Investigating the Efficiency of the Egyptian Sea Port Authorities using the Data Envelopment Analysis (DEA)

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ABSTRACT

The competitiveness and performance of seaports have changed evolved during the last years not only because of new ports are equipped with the newest technology or because new established ports strive to become more efficient in order to remain competitive. Moreover, seaports engage in more than just competition with their neighbor countries but also with other ports in adjacent regions.
Alternatively, Containerization has improved the global supply chain performance and resulted in lower transportation costs. The capacity of container ships has grown during the last decades. In this respect, sea port authorities and container terminal operators alike must be able to increase the effectiveness of business operations at container ports in order to boost the efficiency of sea port container terminals.
This study provides analyze the sea port performances in Egypt in comparison with other Arab states , further this research investigate the efficiency of the Egyptian port authorities in 2022.

1. Introduction.

Seaports are facing a changing logistics and economic environment. The quality of the maritime facilities seaports significantly affect the global trade ,during the previous years the disruption of a maritime canal or sea port hugely affected the global trade , for instance the blockage of the Suez canal in 2021 cost global trade between $6bn to $10bn a week and reduced annual trade growth by 0.2 to 0.4 percentage points.

Due to their advantageous geographic location and significant infrastructural investments, Middle Eastern ports account for almost 20% of global maritime traffic Consequently, The Israel-Hamas War started in October 2023 resulted in a massive increase in shipping rates for routes passing between the Red Sea and Gulf of Aden.

Due to its complexity, seaport competitiveness is an unclear notion, and the form and characteristics of competition vary de-

pending on the commodity and the type of port involved. In this regard, the emergence of new ports equipped with advanced technology to boost their efficiency have led to changes in seaport performance and competitiveness. In this respect, Seaports face more challenges to compete with neighboring ports within the same region.

In the other hand, Containerization has improved the global supply chain and resulted in lower transportation costs. The capacity of container ships has grown throughout time. The more effective ship-to-shore operations have been made possible by the growth in containership size and the consequent growth of cargo handling technology.

Container transportation represents an important turning point in the maritime trade industry that has been developed along with the rapid advancement of transportation and information technology. Which includes the land, air, railway, and marine transport simultaneously, respectively. Logistics integration can be defined as the extent to which service providers participating in logistics or supply chain operations collaborate to improve the overall operational effectiveness of the supply chain. .

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From another perspective, during the last decade, there has been a global trend towards the institutional restructuring of the public sector.

In this regard, many administrations used the port concession agreement to increase investments in the port operations, in the port concession the government grants operating rights to a private company, which may be required under the contract to build or renovate infrastructure.

The primary driving forces behind port privatization have been the anticipated financial gains from increased productivity and performance as well as the political goal of reducing the government's long-term financial and administrative burden for an extremely costly industry.

Efficient terminal operation aims to reduce transportation costs and facilitate the imports and exports procedures that significantly promote terminal operations effectiveness. Thus, high freight and handling costs are a result of inefficient terminals.

Munim, Z. H., & Saeed, N. (2019) identified seven key research topics regarding the seaport competitiveness which includes; 1- port competition, 2- port efficiency, 3- institutional transformation, 4- port pricing, 5- port embeddedness, 6- port choice, 7- port cooperation.

Given the continued market concentration and consolidation China Merchants Port Holdings, Terminal Investment Limited, Ports America, Evergreen Marine Corporation and DP World the five biggest container port operators in the world account for 36.1 percent of global container traffic in 2023.

The effectiveness of the international supply chain is significantly impacted by the port selection decision. A port user's access to terminals and distribution centers, which are necessary for transshipment and storage, may be hindered if a port is chosen incorrectly. On the other hand, the port user's access to qualified labor pools, navigation routes, foreign trade zones (FTZs), and intermodal transfers may be restricted by the chosen port and its associated infrastructure, which may have an impact on the availability of port services.

In this respect, this research has chosen to emphasize the seaport containers competitiveness due to the growing significance of containerization and container transport.

This research paper is organized as follow; background followed by an Introduction, literature review ,data and analysis and finally Results, and Discussion.

2. Background.

The competition among regional ports intensifies as global container traffic and ship sizes increase. The ability of shipping lines to bargain is strengthened by this condition. Ports encounter challenges while adjusting to handle increased global container traffic, growing ship sizes, and heightened competition among regional ports. The ability of shipping lines to bargain is strengthened by this condition. In order to serve long draughts and provide dynamic supply networks, however, Due to competing interests between shipping companies and agencies, ports encounter difficulties in meeting the needs of all parties.

Concession agreements (CA) in the port sector can be described as an agreement that aims to create mutually beneficial outcomes for all participants. Ports can attract experienced private investors and secure funding from the private sector to invest in infrastructure and provide high-quality services.

In this regards, An agreement on the development and management of the container terminal of Sokhna Port on the Red Sea was signed in March 2023 by the General Authority for the Suez Canal Economic Zone (SCZONE), which is composed of the consortium of Hong Kong-based Hutchinson Ports, French container transportation and shipping company CMA CGM, and Chinese state-owned Cosco Shipping.

These projects, according to Hutchinson Ports, would increase the company's total investment in Egypt to over $1.5 billion and lay a solid foundation for its strategy to grow its network and strengthen its position in emerging markets.

Alternatively, in 2008, state-owned China COSCO Shipping became the first entity to be granted permission to operate portions of Piraeus seaport in Greece. It bought 51 percent of the Greek state-owned port operator in 2008 and raised its ownership to 67 percent in October 2016, respectively, The Xinhua-Baltic International Shipping Centre Development (ISCD) Index placed the Port of Piraeus among the top ten performing seaports in 2022.

Port competition can be referred to as a competition for trades, with terminals as the competing units, logistics, transport, and industrial enterprises as the chain managers of the respective trades with port authorities and port policymakers as co-developers.

Port competition has become a complex and multi-faceted concept. The nature and characteristics of competition depend, among other things, upon the type of the competing ports (e.g. feeder port, hub port) and the cargo group (e.g. containers, liquid bulk, dry bulk, non-containerized general cargo). In container transport, a distinction has to be made between the large load centers or main/hub ports and the smaller regional or feeder ports. The load centers are primarily competing for deep-sea intercontinental liner services, in which large ships of up to 24,000 TEU are being deployed. Regional ports strive for connections to as many nearby load centers as possible that have good regional hinterland connectivity.

3. Literature Review.

Wahyuni, S., Taufik, A. A., & Hui, F. K. P. (2020) Observed that six out of 10 of the most challenging are related to the governmental policies and regulation facing the sea port operators in Indonesia. Respectively, the policy instability, government bureaucracy, and corruption were significantly affecting the sea port operations performance in Malaysia.

Rosa Pires da Cruz, M., Ferreira, J. J., & Garrido Azevedo, S. (2013 Considered the ; (ii) land and sea access to seaports; (iii) the state of the resources available and the influence of their costs on seaports; (iv) seaport productivity; (v) shippers' preferences; and (vi) comparative advantage in terms of location are the six factors that mostly affect the seaport competiveness .

Alternatively, Min, H., & Park, B. I. (2020) utilized to weigh the relative importance of port selection factors by Analyzing the characteristics of port selection factors based on the modified Kano model and the refined importance–performance analysis (IPA), the research concluded that the most important port selection Criteria were the intermodal links and network accessibility, the size of the port and terminal.

Tijan, E., Jović, M., Žgaljić, D., & Aksentijević, S. (2022) analyzed Container operations in the Port of Rijeka, the research considered the port geographical location, access to the road and railway infrastructure, port reputation, customs procedure efficiency, and digitalization as additional factors that affect the competitiveness of the seaports .

Kavirathna, C. A., Kawasaki, T., & Hanaoka, S. (2018) investigated the factors the market share of the port of Colombo , accordingly In order to improve operational efficiency and market potential, the infrastructure development of the port needs to be promoted along with the development of the port main performance indicators .

In the other hand, Wang L, Zheng Y, Ducruet C, Zhang F. (2019), identified the port of Klang and Singapore port as the main hub ports that Chinese ports rely on in the shipments transfer from and to China.

Baştuğ, S., Haralambides, H., Esmer, S., & Eminoğlu, E. (2022) utilized the Fuzzy Analytic Hierarchy Process (FAHP) to review the factors affecting the port competitiveness , according to the research results ,the most important criterion was port location, followed by service level, port tariffs, and port facilities.

Gracia, M. D., González-Ramírez, R. G., Ascencio, L. M., & Mar-Ortiz, J. (2022).found that throughput and connectivity are positively correlated with port performance, while the time spent in port is negatively correlated with optimal governance practices.

Elgazzar, S., & Ismail, A. (2021) used the DEA technique to measure the competitiveness of six Egyptian container terminals, in this regards , the research considered the storage capacity , draught , berth length and the gantry cranes as the main indicators of the operation efficiency of seaports , according to research results ,Alexandria sea port was the most efficient Egyptian container terminal however the port competitiveness was less competitive in comparison with the other container terminals .

Aksoy, S., & Durmusoglu, Y. (2020) utilized ARENA discrete simulation modeling software to simulate the cargo handling activities of a Turkish container terminal, within different scenarios. The BCG portfolio analysis method was then employed to study the simulation results of each scenario and examine the potential increase in competition for the container terminal.

Tongzon, J. L., & Nguyen, H. O. (2021).demonstrates how supply chain allocative and technical efficiency may be impacted by logistics integration between ports and shipping lines.

On the other hand, According to Wang, L., Zheng, Y., Ducruet, C., & Zhang, F. (2019) Port Said, Jebel Ali, Durban, Dammam, Louis, Jeddah, and Cape Town are key investment ports due to their strategic location, with Jeddah in the Red Sea serving as a fulcrum along the maritime global routes. Aside from COSCO Shipping Ports, which owns 16.5% of Port Said, Hutchison Ports has invested in Daman Port; the rest of these ports have not been invested in by Chinese terminal operators, and there has been little investment from other international terminal operators.

Respectively, Wu, Y. C. J., & Goh, M. (2010) considered the port of Damietta as one of the most efficiently operated terminal ports alongside the major seaports as the port of shanghai, Chittagong and Santos.

Mustafa, F. S., Khan, R. U., & Mustafa, T. (2021).applied the DEA method to analyze the operational efficiency of some Arab gulf countries in comparison with their Asian counterparts , in this regard , according to the research results port of Jebel Ali port was among the most efficient seaport in carrying out port activities in comparison with other Arab countries , however , in the Asian side the port of Busan and Shanghai were more efficiently operated in comparison to other Asian seaports .

Pagano, A. M., Wang, G. W. Y., Sánchez, O. V., & Ungo, R. (2013) investigated whether economics of scale improves port efficiency in terms of profitability or whether product diversification enhances operating efficiency in selected US container ports ,the research concluded that the greater the number of terminals and facilities, the greater the probability of a lower efficiency.

Yüksekyıldız, E., & Tunçel, A. L. (2020) investigated the efficiency of 22 container terminal operating in Turkey between 2015 and 2017 using the FDEA method, according to the research results the Mar port was the most efficient operating port among the investigated container terminals.

Mustafa, F. S., Khan, R. U., & Farea, A. O. A. (2019) analyzed the TEUs of some Arab ports from 2008 to 2017 using the Herfindahl-Hirschman Index (HHI) , the research results indicated that the competitiveness of the Arab ports increased during the last years because of the increasing amount of exports in 2017 comparing to the imports of the examined ports in 2008.

4. Analysis of the Egyptian sea ports performance in comparison with regional sea ports.

Port competitiveness is influenced by a variety of factors, and once it is, all "stakeholders" and end users—shippers, port operators, shipping firms, freight forwarders, shipping brokers, road hauliers, and logistics operators—benefit from it. Each of those players, of course, uses their own selection criteria, which frequently extend beyond "port competitiveness" to include generic costs and supply chain optimization on a worldwide scale.

Over the last few years, Hutchison Holdings (China), PSA International (Singapore), and COSCO (China) have usually been among the top global seaports operators ,Alternatively , Dubai Ports World (DPW) has made numerous acquisitions and grown to be among the top ranked company in operating port terminals .

On the other hand, The World Bank issues annually the container port performance index which aims to measure the sea-

port performance to identify areas for improvement that will benefit all parties involved, from shipping lines to national governments and consumers. It is intended to serve as a reference point for key stakeholders in the global economy, such as port authorities and operators, national governments, supranational organizations, development agencies, various maritime interests, and other public and private stakeholders in trade, logistics, and supply chain management.

Table 1: Terminal operators of the major Arab seaports listed in the container port performance index 2022.

PORT NAME	Operators
SALALAH port	APM Terminals
PORT SAID	Local Operator
HAMAD PORT	QTerminals
KHALIFA BIN SALMAN	APM
JEBEL ALI	DP World
JEDDAH	National Container Terminals
JUBAIL	GSCCO
BEIRUT	CMA CGM
TRIPOLI (LEBANON)	CMA CGM
SOKHNA	Hutchison ports
AQABA	APM
SHARJAH	Gulftainer Co
ALEXANDRIA (EGYPT)	Hutchison ports
UMM QASR	ICTSI
AGADIR	APM Terminals
ALGIERS	DP World
EL DEKHEILA	Hutchison ports
BENGHAZI	Libyan Ports Company
DAMIETTA	DCHC
PORT SUDAN	Sudan Ports Corporation
UMM QASR	ICTSI
EL DEKHEILA	Hutchison ports
BENGHAZI	Libyan Ports Company
DAMIETTA	DCHC
PORT SUDAN	Sudan Ports Corporation

Source: Author.

According to the container port performance index, poor container port performance can cause shipment delays, disruptions in supply chains, increased prices, and decreased competitiveness. Subsequently, poorly performing ports have inadequate efficiency, access, monitoring, and cooperation among public authorities, resulting in decreased predictability and reliability.

Figure 1: Arab states main sea ports scores according to the container port performance index 2023.
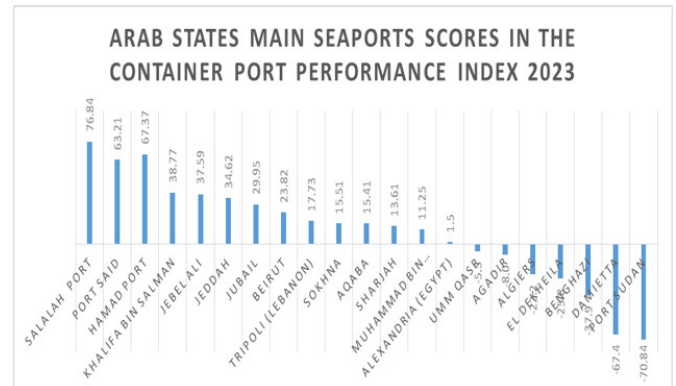
Source: Author.

According to the results of the container port performance index 2023, some huge variation exists between the container port performance of the Arab states container, respectively, some of the Arab container ports are among the top ten or twenty performing container ports (as for ; Salalah ,port said) while other Arab container ports are among the lowest performing ports as for the case of port Sudan and Damietta containers port .

Alternatively, Some Arab seaports have shown significant progress in the efficiency of its operations, for instance, the 2021 Key port performance index showed that the efficiency of the King Abdullah Port handles an average of 97 containers per hour in comparison with 26 containers per hour at North America's main ports.

The market for ports and terminal operations was estimated to be worth USD 3808.94 million in 2022. Over the course of the forecast period, the market is anticipated to grow at a CAGR of 10.28%, reaching USD 6849.63 million by 2028. The term "ports and terminal operations" describes the range of tasks performed by terminal managers each time a ship or vessel arrives carrying goods.

On the other hand, Hub port competitiveness can be effectively determined by investigating its transshipment market share, since fierce competition is generally reflected in a hub port's high market share. Hence, using a multinomial logit model and generalized cost a tried and true technique for examining decision-making patterns market share is approximated. But instead of accounting for the costs or benefits of non - quantitative criteria, generalized cost frequently concentrates on quantitative conditions.

In this respect, this study assumes that sea port performance in the container port performance index is positively affected by the involvement of the global sea container port operators.

H0: The port privatization increases the competitiveness of the sea ports.

Figure 2: Arab countries container operators' market share as per the container port performance index 2023.
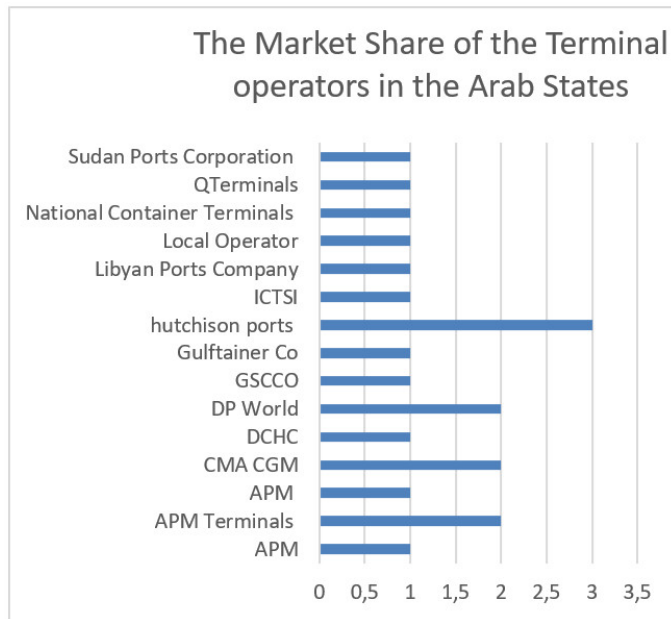
Source: Container Port Performance Index 2023.

The contribution of the global seaport operators to the seaport performance could be observed using the seaports ranking in the container port performance index, Respectively, Hutchison container port operator contributed positively to the ranking of the Alexandria and Sokhna container ports within the container port performance index.

Alternatively, CMA CGM contributes positively to the ranking of the seaport containers terminals ranking in the container port performance index, since its operating container terminals in Beirut and Tripoli in Lebanon, moreover, it operates one of the container terminals in Alexandria Sea ports, taking in to consideration that the three seaports are among the top ten Arab port container terminals in the container port performance index.

In the other hand, APM Terminals also contribute significantly to the seaport containers listed in the container port performance index, in this regards, APM operating Khalifa Bin Salman, Aqba and Agadir in Bahrain, Jordan and Morocco. Respectively, APM contributed significantly to the port performance.

Within the container port performance index especially Khalifa Bin Salman and Aqba containers ports.

4.1. Data Model.

Egypt has four major port authorities in Alexandria, Red Sea And Damietta alongside the Economic zone which includes the west port said sea port and other seaports that significantly contribute to the maritime trade form and to the Egyptian territory, in this respect, A port authority can be defined as a public or private entity that has the authority to carry out, develop, manage, and, sometimes, operate port land and infrastructure. It can also coordinate and oversee port operation activities.

4.2. Egyptian Sea port Authorities.

Table 2: Egyptian port authorities.

Port Authority	Sea Ports
Alexandria Port Authority	Alexandria Port.
	El-Dekheila Port
Suez Canal Economic Zone (SC Zone)	West Port- Said Port.
	Adabiya Port.
	Al Tor Port.
	Al Arish Port
Damietta Port Authority	Damietta port

Source: Maritime Transport Sector, mts.gov.eg.

Table 3: Egyptian Seaports main indicators.

Egyptian Sea port Authorities

Port Authority	Inputs			Outputs	
	Length (m)	Draught (m)	Berth	Cargo (million tons)	TEU
Alexandria Port Authority	14358	20	84	66	2.8
Damietta Port Authority	6600	15	23	33	2.8
Red Sea Ports Authority	5711	14	33	25	1.7
Economic Zone	11506	19	55	60.2	3.7

Source: Maritime Transport Sector, mts.gov.eg.

Table 4: Egyptian Seaports authority's operation efficiency.

Port Authority	Port efficiency (DMU)
Alexandria Port Authority	1.06
Damietta Port Authority	0.40
Red Sea Ports Authority	0.48
Economic Zone	0.77

Source: Author.

4.3. Research Model.

The first Data Envelopment Analysis (DEA) model developed by Charnes, Cooper and Rhodes (1978) under the assumption of a Constant Returns to Scale production technology, i.e., when an increase in the production resources results in a proportional increase in the output.

Considering j = 1, 2, 3,...m; Decision Making Units (DMUs) using x_i | i = 1, 2, 3,...n, inputs to produce y_r | r = 1, 2, 3,...; outputs and prices (multipliers) v_i and u_r associated with those inputs and outputs, we can also formalize the efficiency expression in (1) as the ratio of weighted outputs to weighted inputs:

$$\text{Efficiency} = \frac{\sum_{r=1}^{s} u_r y_{jr}}{\sum_{i=1}^{n} v_i x_{ji}}$$

The research relied on the Data Envelopment Analysis (DEA) model to analyze the Egyptian port authorities' operational efficiency.

When the DMU's efficiency score is = 1, it means that it is efficient and on the efficiency frontier. If the DMU's efficiency score is less than one, it is considered inefficient.

4.4. Description of the results.

Alexandria Port Authority : taking in to consideration the capacity of Alexandria and el-Dekhila seaports that operates under Alexandria port authority in comparison with other port authorities ,having a of 14358 m length and 20 m draught in this respect the cargo handled and TEU amount could be further developed given the capacity of the associated seaports.

Respectively, the Economic zones have shown relatively efficient operation in comparison with their current capacities.

In the other hand, Damietta Port Authority tend to be less efficient in comparison with other port authorities, taking in to consideration the associated sea ports capacities.

And finally, the Red Sea Ports Authority have had the lowest TEU handled in comparison with the other port authorities.

4.5. Limitations of the Study.

This research has taken in to consideration the main performance indicators of the sea port authorities , further studies may include a detailed data set which would present a more comprehensive analysis and results for the topic in hand .

Conclusions.

As seaport competitiveness becomes more and more important, this study provided insights using the Arab seaports ranking in the container port performance index (CPPI), in this respect, the global container terminal operators tend to significantly affect in the Arab countries seaports operational scores within the container port performance index (CPPI).

The efficient terminal operation aims to lower transportation costs and streamline import and export processes, both of which greatly increase the efficacy of terminal operations. Therefore, inefficient terminals lead to high freight and handling costs.

Since the DEA technique's computations are nonparametric and can handle many outputs without requiring an explicit determination of the relationships between input and output in advance, according, this research relied on the DEA technique to measure the sea port operational efficiency.

Jebel Ali is considered as a hub port in the Arab region in terms of throughput (TEU), shipping lines and global terminal operators.

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