, it can easily disaggregate total index to identify which criteria needs an improvement in the Egyptian and Libyan container ports.

By using the FAHP tool, the main outcomes are; the port authorities of Alexandria, for example, container terminal will determine the amount that should be invested in these sections in order to improve storage capacity, terminal area and handling equipment from the current level to another one. The FAHP outcomes can be used by terminal authorities and practitioners to improve terminal efficiency through identify needed investment in order to improve any container terminal efficiency in specific criteria.

Furthermore, the analysis demonstrated that the stated container ports in Egyptian and Libyan were suffered from inefficiency due to the geopolitical conflict, turbulence, and instable environment which affect their national security, economy and direct investment, and reflected negatively on the shipping lines and port activities. Added to this, the negative impact was stretched to their maritime transport system including the related logistics services and activities in Egypt which already suffered from a number of regulatory and policy pitfalls including; overlapping jurisdictions between different authorities in ports, absence of separating ownership and regulation, heavy governmental control over pricing, domination of the public sector in logistics services and lack of clear regulations (Ismail and Wanis, 2019).

The scored efficiency level of the stated Libyan container ports which operated by a public company known the Libyan Ports Company (LPC), however, in the context of all Libyans container ports, the performance of seaside operations in Libyan ports is low, because of the lack of efficient and specialized cranes at these ports. Added to this, Libyan ports use insufficient equipment such as; external trucks for container transport, with some port tractors and trailers (Ismail and Wanis, 2019).

Consequently, terminals are continuously focused on increasing the productivity and efficiency by reducing their costs in order to obtain outstanding overall performance. Although, terminal operators are relying heavily on the Terminal Operating System (TOS) for data storage and order management, they need to rely on people for terminal planning and control. Added to this, operations require human intervention for various decision-making scenarios, considering the working environment is very dynamic and there are different constraints which cannot be determined ahead of time. The lack of foreseen human behavior is a recurring reason for certain mistakes during execution and planning. These mistakes are not easily identified by reviewing the data in the TOS.

6. Conclusion

Port competition is a term commonly used to reflect the current status of the industry. In this vein, this study attempts to empirically evaluate the competitiveness level of the Egyptian and Libyan container ports by examining the components and factors influencing the competitive edge under the framework named the FAHP. The empirical results showed that Egyptian container ports are more efficient than Libyan, where were ranked in the first, second, third, fourth, fifth and seventh positions out of ten ports that conducted in both countries.

One important finding in this study was digitalization and automation are transforming the shipping sector and requiring new skills. The latest technologies provide new opportunities to achieve greater sustainability in shipping and ports, as well as enhanced performance and efficiency. Digitalization and joint collaborative platforms and solutions enabled by new technologies and innovations, including block chain, are being increasingly used by the shipping industry, transforming business and partnership models (UNCTAD, 2019).

Another findings in this study was that using FAHP as a multi criteria decision making technique can help container ports' managers to enhance ports' technical efficiency through identifying the relative importance weight of each dimension of efficiency and define dimensions that are working well and those need improvements. Accordingly, the port managers of the in-efficient container ports in both countries have to utilize their resources in terms of terminals infra/superstructure in order to increase their market share, to enhance port's efficiency, and accordingly to improve competitive position and enable to meet their customers' requirements as well.

7. References:

Akbaraian, D., (2015) "Ranking all DEA-efficient DMUs based on cross efficiency and AHP methods", *Journal of Optimization, Article 594727, pp.1-10*.

Al-Harbi, K., (2001) "Application of the AHP in project management", *International Journal of Project Management. Vol.19 (1), pp.19-27*.

Alirezaee, M., and Sani, M., (2011) "New analytical hierarchical process/data envelopment analysis methodology for ranking decision-making units", *International Transactions in Operational Research, Vol. 18 (5), pp. 533–544.*

Almawsheki, E. S. and Shah, M. Z. (2015) "Technical Efficiency Analysis of Container Terminals in the Middle Eastern Region", *The Asian Journal of Shipping and Logistics, Vol 31 (4), pp. 477-486*.

Ayag, Z., (2004) "A fuzzy AHP-based simulation approach to concept evaluation in a NPD environment". IIE Transactions, *Vol.37, pp.827-842*

Cabała, A. (2010) "Using the Analytic Hierarchy Process in Evaluating Decision". *Operations Research and Decisions. Vol 1, pp. 5-23.*

Caldeirinha V. and Felício J. A. (2014) "Port and container terminal characteristics and performance". School of Economics and management; University of Lisbon. Portugal

Caldeirinha, V., Felício, J. A., and Dionísio, A. (2015) "Effect of the container terminal characteristics on performance". Maritime Economics and Logistics. *Vol 17 (4), pp. 493–514*

Cheng C., Yang, K. and Hwang, C., (1999) "Evaluating attack helicopters by AHP based on linguistic variable weight". *European Journal of Operational Research, Vol. (116), pp. 423-435*.

Cullinane, K. and Song, W. (2006) "Estimating the relative efficiency of European container ports: a stochastic frontier analysis", *Port Economics, Transportation Economics. Vol 16, pp.85-11*.

Cullinane, K. and Wang T.F. (2010) "The efficiency analysis of container port production using DEA panel data approaches", *OR Spectrum. Vol 32, pp. 717-738.*

Cullinane, K., Ji, P. and Wang, T-F. (2005) "The relationship between privatization and DEA estimates of efficiency in the container port industry", *Journal of Economics and Business, Vol 57, pp. 433-462.*

Elgazzar, S., Tipi, N., Hubbard, N. and Leach, D. (2010) "Incorporating fuzzy AHP in SCOR model for measuring supply chain operations performance: a case study of an Egyptian natural bottled water company". *In: Proceedings of the 15th Annual Logistics Research Network Conference (LRN 2010), Harrogate*, UK, 8-10 September 2010, *pp.180-187*.

Elsayeh, M. (2015) "The impact of port technical efficiency on Mediterranean container port competitiveness", PhD Thesis. University of Huddersfield. UK

Ghashat (2012) "Identifying the right 'fit': What can Libya learn from port devolution in Malaysia". Napier University. Edinburgh.

Gu, Y., and Dong, S. (2006) "An Application of the Hierarchical Fuzzy Process to Container Port Competition", *Policy and Strategic Implications Transportation. Vol. 33(4):pp. 409-422.*

Herrera, M., and Ancor, S. (2016) "Competitiveness of South Asia's Container Ports A Comprehensive Assessment of Performance, Drivers, and Costs. World Bank Publications. Washigton. USA.

Herrera, S. and Pang, G. (2008) "Efficiency of Infrastructure: The Case of Container Ports", *EconomiA***.** *Vol. 9 (1), pp. 165-194.*

Hlali, A. (2018) "Efficiency Analysis with Different Models: The Case of Container Ports". *Journal of Marine Science: Research & Development. Vol.8 (2).*

Ismail, A and Wanis, A. (2019) "Benchmarking the efficiency of the Egyptian and Libyan container ports", paper presented *to The International Maritime Transport & Logistics Conference (MARLOG 8) INVESTING IN PORTS "Towards Global Maritime Markets".* EGYPT, ALEXANDRIA. 17-19 MARCH 2019.

Ismail, A. and Elgazzar, S. (2018) "Measuring the Egyptian container ports' efficiency: A FUZZY AHP framework", paper presented to *23rd Annual Conference of The Chartered Institute of Logistics and Transport, Logistics Research Network (LRN).* Plymouth, UK. 5-7 SEPTEMBER 2018.

Jimenez, Z. I., Gutiérrez, A. and Ortiz, C. (2013) "Port Efficiency in APEC", *México y la Cuenca del Pacífico, Vol 3, pp. 41-74.*

Kaufmann, A. and Gupta, M. (1988) "Fuzzy mathematical models in engineering and management science", Elsevier Science Inc.

Kousalya, P., Reddy G., Supraja, S. and Prasad V. (2012) "Analytical Hierarchy Process approach – An application of engineering education", Mathematica Aeterna. *Vol 2 (10), pp. 861-878.*

Lansink O., Pietola K. and Backman S., (2001) "Efficiency and Productivity of Conventional and Organic Farms in Finland 1994-1997". European Review of Agricultural Economics, *Vol 29 (1), pp. 51-65*

Mu, E., and Rojas, P. (2017) "Understanding the Analytic Hierarchy Process". Practical Decision Making using Super Decisions". *pp. 7-22.*

Muhisn, L., Omar, M., Ahmad, M., and Muhisn, A. (2015) "Team Leader Selection by Using an Analytic Hierarchy Process (AHP) Technique", *Journal of Software, Vol 10 (10), pp. 1216-1227.*

Osuri, P. K. G. M. (2014) "Evaluation of Multi Criteria Decision Making Methods for Potential Use in Application Security". School of Computing, Blekinge Institute of Technology, Sweden.

Port Technology website (2019). Available online at: www.porttechnology.org (Accessed 11 Nov.2019)

Saanen, Y. (2019) "10 pre-requisites for smart terminals. Port Technology". Available online at: https://ast.porttechnology.org/wp-content/media/20190712231121/TBA86.pdf (Accessed 3 Nov.2019)

Saaty, T. (1990) "How to make decisions: the analytical hierarchy process". *European Journal of Operation Research, Vol. (48), pp. 9-26.*

Saaty, T. (2004) "Decision-making, the analytic hierarchy and network processes (AHP/ANP)". *Journal of Systems Science and Systems Engineering, Vol. (13), pp. 1-35.*

Saaty, T. and Kearns, K. (1985) "*Analytical Planning; The Organization of Systems",* Oxford: Pergamon Press.

Schinas, O. and Papadimitriou, S. (2000) "Approaching the Relative Productivity of Infrastructure in Mediterranean Container Terminals with the Use of DEA. European Research Studies", *Vol. 1(4)*, pp. 99-114

Sumi, R., and Kabir, G. (2010) "Analytical Hierarchy Process for Higher Effectiveness of Buyer Decision Process". *Global Journal of Management and Business Research, Vol 10 (2).* pp. 1-9.

Tongzon, J. (2001) "Efficiency Measurement of Selected Australian and Other International Ports using DEA". *Transportation Research Part A: Policy and Practice. Vol.35(2), pp. 107-122*

Tongzon J. and Heng W., (2005): "Port privatization, efficiency and competitiveness: some empirical evidence from container ports and terminals". *Transport Research and Policy Practices. Vol. 39 (5), pp.* 405–424

UNCTAD (2019) "Review of Maritime Review 2019 Report". Geneva. Available online at: https://unctad.org/en/PublicationsLibrary/rmt2019_en.pdf (Accessed 30 Nov. 2019)

UNCTAD (2018) "Review of world maritime transport". Geneva. Available online at: https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf (Accessed on 2 Nov. 2019)

Wang, F., Cullinane, K. and Song, W. (2005) "*Container Port Production and Economic Efficiency".* Palgrave Macmillan, Basingstoke, Hampshire; New York.

Zadeh, L. (1965) "Fuzzy sets. Information and Control", *Vol (*8)**,** pp. 338-353.

Zahedi, F. (1986) "The analytic hierarchy process-a survey of the method and its applications", *Vol. 16 (4), pp. 96-108.*