Measuring the competitiveness of Aden container terminal and neighboring terminals using Fuzzy Analytic Hierocracy Process

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Abstract:

The Globalization of world trade has led to an increase in maritime transport, especially containerization transport, which plays the main role in maritime transport and considered the backbone of global trade and world economy. Moreover, around 80% of world trade is transported by sea. This research aims to propose a framework using Fuzzy Analytical Hierarchy Process (FAHP) on Aden container terminal for 2022, looking for the increase of the Port's competitive position. In fact, FAHP reveals

the relative importance of the variables which have been used to determine the competitive capability of Aden container terminal. The Researcher found that Aden container terminal has shortcomings and defects in all variables, which have been selected to measure its competitiveness such as: navigational channel depth, storage capacity, berth length and handling equipment. Actually, it has been found that Aden container terminal suffers from poor performance in these variables.
Key words: Competitiveness, Fuzzy Analytical Hierarchy, Aden container terminal.

قياس القدرة التنافسية لمحطة عدن للحاويات وللمحطات المجاورة المنافسة لها بإستخدام نموذج التحليل الهرمي

المستخلص:

أدت عولمة التجارة العالمية إلى زيادة النقل البحري، وخاصة النقل بالحاويات والذي يلعب دوراً رئيسياً في النقل البحري ويعتبر العمود الفقري للتجارة العالمية والاقتصاد العالمي، حيث يتم نقل حوالي ٨٠٪ من التجارة العالمية عن طريق البحر. يهدف البحث إلى اقتراح إطار باستخدام عملية التسلسل الهرمي التحليلي (FAHP) بالتطبيق على محطة عدن للحاويات خلال عام 2022 لزيادة قدرتها التنافسية، حيث يحدد نموذج FAHP الأهمية النسبية للمتغيرات التي تم استخدامها لتحديد القدرة التنافسية لمحطة عدن للحاويات. وجد الباحث أن محطة حاويات عدن بها أوجه قصور في جميع المتغيرات التي تم اختيارها لقياس قدرتها التنافسية مثل: عمق القناة الملاحية وسعة التخزين وطول الرصيف ومعدات المناولة. ووجدت أن محطة حاويات عدن تعاني من ضعف الأداء في هذه المتغيرات.
كلمات افتتاحية: القدرة التنافسية، نموذج التحليل الهرمي، محطة عدن للحاويات.

1. Introduction:

Seaport is a vital part of the logistic chain, ports are a connection points between two geographic areas, for handling shipments and sometime passengers (Rodrigue et al., 2017). No longer are ports only regarded as places for handling ships and shipments; but they have also become capable of economic competition in all aspects for seaport's stakeholders. As a matter of fact, containerization industry has become one of the most important economic development keys in many countries. Seaports have also become areas for economic competitiveness zones, which have subsequently forced ports to increase their competitiveness capability (Akgul et al., 2015).

The second half of the twentieth century has witnessed an increasing growth in the role of seaports in international trade which is described as a connection point between production and consumption centers. Furthermore, seaports have moved from just maritime stations intended for receiving ships to a complex and intertwined global industry in which financial investments overlap with technological developments and technical and administrative requirements. Accordingly, many countries have worked to develop their seaports; to enhance their competitiveness; to maximize their returns from international trade and achieve economic development. In recent decades, there has been an increase in seaports competitiveness of seaports in general, as among the most important objectives of ports

management is to increase the profitability of ports and their market share (Ismail, 2019).

One of the most important challenges facing shipping industry is the intense regional and global competition in maritime transport industry in the light of political and economic changes. Decision makers should raise their competitiveness and develop the infrastructure of seaports, and increase the depth of navigational channels and berth length; as geographical location is no longer the only attractive factor for the shipping lines for selecting seaports, but rather the capacity and depths that allow receiving of advanced generations of the giant container ships. This is in addition to their commitment to apply the latest developments in global seaports in varied operational and technical fields, through exchanging experiences by visiting and getting training in the neighboring seaports. Therefore, decision-makers in Yemen should work to attract shipping lines and acquire the largest share in both international and regional shipping markets (Qardash, 2021).

Competition in container terminals depends on developing the services of these terminals, which helps to increase their competitiveness and improve their services. At the regional level, it was found that there is a huge increase in competition between neighboring ports and the development of their services. This requires reaching an advanced solution, to increase the competitiveness of seaports in order to keep pace with the

surrounding developments when all neighboring seaports have sought to increase their competitiveness (Wanis et al., 2021).

2. Previous studies:

Previous studies have evaluated and assessed the competitiveness in ports. Gaur et al., (2011) highlighted how the container ports in the developing countries should consider and determine the competitiveness of ports. Musso et al., (2013) have conducted an empirical analysis to study the external and internal factors that could affect the competitiveness of Italian ports. The study suggested a number of potential strategies that could be applied to increase the competitiveness of Italian ports; to reduce costs, increase capacity, stimulate cooperation between ports and focus on system strategies.

Competitiveness has been defined as the process of applying differentiated strategic alternatives to attract more customers (Elsayeh, 2015). There are four types of competition. The first is perfect competition which is a perfectly competitive market characterized by the presence of a large number of buyers and sellers and firms producing homogeneous goods. As for the second, it is called monopolistic competition which is characterized by the presence of a large number of producers of similar but heterogeneous goods who compete through marketing and promotional methods. The third is oligopoly competition which is characterized by the presence of a small number of

establishments that control the largest part of the market and produce distinct goods, and there are obstacles that prevent the entry of new producers. The fourth is the monopoly marke. In this market, there is a single producer of the commodity and there are no alternatives for this commodity (Qardash, 2021).

Dang and Yeo, (2017) have studied the strategic competitive position of ports using methods for the strategic positioning of the competitive positions of the top 20 container ports in five countries of the Association of Southeast Asian Nations. Taghavi (2017) has listed five interacting forces responsible for competition between port service providers and port authorities. These are: (i) the competition between existing competitors; (ii) the created threat due to new competitors; (iii) global alternatives and alternative suppliers entering the field; (4) the bargaining power of port users; and (5) the bargaining power of port service providers. These forces affect ports of all sizes and lead to increased port expansion requirements, service improvements, pricing decisions, and other management actions.

Many researchers have analyzed the competitiveness capability of seaports through different models, such as; Data Envelopment Analysis (DEA), Analytic Hierocracy Process (AHP), Free Disposal Hull (FDH) and etc. where AHP is the most used method for analyzing the competitiveness capability of the container terminal and the most attractive way for users. AHP used to analyze the factors and secondary factors that affect

seaports' competitiveness capability. Whereas it has given proportionality ways for each factor through a standard rate in calculating the final result for the whole competitiveness of each Port or simply determining the most competitive capability determinants.

Pongpanich and Peng (2016) measured the efficiency of Thai container port by using Data Envelopment Analysis (DEA) Approach from 2006 to 2013. The empirical results of this paper can help the Thai government to examine the efficiency of infrastructure investment and operation which lead to plans improvement and create a competitive advantage of a container port in Thailand. The following table shows the previous studies that used different models in assessing ports' competitiveness.

Table (1) Previous studies on port competitiveness and tools used.

1	**Tetteh et al., (2016)**	**Data Envelopment Analysis (DEA)**	**Container port in China and 5 west Africa for the period from 2008-2013**	**Length of quay, number of cranes and number of berths**	**Container throughput (TEU) and vessel calls**	**Bigger ports are not absolutely efficient**
2	**Nguyen et al., (2016)**	**Bootstrapped DEA method, SFA and standard DEA methods**	**43 largest seaports in Vietnam.**	**Berth length Storage area Quay, cranes Number of equipment**	**Number of containers**	**Fail to underlying factors of the low levels of efficiency**

3	**Wanke and Barros (2016)**	**Bootstrapped DEA method**	**27 Brazilian ports for the years of 2007-2011**	**Quay length, maximal quay depth, number of berths, warehousing area, yard area, channel width and channel depth**	**Solid bulk loading hours, Container loading hours, Solid bulk throughput, Container throughput, Solid bulk frequency and Container frequency**	**Ports owned /managed by governments are significantly less efficient than ports with a private majority ownership.**
4	**Serebrisky et al., (2016)**	**Data Envelopment Analysis (DEA) &Stochastic Frontier Analysis (SFA)**	**63 ports in Latin America and the Caribbean during the period from 1999 to 2009**	**Terminal area, berth length, mobile cranes and STS gantry cranes**	**Container throughput (TEU)**	**There is a positive and significant association between technical efficiency and private sector participation**
5	**Hajizadeh et al., (2016)**	**DEA-BCC and Anderson-Peterson Model**	**Major 12 container port in Middle East for the period of 2011-2013.**	**Berth, berth length terminal area and quay and yard gantry**	**Container throughput (TEU)**	**Port inefficient in management of operations and how to use inputs.**
6	**Yingigba (2016)**	**Stochastic Frontier Analysis (SFA)**	**Eight Nigerian ports during the period 2000-2011**	**Port length, port area and waiting time**	**Container throughput (TEU)**	**Private sector participation in the port industry has improved port efficiency**

7	**Ago et al., (2016)**	**Data Envelopment Analysis (DEA)**	**China ports and five West African container ports (2008-2013)**	**Length of quay, number of cranes and number of berths**	**Container throughput (TEU) and ship calls number**	**Although China's ports are the largest in terms of throughput and size, they are relatively inefficient due to over-capacity.**
8	**Kutin et al., (2017)**	**DEA-CCR & DEA BBC**	**50 ASEAN container ports and terminals**	**max depth at berth, size of the container yard, length of the quays, number of quay cranes, number of RTGs, number of yard cranes, number of FTs and number of trucks.**	**Container throughput (TEU)**	**The reason of inefficiency in most of ASEAN container ports is their small size**
9	**Sun et al., (2017)**	**Multiple regression method**	**17 port "include 14 coastal port and three inland port"**	**Staff number and fixed assets**	**Operating cost, Net profit, Cargo throughput and NOx**	**large and medium-scale ports perform worse**

10	**Wiśnicki et al., (2017)**	**DEA-CCR**	**Nine European port "three conventional terminals, five semi-automatic terminals and one fully automatic terminal"**	**Quay length, Ships' Draught, Number of STS, Number of RTG/ASC and Yard capacity.**	**Container throughput (TEU)**	**Terminal efficiency is not closely related to the level of their automation.**
11	**Cabral and Ramos (2018)**	**DEA-CCR, DEA-BCC, and FDH**	**44 Brazilian port terminals for the year 2016**	**Berth length, Berth depth and N. of berths**	**Container throughput (TEU), units of containers /ship, and units of Containers**	**There is a strong relationship between efficiency and the size of a terminal port**
12	**Kammoun , R. (2018)**	**SFA with Cobb-Douglas production function and DEA with CCR and BCC models**	**7 seaports in Tunisia From 2007-2017**	**Number of Stevedoring equipment, Area stores and employees' number**	**Container throughput (TEU)**	**total average scores of operating efficiency scores were DEA-BCC (0.746) >SFACD (0.536) > DEA-CCR 3 out of 7 are technically efficient.**

13	**Hlali "a" (2018)**	**Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) models**	**26 world's major container ports in 2015**	**Total quay length, the maximum alongside depth, the total terminal area and the storage capacity**	**Container throughput (TEU)**	**The total average scores SFA method is better than the DEA method in measuring container ports efficiency**
14	**Hlali "b" (2018)**	**DEA-CCR and DEA BBC**	**7 Tunisian ports during 18 years (1998-2015)**	**Ships traffic entry and exit & Goods traffic**	**Container throughput (TEU) and containerized freight quantity**	**All the inefficient ports show increasing returns to scale.**
15	**Gökçek and Şenol (2018)**	**DEA-CCR & BBC, Scale efficiency and return to scale**	**28 leading container terminals across 9 Mediterranean countries (2016)**	**Terminal Length, Terminal Area, Quayside Gantry cranes and Yard gantry cranes**	**Container throughput (TEU)**	**Regional characteristics and geographical position would influence the level of efficiency and comparative competency.**

Source: By researcher.

The Fuzzy Analytic Hierarchic Process (FAHP) is one of the methods adopted in the decision-making process according to multiple criteria. It is based on employing quantitative methods in the decision-making process concerned with selecting the optimal alternative through a group of alternatives and according to multiple criteria.

The FAHP method weights alternative decisions by organizing objectives and sub-criteria into a hierarchical structure (Al-Harbi, 2001; Ismail, 2019). FAHP can be broadly understood as a theory of measurement using quantitative and/or qualitative data; it allows the use of qualitative as well as quantitative criteria in the evaluation (Elgazzar, 2013).

FAHP method is used as a multi-criteria decision-making technique that can help container port managers to enhance port efficiency. It increases its competitiveness by determining the relative importance of each variable applied in the model. Therefore, this helps in identifying the dimensions that work well while identifying the variables that need improvement. Perhaps the biggest advantage of this method is that it allows inclusion of intangible materials such as experience; subjective preferences; and intuition in a logical and organized way (Mu, and Rojas, 2017; Ismail, 2019).

AHP is based on ranking decision alternatives; and then choosing the best of them in the light of a number of criteria that are determined. Among the most important advantages of AHP method are the following (Elgazzar, 2013; Ismail and Elgazzar, 2018):

1. Combining the total and partial method. The total method builds the pyramid, where all variables are viewed in an integrated manner rather than separately. On the other hand, the

partial method looks at each variable separately, through binary comparisons between them.

2. Reliance on the quantitative and qualitative aspects.

3. Combining objectivity and subjectivity, as this method is based on the opinions of specialists and experts in this field.

4. A tool for monitoring and guiding organizational achievement towards a set of vital goals.

However, (Ismail, 2019) has analyzed the efficiency and competitiveness capability for the Egyptian Seaports. The research objective was to measure the Egyptian container terminal efficiency by using DEA and FAHP for the period from 2007 to 2016, to understand the current status of the Egyptian container terminals and suggest solutions to eliminate defects and enhance container terminals competitiveness.

FAHP approach has revealed that East Port Said port took the first position in these container terminals while Alexandria took last position, this index can be used to identify the criterion that needs improvement in the Egyptian container terminals.

Critical analysis of previous studies:

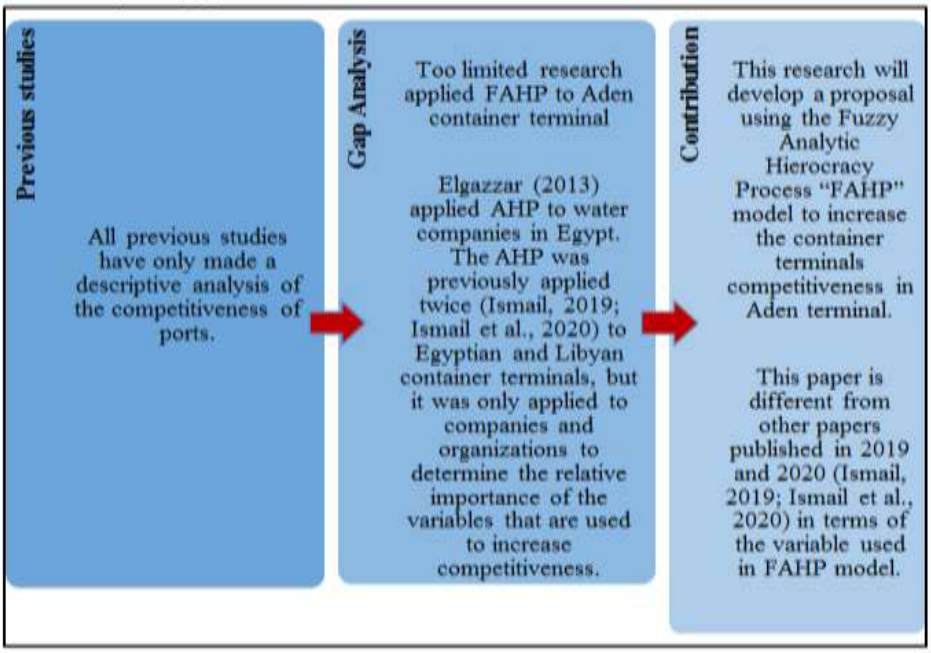

Figure no. (1) Critical analysis of previous studies.
Source: By researcher.

3. Research Problem:

The Port of Aden is the largest and most important Yemeni Sea port. Research problem can be summarized in the lack of a clear vision to increase the competitiveness of Aden container terminal. Due to the failure in taking any of the necessary measures to develop and invest in Aden port's container terminal, it negatively affected the competitiveness of the

terminal. This has caused inability to keep pace with the developments in neighboring ports at a time when all neighboring ports sought to increase their competitiveness, which is considered as a challenge for the port of Aden to keep pace with developments in these ports.

The researcher will answer the following question:

- Why the Port of Aden has poor competitiveness ability in compare to the other regional sea ports despite the Port's strategic location and natural harbor?
- What is the competitiveness of Aden container terminal?

4. Objective:

The main objective of the research is to define areas that need improvement in Aden container terminal using Fuzzy Analytic Hierocracy Process "FAHP" to increase Aden container terminal competitiveness.

5. Research Hypothesis:

To achieve the objectives of the research, a single basic hypothesis used as follow:

There is a relation between Aden container terminal competitiveness and variables used in FAHP technique. That are; storage area, quay length, navigational channel depth and handling equipment.

6. Research Methodology:

To achieve the desired objectives of the study, depending on its type and field; the researcher will depend on a descriptive-analytical approach, as the main approach. Therefore, the researcher has used the FAHP, to determine the relative weights of the existing variables affecting the competitiveness of Aden container terminals. This is achieved by distributing a questionnaire designed according to FAHP method, with the aim of determining the arrangement of Aden container terminal among the neighboring container ports.

To determine ports competitiveness; there are many programs to determine competitiveness in ports, such as the Stochastic Frontier Analysis (SFA), Free Disposal Hull (FDH), Data Envelopment Analysis (DEA). In this paper, Fuzzy Analytic Hierocracy Process (FAHP) is employed to enhance the competitiveness of Aden container terminal due to the ease of application by using personal opinions of decision-makers in ports, unlike other programs that rely on data analysis only. In fact, the AHP model is used to determine which variables need to be developed at ports so that they can increase their competitiveness, as they were applied before in ports in general; however, they were not previously applied to container ports in particular, except in a single Ph.D. thesis (Ismail, 2019).

The Analytic Hierocracy Process model is utilized to determine the relative importance of the variables that are used to measure port competitiveness. It is employed in decision-making procedures and it is the most commonly used method in the decision-making process; because of its accuracy and simplicity (Elgazzar, 2013; Ismail, 2019).

One of the most important advantages of AHP model is that it is used to identify, know and measure the relative importance of the variables affecting the competitiveness of ports to determine and evaluate their competitiveness (Ismail, 2019) mentioned some additional advantages of FAHP including correlation, hierarchy structuring, scaling, consistency and compatibility. Moreover, the hierarchical analysis model uses more than one variable, and has the ability to deal with both tangible and intangible aspects. However, to increase the competitiveness of Aden container terminal, the FAHP model will be utilized to determine the port of Aden ranking among the neighboring ports. This is done by determining the relative importance of the variables that will be applied to make a proposal to raise the competitiveness of Aden container terminal.

Furthermore, AHP shows which variables are most important for container terminals, according to the following studies of: Cullinane et al., (2005), Lin and Tseng (2005), Cullinane and Wang (2006), Cullinane and Song, (2006) Lin and Tseng (2007), SoonHoo et al. (2007), Sohn and Jung (2009), (Cullinane and

Wang, 2010), Rajasekar et al. (2014), Dyck (2015), and Serebrisky et al. (2016). These variables are the storage area, quay length, navigational channel depth and handling equipment.

Likewise, there are many variables that affect the competitiveness of ports, including: storage capacity, number of berths, berth depth, container yard, navigational channel depth, and handling equipment with its different types. In this research; berth depth was not used as a variable to determine port competitiveness because the development of berth depth is related to berth length. Moreover, the number of berths was not used because it is possible that the number of berths in a port is greater than that in another port, while at the same time it is possible that the lengths of the berths in the port with the smaller number of berths are greater than those with the larger number of berths (Elsayeh, 2015). Accordingly, only four variables are applied, and they are as follows:

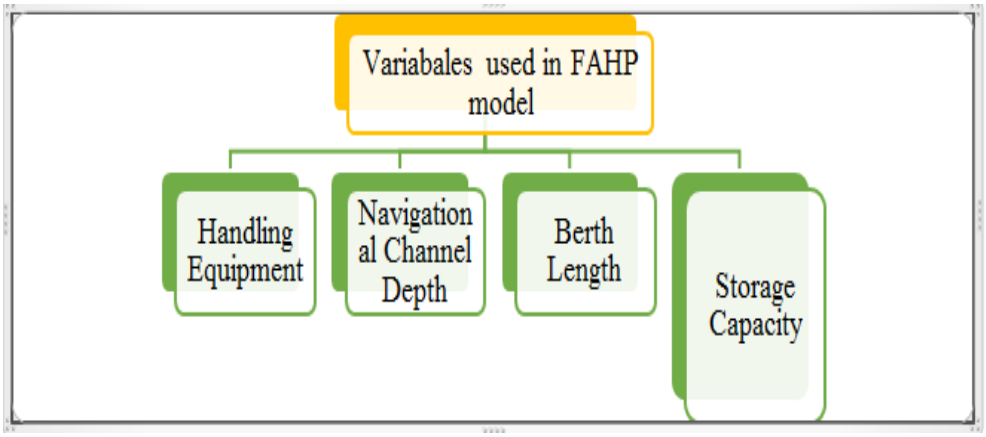

Figure no. (2) Applied variables.
Source: By researcher.

The reason for using these four variables in particular is that a very strong and positive relationship exists between these variables, greater than 0.5, by calculating the correlation between these variables, as shown in the following table no. (2):

Table no. (2): Variables correlation.

	Storage capacity	Berth length	Navigational channel depth	Handling equipment
Storage capacity	**1**	**0.98١**	**0.99٧**	**0.93٩**
Berth length	**0.98١**	**1**	**0.962**	**0.853**
Navigational channel depth	**0.99٧**	**0.962**	**1**	**0.963**
Handling equipment	**0.93٩**	**0.853**	**0.963**	**1**

Source: By researcher.

Data Source:

The researcher depends on the data and information collection as follows:

Primary data: represented in the questionnaire presented to the research community.

Secondary data: represented in the books, scientific published papers, as well as scientific theses and reports in this field.

Research Community:

The container terminal of Aden is one of the main and most important seaports in the Gulf of Aden region. It is located in the city of Aden, and the port of Aden is one of the largest natural ports in the world. It has been noticed that there is an increase in the annual productivity of the Aden container terminal. The productivity has increased from 290,011 20-foot equivalent containers (TEUs) in 2013 to 296,035 TEUs in 2014.

Nevertheless, it has declined to 178,101 TEUs in 2015; due to the civil war that Yemen has witnessed. Then it increased again to reach 268,208 TEUs in 2016 and 334,894 TEUs in 2017. Gradually, it continued to rise in 2018 to reach 398,999 TEUs, while it reached the peak, 464,952 TEUs, in 2019 and decreased again in 2020 to 423,393 TEUs (Aden Ports Development Company, 2021).

The study community is represented in Aden container terminal; Djibouti and Salalah. The questionnaire shall depend on Shipping agencies, chamber of commerce and transport offices, port employees and the customs authority that represent the source of the primary data for the research in addition to the shipping companies and cargo owners.

7. Statistical analysis:

To increase the competitiveness of Aden container terminal, FAHP model will be built which is used to determine the relative weights of variables in container terminals, by distributing a questionnaire designed according to FAHP method, in order to determine the arrangement of Aden container terminal among neighboring terminals.

The proposed framework for analyzing the competitiveness of Aden container terminal:

The research proposes a framework to determine the competitiveness of Aden container terminal using FAHP based on the following four steps:

Step 1: Determine the criteria used to assess the level of competitiveness in container terminals.

The objective of the FAHP is to determine the relative importance (weight) of each criterion used in the assessment of a container terminal **(**Ismail, and Elgazzar, 2018). A review of

previous studies is conducted to determine the main criteria that reflect the efficiency level of the container port. The review concluded with four main criteria to measure the competitiveness of Aden container terminal; because it is the most common criteria for evaluating container terminals. They are the navigational channel depth, storage capacity, and quay length and handling equipment.

Step 2: Develop a FAHP questionnaire to determine the relative importance of selected criteria.

The FAHP was prepared to weigh the relative importance of the competitiveness criteria at the container terminals based on the pair wise comparison scale that ranges from 1 to 9 as shown in Table (3), where

1 indicates equal importance, 3 moderately more significant, 5 more much importance, 7 more importance and 9 extremely important.

Table (3): Pairwise comparison scale.

Numerical value	Verbal judgment
9	Extreme importance
7	Very strong importance
5	Strong Importance
3	Medium Importance
1	Same level of importance

Source: (Ismail, 2019)

To determine the relative importance (W) of specified criteria, questionnaire is distributed to a group of experts in this field such as: port authority, shipping companies, shipping agencies, academic experts and other decision makers in the field as shown in the following table no. (4).

Table no. (4) Questionnaire model.

With respect to (Profitability)	Importance or preference of one factor over the frame of discernment									
Navigational channel depth	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	Handling equipment
Storage capacity	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

Source: By researcher.

Once the expert entered the judgments, the level of consistency of the responses was tested to check the consistency of the comparison matrix. Then the Consistency Index (CI) and Consistency Ratio (CR) were calculated using the Saaty method. This is conducted to verify the validity of the data in the questionnaire (Elgazzar, and Ismail, 2021).

If CR is less than or equal to 10%, the discrepancy is acceptable; whereas if CR is greater than 10%, pairwise comparisons should be repeated until the consistency is less than 0.1 (Mu and Rojas, 2017).

Step 3: Develop a performance rating scale; to evaluate each efficiency criterion;

A five-points performance evaluation scale has been developed; (very bad, poor, good, very good, excellent) based on the advantages of a container ship to evaluate the five efficiency criteria in order to evaluate the efficiency of a container port. Each criterion is assigned a performance rating (R) (0.2, 0.4, 0.6, 0.8 or 1), with 0.2 indicating very poor performance, 0.4 poor performance, 0.6 good performance, and 0.8 good performance, while the number 1 signifies extremely excellent performance.

Step 4: Calculating Container Terminals Index

After determining the performance rate (R) and 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 the weighted average aggregation method to determine the efficiency index for container port and rank it compared to other ports indexes.

Applying FAHP Model:

The process of AHP begins by placing the problem elements in a hierarchical manner. Then a pair comparison between the elements of the problem is made at one of the levels, based on the selected criteria. Next the priorities are obtained from these comparisons till the overall priorities are reached.

A framework has been applied to determine the competitiveness of Aden container terminal using FAHP technology based on the following four steps:

The following figure no. (3) shows AHP model of the container terminals under study:

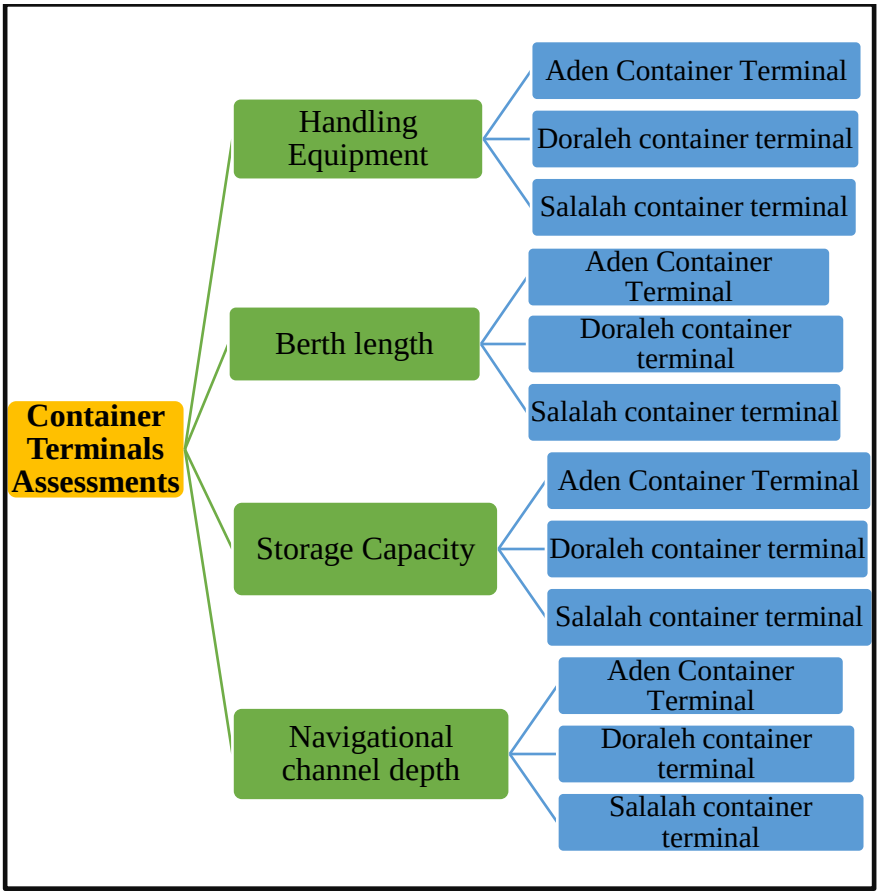

Figure (3): Hierarchy model for terminals under study.
Source: By researcher.

Step 1: Determine the criteria used to assess the level of competitiveness in container ports.

Based on previous studies related to studying, evaluating and analyzing the competitiveness of ports, four main criteria were selected that were used in many researches to measure the competitiveness of container terminals around the world. These are some of these researches: Lin and Tseng (2005), Tongzon and Heng (2005), Cullinane and Wang (2010), Cullinane and Song (2006), Lin and Tseng (2005) Cullinane et al., (2006), Cullinane and Song (2006), Lin and Tseng (2007) Soonhoo et al. (2007) Sohn and JUNG (2009), Cullinane and Wang (2010), Rajasekar et al. (2014) Vandyck (2015), and Serebrisky et al. (2016).

Step 2: Developing FAHP questionnaire to determine the relative importance of the selected criteria.

As shown in table no. (4), this questionnaire distributed to a group of experts in Aden port, shipping companies, shipping agencies, academic experts and other decision makers in this field. The main objective of this questionnaire is to determine the materiality weights of the main criteria affecting terminal competitiveness using FAHP approach.

The respondents in this research are port authority, shipping companies, shipping agencies and academic experts in this field. Table no. (5) shows the participants in the questionnaire and the number of questionnaires sent and received from them.

Table (5) Questionnaire participation percentages.

Participants	Questionnaires sent	Received	Invalid	Valid
Terminal management (managers and employees)	40	35	5	30
Port users	٤٠	15	1	14
Shipping agents and clearance agents	20	18	3	15
Academic experts	20	18	2	16
Total	١٢٠	٨٦	١١	٧٥

Source: by researcher.

Step 3: Develop performance-rating scale.

To determine the weight of each variable, a duplicate questionnaire, based on numbers, is used to facilitate comparison of attributes. As shown in table (5), the importance of the two scales related to each other was classified using a scale with values of 1, 3, 5, 7 and 9. The value (1) indicates the same importance, 3 is slightly more important, 5 is strongly important, 7 is clearly important, and 9 is extremely important.

The following table no. (6) shows the relative importance of weights related to criteria based on questionnaire response. The results revealed that handling equipment has the highest relative importance to the main variables, 33%. Storage capacity took second place with 31%. The length of the berth ranked third in

the relative importance of the variables by 27%, and depth of the navigation channel came fourth according to the weight of the relative importance by 10%.

Table (6) Relative importance of weights for the main criteria.

Criteria	Priority (relative importance)	
Navigational channel depth	4	0.101
Storage capacity	2	0.305
Berth length	3	0.266
Handling equipment	1	0.327

Source: by researcher.

To check the consistency of the responses, CR and CI were calculated. As shown in the following, table no. (7), the results revealed that CR = 0.05 was less than the maximum permissible value which is (0.1); therefore, our results are valid (Elgazzar, 2013).

Table (7) Consistency test table.

EIGENVALUE	N	CI	RI	CR
4.159	4	0.053	0.9	0.058888889

Source: by researcher.

Step 4: Calculating container terminals index

The scale was made based on the statistical data collected from Aden Ports Development Company, as shown in the following table no. (8):

Table (8) Variables used in the research for container terminals under study.

Container terminals	Handling equipment STS (no.)	Quay length (meter)	Storage capacity (TEU)	Navigational channel depth (meter)
Aden container terminal	6	700	1,000,000	14.2
Doraleh container terminal	٨	1,050	1,300,000	18
Salalah container terminal	٢٥	2,400	6,000,000	20

Source: (Aden Ports Development Company, 2021)

The rating performance was determined by using a five-point performance rating scale (very bad, poor, good, very good, and excellent) to evaluate four main criteria in order to classify the competitiveness of container ports under study. The following table no. (8) shows the aggregate rates of the four main criteria of the container terminals under study.

The following table no. (9) illustrates the strength and weakness of ports under study during the year 2021. Then the amount that must be invested in these variables will be determined; in order to improve all variables that affect competitiveness to transform these terminals from the current level to another better level.

Table (9) Aggregate rates for criteria.

Container terminals	Handling equipment STS			Quay length			Storage capacity			Navigational channel depth			Total	Classification
	WR	R	W	WR	R	W	WR	R	W	WR	R	W		
ACT	0.066	0.2	0.33	0.05	0.2	0.27	0.124	0.4	0.31	0.04	0.4	0.1	0.284	3
DCT	0.066	0.2	0.33	0.22	0.8	0.27	0.248	0.8	0.31	0.08	0.8	0.1	0.610	2
SCT	0.264	0.8	0.33	0.11	0.4	0.27	0.186	0.6	0.31	0.06	0.6	0.1	0.618	1

Source: By researcher.

For example, in Aden container terminal, shortcomings and defects are found in all variables selected to measure competitiveness. It was found that Aden container terminal suffers from a very poor level of performance in all variables. Thus, in order to raise the competitiveness of this terminal, investments must be made in all the variables applied in this research to convert it from very poor to a good or very good level of performance. It was also shown from the following table that Salalah container terminal (SCT) occupied the first place in the competitiveness among container terminals under study, while the Djiboutian container terminal (DCT) occupied the second place.

8. Conclusion and Recommendations:

It turned out that Aden container terminal suffers from major problems in the operating environment, which are related to the use of berth length; that is the level of space sufficient from the

distance of berth length to accommodate ships. This is in addition to the high level of malfunctions in one of the terminals resulting from the terminal's reliance on old equipment that did not get enough adequate maintenance programs, both on berth and in the yard.

Maritime transport technology has proven that container industry is the best means of transporting general cargo. It is clear that it will remain in the future the continuous means of transport in global trade as the industry is currently exposed to economic and technological changes in container vessel sizes.

There are new trends towards designing container ships efficiently in their economic size and optimum speed in energy use in order to reduce gas emissions that have negative effects on the climate change. Actually, this has become a mandatory administrative method in the manufacture and operation of ships to move freight more sustainably in order to help the international shipping sector achieve cost-effective improvements to its operations.

Increasing the size of ships in terms of length, width and draft makes it more difficult to choose ports commensurate with their capabilities with depths and dimensions to accommodate them. These huge ships are sensitive to time when operating, meaning that it is necessary that these ships have to be loaded with full capacity. Thus, ports have to reduce their berthing time and speed of the handling rates.

Researcher makes some recommendation as follows:

- ❖ Depths are one of the determinants for a new generation of ships, therefore; ports have to take specifications of new ship into consideration.
- ❖ Rehabilitation of all handling equipment related to berths and yards in the terminal and modernizing them with new units commensurate with the current and future operating requirements, and enhancing the role of container terminals in light of the existing competition with the neighboring ports.

Future Studies:

The researcher recommends conducting future studies and using intangible variables that affect the competitiveness of container terminals; such as service level and customer satisfaction; and applying Key Performance Indicators (KPIS).

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