Case study on the Competitiveness Comparisons of Karachi Port with the Neighbouring Emerging Ports in Persian Gulf and Indian Ocean.

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Received: 10 June 2020
Revised: 18 Aug 2020
Revised: 11 Sep 2020
Accepted: 24 Sep 2020

Raja Awais Liaqait[a]
[a] *Department of Mechanical Engineering, Capital University of Science & Technology, Islamabad, Pakistan; Email: awais.liaqat@cust.edu.pk*
Mujtaba Hassan Agha[b,*1],
[b] *NUST Business School (NBS), National University of Science and Technology, Islamabad, Pakistan; Email: mujtaba.agha@nbs.nust.edu.pk*
Till Becker[c]
[c]*Faculty of Business StudiesUniversity of Applied Sciences Emden/Leer Emden, Germany; Email: till.becker@hs-emden-leer.de*
Salman Sagheer Warsi[d]
d Department of Mechanical Engineering, Capital University of Science & Technology, Islamabad, Pakistan

Abstract

Purpose: This study evaluates competitiveness of emerging ports located in the Indian Ocean and the Persian Gulf. Traditionally, ports operational efficacy is evaluated only on basis of throughput, a case in point being the Lloyds International Port ranking. However, we do not concur with this approach and adopt a multi-criteria methodology.
Methodology: Three criteria - throughput, physical infrastructure, and performance are used to assess the operational efficacy of the ports. TOPSIS augmented with the "entropy weight" is used to devise weights for the chosen criteria and overall operational efficacy for each port is calculated.
Results: The study revealed that infrastructure plays a critical role in the overall operational efficacy of the port. Karachi port is behind the contemporary ports in the Indian Ocean and the Persian Gulf because of its inadequate infrastructure. The results also highlighted that Jawaharlal Nehru Port ranked highest in considered ports while Port of Mundra ranked the worst.
Practical Implications: The study can provide an insight to the port users about the competitive advantage amongst ports. Moreover, it also identifies the areas that can be improved for better efficiency.
Originality: The research article is novel because no similar study has been conducted specifically on the ports in the Indian Ocean and the Persian Gulf.

NBR

NUST Business Review
NBR- NBS20061001
Vol. 02, No. 01
10, 2020
pp. 12-42
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Key Points:

- *Proposed Framework for Port Competitiveness Evaluation using Multi-Criteria Decision Making Techniques.*
- *Port Physical Criteria plays a significant role in overall port competitiveness.*
- *Karachi port lacks behind its neighbouring ports due to enervated Physical Infrastructure and Operational Performance.*
- *Throughput alone is not a sufficient measure to gauge port performance.*

Keywords: *Physical Infrastructure; Port Competitiveness; TOPSIS; Karachi Port.*

Paper Type: Research Paper

1.0 Introduction

According to Li & Oh (2010), 90% of the international trade is done via sea with cargo containers being the most preferred mechanism for transport of goods globally. Ports are considered to be the backbone of international trade and essential for the efficient management of any supply chain network (Cheon, Dowall, & Song, 2010). Nowadays, ports are thought as providers of comprehensive logistics services and are no longer considered simple land/sea interfaces. (Kim, 2016). Therefore, the port operational efficiency significantly affects its competitiveness and productivity (Jovic et al., 2019).

China's Belt and Road Initiative (BRI), intends to promote international trade between China and 64 countries by connecting Europe, Asia, and Africa via Maritime Silk Route (Dossou, 2018). It has increased the significance of ports along this route (Wei, Sheng, & Lee, 2018). China Pakistan Economic corridor (CPEC) is a part of BRI that starts from Guangzhou (China) connecting China and Pakistan at Khunjerab. It gives China access to Africa and Middle East through Arabian sea at Gwadar (Ali, Gang, & Raza, 2016). CPEC will not only generate trade opportunities for Pakistan but will also has an ability to integrate the neighbouring countries in the region (Ali et al., 2017).

Nomenclature

Nomenclature	
DM	Decision matrix
NDM_{ij}	Normalized Decision Matrix
EM_{ij}	Entropy Normalized Decision Matrix
E_j	Entropy Value
div_j	Degree of Divergence
EW_j	Entropy Weight
Z_{ij}	Weighted Normalized Matrix
Z_J^+ and Z_J^-	Positive ideal (best) and Negative Ideal (worst) value of the attribute
Sep_i^+ and Sep_i^-	Positive and Negative separation Measure
RC_i	Relative Closeness

CPEC will tend to reduce the transportation distance and time for 33% of China's container traffic (Liaqait, Agha, & Becker, 2019). According to Lee et al. 2018, the projected developments of the CPEC will affect the international cargo flow patterns and increase competitiveness of ports in the region. Hence, an investigation of various aspects of ports in this region is of significance. The competitiveness evaluation of ports can help shippers, managers, and decision makers for selecting appropriate port among the multiple alternatives (Ren, Dong, & Sun, 2018a). Moreover, such analysis is necessary in order to identify significant aspects for increasing a port's ranking in the region. Traditionally, the international port ranking, for example "Lloyd's List Top 100 Ports 2018", is done on the basis of parameters such as throughput. However, it is frequently argued in literature that other parameters (such as port infrastructure and performance measures) should also be considered when evaluating the competitiveness of ports (Tongzon, 2001).

In context of Belt and Road Initiative (BRI), the emerging ports in the Persian Gulf and Indian Ocean will play a significant role in the international logistics (Cai, 2017). Several studies have been done to evaluate the relationship between port development and global maritime integration (Ashrafi et al., 2019; Wendler-Bosco & Nicholson, 2019). As an extension of BRI, CPEC directly encompasses the ports of Pakistan. Therefore, we need to evaluate the competitiveness of Pakistan's ports with its neighbouring emerging ports that lie on or near to the Maritime Silk Route. Currently, Pakistan has three major ports: Karachi Port, Port Muhammad bin Qasim, and Gwadar Port. As, Gwadar Port is at its initial stage of the development and Port Muhammad bin Qasim handles only 20% cargo traffic, therefore, for coming years Pakistan's imports and exports will be hugely reliant on the Karachi Port.

Approximately 95% of the Pakistan's international trade is handled by sea (Ministry of Port and Shipping, 2019), via Karachi Port which is the biggest port of Pakistan. According to Ministry of Port and Shipping, Pakistan, Karachi Port handled 52.49 million tons (almost 70%) of the country's cargo traffic in the year 2017-18 ("Karachi Port Trust," 2018.). Karachi Port ranks 83rd among the world's top 100 ports as shown in Table 1. The current port ranking was based only on throughput criteria (Llyod's List, 2019). However, port infrastructure, performance and, efficiency are pivotal for shaping the logistics and supply chain strategies in the region (Ren, Dong, & Sun, 2018b). Moreover, location plays significant role in the socioeconomic development of the port region (Elbeih, Elkafrawy, & Attia, 2019). Thus, the port's ability to compete is determined by a number of service parameters, such as frequency of shipping services, geographical location, physical infrastructure, hinterland logistics cost, and connectivity of ports (Merk & Hesse, 2012). All these criteria assist to determine a port's competitiveness.

Table 1.
Lloyd's port ranking 2019 of selected ports in Pakistan and the surrounding regions.

Sr. No.	Ports	Lloyd's Ranking
1	Colombo	24
2	Jawaharlal Nehru (Mumbai port)	28
3	Mundra	36
4	Jeddah	40
5	Salalah	51
6	Port said	57
7	Shahid Rajaee (Bandar Abbas)	86
8	Chittagong	64
9	Sharjah (Khor Fakhan)	87
10	Karachi	83
11	Alexandria	--
12	Dammam (king Abdul Aziz)	--
13	Chennai	--

Source: *Lloyd's port ranking 2019*

Considering the significance of the Karachi Port in the region, this study tends to evaluate its competitiveness amongst neighbouring developing ports using the TOPSIS (Technique for Order Preference by Similarities to Ideal Solution) methodology based on established criteria in the literature. In addition to throughput criteria, performance and infrastructure criteria are also considered. The ranking of the ports is established on the basis of the obtained relative closeness (RC) matrix. It is then compared with Lloyd's International Port Ranking (Llyod's List, 2019) to provide a better understanding for the decision-makers. To the best of our knowledge, no study has been conducted to evaluate the competitiveness of ports for Persian Gulf and Indian Ocean. Figure 1 presents the geographical location of ports included in this study.

Figure 1: *Geographical location of Ports.*

2.0 Literature Review

Container shipping is experiencing an unprecedented growth in the major container ports in the Persian Gulf and the Indian Ocean, along with ever-increasing port competition. The economic cooperation between local economies is dependent upon the deployment of mega container ships, that incorporate the overall production and distribution systems (Imai, Nishimura, & Papadimitriou, 2013).

Several studies have been conducted for the evaluation of ports' competitiveness. Multiple criteria have been proposed to investigate ports' ranking with Multi Criteria Decision Making (MCDM) methodologies (Qu et al., 2018). Fung, Cheng, & Qiu, (2003) analysed the effect of terminal handling charges (THCs) on Hong Kong Port. They highlighted that increase in the container's THCs impacts the profitability of shipping lines by reducing their throughput. Saeed, (2009) used performance (i.e. total stay time in port, vessel calls per year, and past visits of the shipping lines) as criteria to evaluate the productivity of two major ports of Pakistan (i.e. Karachi Port and Port Muhammad Bin Qasim). Sayareh & Alizmini, (2014) established that performance, infrastructure, and safety policies are critical criteria for selecting a seaport. Yu et al., (2018) proposed the event-based discrete simulation model to evaluate the performance of GCR on transshipment terminal with container allocation. Terminal Handling Charges is also developed as a performance criterion for evaluating the port competitiveness. Peng et al., (2018) evaluated the proposed Maritime Silk Route by making comparison of ports along the route. Their study considered criteria like natural condition, infrastructure, services, location advantage, and efficiency of the port for comprehensive evaluation of ports. Rezaei et al., (2019) highlighted the key factors that influence port selection by shippers and freight forwarders. Their study analysed the ports on the basis of various physical and performance criteria and evaluated that transport costs, number of terminals, and frequency of shipping are the dominant factors for port competitiveness. Kaliszewski et al., (2020) highlighted that service level, smoothness of port operations, and flexibility are the critical factors in increasing the throughput of ports. Wahyuni et al., (2020) indicated that government support, business support, and operational performance are the three distinct factors of port competitiveness in Indonesia. The study further argued that port overall performance is dependent upon physical infrastructure and port operational improvements.

Furthermore, the influencing factors for the competitiveness of ports are geopolitical location, port throughput, port facilities, and the port service level (Kuo et al., 2020). In addition, port ownership model (public or private), legal structure—concessionary ports or not, superstructure and, service quality are also parameters for determining port efficiency, see e.g. (Gunasekara & Bandara, 2018; Hung, Lu, & Wang, 2010; Pagano et al., 2013). A regional survey of ship owners and companies conducted by Yeo, Roe, & Dinwoodie, (2008) revealed that port service, regional centres, hinterland condition, logistics cost, and connectivity are the critical factors that influence the overall performance of container ports in China and Korea. Similarly, Vega et al., (2019) accessed the impact of port infrastructure on Colombian ports. Their study argued that adequate port infrastructure influences the port services and connectivity to other ports. Other studies have also been conducted using several methodologies to elucidate and identify the various factors that influence a port's competitiveness and efficiency, see for instance (Ha, Yang, & Lam, 2018; McIntosh & Becker, 2019). Researchers used these criteria for establishing port competitiveness. Based on these observations, we compile major factors that influence the ranking of a port listed in Table 2. After carefully eliminating the overlapping and interrelated elements, this study divided the criteria into three major categories i.e. throughput, infrastructure, and performance. It is noteworthy that the criteria selection is based on publicly available data.

Table. 2, highlighted the classification of studies with respect to various criteria used for MCDM analysis of ports. For instance, Kim, (2016) used the throughput and physical criterion to evaluate the competitiveness of ports in Korea and China. Tetteh, Yang, & Gomina Mama, (2016) compared the overall container throughput of China along with five West African ports using Data Envelopment Analysis (DEA) to compute the efficiencies of ports that can be considered as hub ports in the region. Rezaei et al., (2019) evaluated the competitiveness of major European ports on the basis of various criteria using Best-Worst Method (BWM). The obtained results highlighted that total cost and marine transit time are instrumental in the overall performance of the ports. Kuo et al., (2020) analysed the performance of the 53 ports and terminals of Vietnam by applying the context-dependent DEA model. Mou et al., (2020) evaluated the development potential of eight representative ports in the Yangtze River Delta using Entropy-Fuzzy Analytical Hierarchy Process (EF-AHP). The study highlighted the primary (i.e., Port Policy) and secondary factors (i.e., gross domestic product, number of berths, and port network status) that affects the potential development of ports. However, to the best of authors knowledge no study has been done to analyse the emerging ports in Indian Ocean and Persian Gulf.

3.0 Methodology

For Multi-Criteria Decision Making (MCDM) several techniques such as AHP, Hybrid MCDM, Aggregation DM method, Analytical Network Process (ANP) and, TOPSIS have been used to define objective function (Mardani et al., 2015). The main reason behind using TOPSIS is its transparency, simplicity, and reliable preference order which can be recognized by decision makers (Roszkowska, 2011). In the present study, we have used TOPSIS model which was firstly developed by Hwang & Yoon, (1981) augmented with entropy weights in order to evaluate the overall competitive of emerging ports.

TOPSIS has been used to identify the factors that affect the competitiveness of ports. See for example (Ertuğrul & Karakaşoğlu, 2008; Hwang, Lai, & Liu, 1993; Kim & Lu, 2016; Kim, 2016; Moon, Kim, & Lee, 2015; Shih, Shyur, & Lee, 2007; Supraja & Kousalya, 2016). Several techniques have been established with the sophisticated algorithms and propositions in order to analyse the MCDM problems. However, the objective of this study is to analyse the emerging ports in the region to provide an insight for the decision makers and managers to design the logistics strategies in the region.

The underlying concept of TOPSIS is ranking of the alternatives based on shortest distance from a Positive Ideal Solution (PIS) and longest distance from a Negative-Ideal Solution (NIS) (Wang, 2011). Figure 2 presents the calculation procedure of the TOPSIS methodology. Firstly, the objective and relevant attributes of the objective (in this case, port throughput, infrastructure, and performance) are decided. Afterwards, a decision matrix with n rows and m columns is developed as shown in equation 1. Each row of the matrix represents a port and each column an attribute.

$$DM=\begin{pmatrix} q11 & q12 & \cdots & q1m \\ \vdots & & \ddots & \vdots \\ qn1 & qn2 & \cdots & qnm \end{pmatrix} \qquad (1)$$

A normalized decision matrix is derived to transform dimensional attributes into non-dimensional attributes.

$$\text{NDM}_{ij}=\left[\frac{qij}{\left[\sum_{i=1}^{n} q_{ij}^{2}\right]^{1/2}}\right] \qquad (2)$$

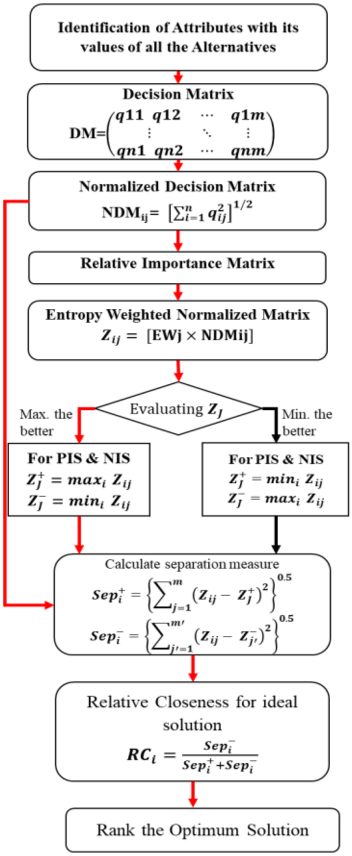

Figure 2: *Hierarchal Structure of TOPSIS Methodology*

The "Entropy Weight Method" is adopted to determine the weight of each criterion (Kumar, Bilga, & Singh, 2017).

$$\text{EM}_{ij}=\begin{cases}\dfrac{q_{ij}}{MAX\,\{q_{ij}\}_{j}} : for\ maximum\ criteria \\ \dfrac{q_{ij}}{MIN\{q_{ij}\}_{j}} : for\ minimum\ criteria\end{cases} \qquad (3)$$

The decision matrix is normalized using equation (3), while Pij in equation (4) defines the probability of criteria. The Entropy value (Ej) of jth criteria is determined using equation (5).

$$\text{P}_{ij}=\frac{EM_{ij}}{\sum_{i=1}^{n} EM_{ij}} \qquad (4)$$

$$\text{E}_{j}=-\text{P}\sum_{i=1}^{n} P_{ij\,\log_e(P_{ij})} \qquad (5)$$

Here, $P=\frac{1}{\log_e(n)}$ is the constant term and its value ranges between $0 \leq E_{ij} \leq 1$ while n denotes the number of ports (alternatives). The degree of divergence (div_j) of average information enclosed by each response is shown in equation (6) and weights (EW_j) of of j^{th} criteria by the equation (7).

$div_j = |1 - E_j|$ (6)

$EW_j = \frac{div_j}{\sum_{j=1}^{m} div_j}$ (7)

The weighted normalized matrix is constructed using equation 8.

$Z_{ij} = [EWj \times NDMij]$ (8)

The PIS and NIS is then obtained by using equation 9 and 10, respectively.

$Z_J^+ = \{best\ (Z_{ij})\}_{i=1}^{n}$

$Z^+ = \{Z_1^+, Z_2^+, \dots\dots, Z_j^+, \dots, Z_m^+\}$ (9)

$Z_{J'}^- = \{worst\ (Z_{ij'})\}_{i=1}^{n}$

$Z^- = \{Z_1^-, Z_2^-, \dots\dots, Z_{j'}^-, \dots, Z_{m'}^-\}$ (10)

Where, j= {1, 2, ……, m} are associated with beneficial attributes and j′= {1, 2, ……, m′} are associated with non-beneficial attributes. It is the maximum or minimum value for the particular attribute out of all the values of the specific attribute. The separation measure between alternatives is calculated by Euclidean distances (i.e. $\mathbf{Sep_i^+}$ and $\mathbf{Sep_i^-}$) using equation 11 and 12, respectively.

$Sep_i^+ = \left\{\sum_{j=1}^{m} (Z_{ij} - Z_J^+)^2\right\}^{0.5}$ (11)

$Sep_i^- = \left\{\sum_{j'=1}^{m'} (Z_{ij} - Z_{j'}^-)^2\right\}^{0.5}$ (12)

Finally, the relative closeness RC_i of the alternatives from the ideal solution is obtained from which the alternatives are ranked using equation 13.

$RC_i = \frac{Sep_i^-}{Sep_i^+ + Sep_i^-}$ (13)

Figure. 3, shows the holistic approach of the methodology used for the analysis of the ports. The competitiveness is evaluated based on three major criteria, i.e. throughput, physical, and performance which are further divided into thirteen sub criteria. TOPSIS integrated with entropy weight method is applied on each major criterion in order to gain the relative closeness matrix of each criteria. For the overall competitiveness, the relative closeness matrices of all the major criteria is considered as a decision matrix and TOPSIS augmented with entropy weight method is applied to get more precise results. The use of two stage approach showed better results as compared to the conventional way of applying TOPSIS.

Table 2: *Classification of relevant researches with respect to Evaluated Criteria.*

Relevant Researches	Throughput Criteria		Physical Criteria							Performance Criteria			
	Container throughput	Throughput rate	Number of cranes	Total berth length (km)	Total Land area (km²)	Depth (m)	Overall covered storage area (km²)	Length of the dock (km)	Quay Wall length (km)	Commercial vessels call per year	Dwell time (days)	Gross crane rate (GCR)	Terminal cargo handling charges
Liu & Park (2011)	•												
Kim (2016)	•												
Chen, Jeevan, & Cahoon (2016)	•	•			•								
Wan, Zhang, Yan, & Yang (2017)		•											
Ma, Wang, Peng, & Song (2018)		•											
Chang, Lee, & Tongzon (2008)				•									
Saeed, (2009)			•	•									
Yeo et al. (2008)			•										
Ng & Mak (2005)			•	•									
Yeo (2010)				•									
Cheon et al. (2010), Imai, Nishimura, & Papadimitriou (2001)				•									
Chow & Chang (2011)					•								
Langen (2007)						•							
Song & Cui (2014)						•							
Flor & Defilippi (2003)							•	•			•		
Almawsheki & Shah (2015)								•					
Cullinane & Wang (2006)									•				
De Martino et al. (013)										•			
Dutra et al. (2015)										•			
Gengyong, Ynuqi, & Wangyi (2012)										•			
Dyck (2015); Van Dyck & Ismael (2015)											•		
Veldman, Bückmann, & Saitua (2005)											•		
Yu et al. (2018)												•	
Yu et al. (2018)												•	
Esmer (2008)												•	
Gohomene et al. (2016)													•
Zheng et al. (2017)													•

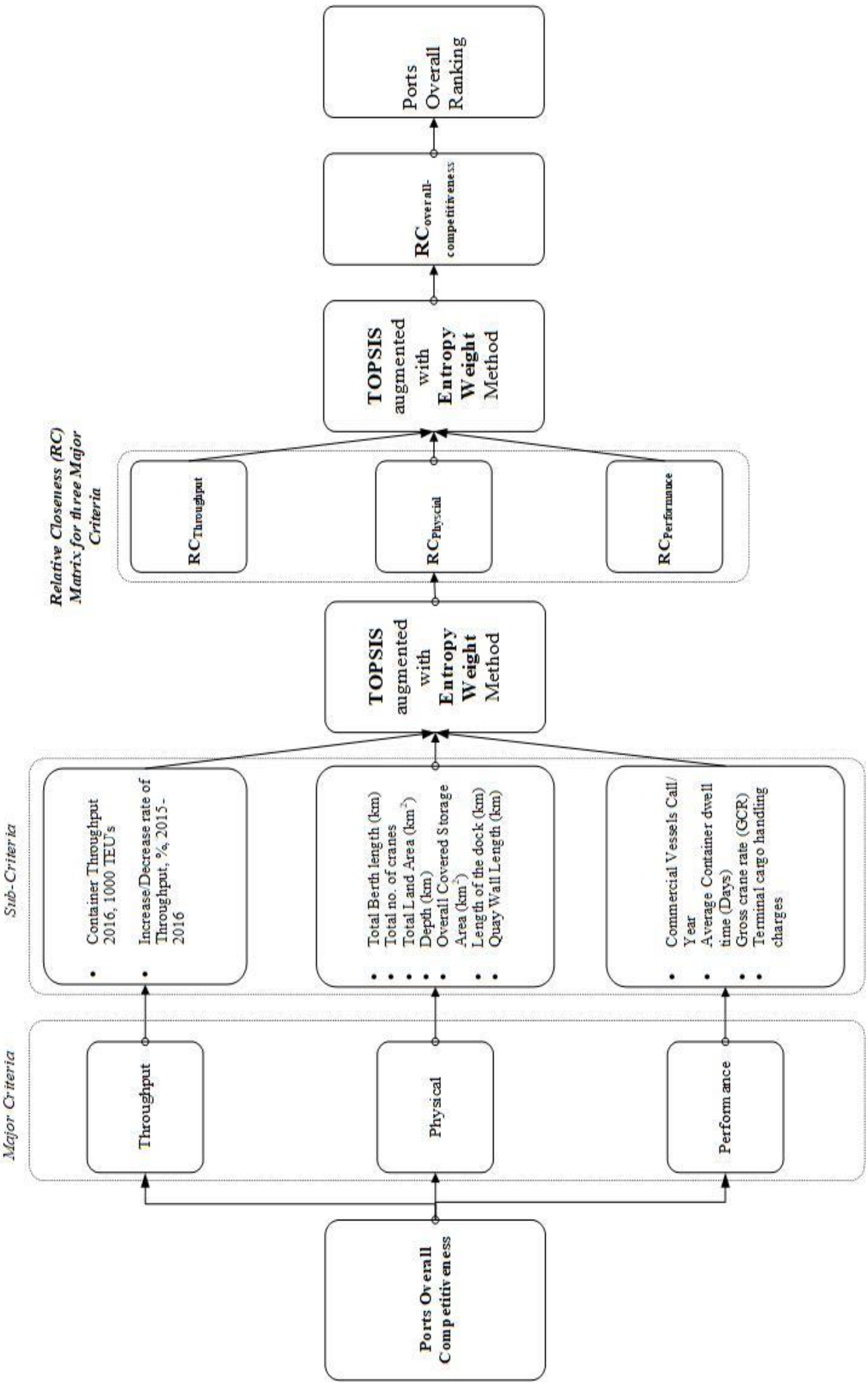

Figure 3: *Flow chart of proposed methodology*.

4. Data Collection

Relevant literature was reviewed to extract the significant factors for ports competitiveness evaluation. Data were collected through official sources for all the considered ports based on the year 2019. As the considered ports are of emerging economies, therefore, selection criteria are limited due to unavailability of data. Table 3 presents the data of each criteria and sub-criteria used for the case study.

Table 3: *Ports criterion data for competitiveness evaluation*

Descrition		Throughput criteria		Physical criteria							Performance criteria			
Sr. No.	Ports	Container Throughput 2018, 1000 TEU's	Increase/ Decrease rate of Throughput, 2017-2018	*Total Berth length (km)	Total no. of cranes	Total Land Area (km^2)	Depth (km)	Overall Covered Storage Area (km^2)	**Length the of dock (km)	***Quay Wall Length (km)	Commercial Vessels Call per Year	Average Container dwell time (Days)	Gross crane rate (GCR)	**** Terminal cargo handling charges
1	Alexandria	1,613	0.968	7.08	43	2	0.0125	0.71	0.21	0.71	5923	5.5	36	0.48
2	Chennai	1,549	1.035	8.9	53	2.37	0.0095	0.03	0.38	0.83	2078	2.01	25	1
3	Chittagong	2,566	1.086	3.23	89	0.15	0.0092	0.11	0.19	0.45	2248	11	23	0.78
4	Colombo	6,209	1.077	11	57	0.05	0.016	0.034	0.26	0.5	1200	0.375	23.4	0.48
5	Dammam (King Abdul Aziz)	1,582	0.872	1.79	64	9	0.0095	0.4	0.22	0.7	684	13	34	0.26
6	Jeddah	4,150	1.047	11.02	84	10.52	0.016	0.4	0.28	1.7	1080	7	32	0.34
7	Karachi	2,224	1.056	19.8	66	0.98	0.013	0.1	0.3	0.6	2568	6	27.5	0.45
8	Jawaharlal Nehru (Mumbai) Port	4,833	1.065	18.59	32	0.32	0.014	0.02	1.73	7.8	1033	2.91	35	0.36
9	Mundra	4,240	1.217	3.3	92	1.06	0.0173	0.23	0.8	0.63	540	0.91	31	0.35
10	Port Said	2,968	0.977	12.68	36	3	0.01298	0.11	0.24	0.35	1080	5	35.83	0.78
11	Salalah	3,946	1.157	7	93	4.76	0.0175	0.09	0.4	1.26	3000	6	23	0.62
12	Shahid Rajaee (Bandar Abbas)	2,607	1.183	1.05	93	0.19	0.0125	0.25	0.49	1.01	900	10	20	0.19
13	Sharjah (Khor Fakhan)	2,321	0.134	3.6	20	0.7	0.016	0.3	0.4	0.74	720	5.67	32.2	0.48

Increase/Decrease rate of Throughput = [(Throughput 2017 – Throughput 2018)/ Throughput 2018]

Number of cranes = Total Number of cranes on the port (i.e. floating, gantry, overhead, tower, deck, bulk handling, Panama, Panama max, Post Panama max. etc.

*Total berth Length = No. of Berths * Average Berth length (km).

(The entire quay space is partitioned into several blocks (or berths) by a specific length (hereafter referred to as a berth length)).

**Length of the dock (km) = A length of structure built along, or at an angle from, a navigable waterway so that vessels may lie alongside to receive or discharge cargo.

***Quay Wall Length (km) = The length of structure built parallel to the bank of a waterway for use as a landing place.

**** Terminal cargo handling charges include (20' Generals, 40' Generals, 20' Reefers, 40' Reefers). The values mentioned in the table are the evaluated on the basis of performing the TOPSIS entropy weight analysis by considering "20' Generals, 40' Generals, 20' Reefers and 40' Reefers "as sub-criterion for each port.

NOTE: Values for port physical criteria are taken in the kilometres to maintain the equivalency between sub-criterion while analysing.

5. Results and Discussion

Initially, each criterion is evaluated individually using TOPSIS augmented with entropy weight method and finally the overall competitiveness is evaluated by using the TOPSIS entropy methodology.

5.1 Analysis for Port Competitiveness with respect to Major Criterion:

Based on collected data, weights for all sub-criteria are calculated using equation 5 and are presented in Table 4.

Table 4: Entropy Weights for Sub Criterion

Major criteria	Sub criteria	*Entropy weight*
Throughput criteria	Throughput	0.64
	Throughput Increase/Decrease rate	0.36
Physical criteria	Total Berth length	0.11
	Total Land Area (km^2)	0.04
	Average Depth (m)	0.29
	Overall Covered Storage Area (km^2)	0.01
	Length of dock (km)	0.17
	Quay Length (km)	0.12
	Total no. of cranes	0.26
Performance criteria	Commercial Vessels Call per Year	0.43
	Average Container dwell time (Days)	0.38
	Gross crane rate (GCR)	0.03
	Terminal cargo handling charges	0.16

The sub-criteria weights are then used to perform TOPSIS for each criterion with the help of equation 8-13 in order to evaluate the relative closeness of the alternatives.

5.2 Ports Overall Competitiveness

On the basis of results obtained from section 5.1, a new 15×3 decision matrix is created. The combined decision matrix that contains the relative closeness of throughput, physical, and performance criteria were again analysed using TOPSIS methodology. Table 5 shows the weights for major criteria used to evaluate the overall competitiveness of ports. It shows that amongst throughput, physical infrastructure, and performance, throughput contains the highest weight of 0.40 with performance and physical infrastructure consisting of 0.34 and 0.26 respectively.

Table 5: Entropy Weights for Major Criteria

Major criteria	Entropy weight
Throughput Criteria	0.41
Physical Criteria	0.43
Performance Criteria	0.16

After calculating weights for each criterion, the entropy weight matrix is formed using equation 4 and 5. Based on the entropy weight calculation, the positive and negative ideal solution for each criterion is determined. The separation measures for each port are evaluated on the account of PIS and NIS values. Finally, the competitiveness of all ports with respect to the major criterion is ranked to the relative closeness matrix obtained from step 9 of Figure 3 and shown in Table 6.

The results indicated that, while evaluating port throughput criteria, Colombo is the highest ranked port with a relative closeness index (RCI) of 0.95. The port provided the highest container throughput in the years 2018 and 2019. Moreover, Jawaharlal Nehru and Mundra ranked second and third respectively. However, Khor Fakhan ranked lowest with 0.15. In contrast, Karachi Port ranked ninth with RCI of 0.32.

Like port throughput, Jawaharlal Nehru Port ranked 1st (i.e. RCI=0.56) in physical competitiveness ranking with Jeddah in second and Dammam in third respectively. The ports developed preeminent infrastructure to port users, reducing port congestion and lead time. Due to the initial stages of development, Chittagong ranked lowest with RCI of 0.05. In contrast, Karachi Port ranked 7th in port physical infrastructure criteria because of limited resources and comparatively less development initiatives and expansion of port in recent years.

Table 6: *Relative Closeness Index of ports for Major criteria*

Ports	Throughput criteria	Physical criteria	Performance criteria	Overall port competitiveness
Alexandria	0.25	0.27	0.79	0.54
Chennai	0.27	0.14	0.46	0.37
Chittagong	0.36	0.05	0.27	0.22
Colombo	0.95	0.08	0.44	0.49
Dammam (king Abdul Aziz)	0.23	0.39	0.15	0.35
Jeddah	0.60	0.46	0.28	0.57
Karachi	0.32	0.15	0.44	0.36
Jawaharlal Nehru	0.73	0.56	0.38	0.72
Mundra	0.63	0.14	0.40	0.43
Port said	0.39	0.17	0.32	0.32
Salalah	0.58	0.24	0.49	0.52
Shahid Rajaee (Bandar Abbas)	0.38	0.12	0.21	0.20
Sharjah (Khor Fakhan)	0.15	0.13	0.29	0.23

Unlike other criterion, the results show that Port of Alexandria ranked 1st amongst its regional emerging ports in port performance parameter. The port provides 5923 commercial vessels call per year, with the average container dwell time of approximately 5.5 days, gross crane rate (GCR) of 36 and minimum terminal handling charges. It offers good service level to the shippers and port users by providing quick access to berths and reducing dwell and turnaround time for the ships. This allows an increase in port throughput and reduction in overall operating cost. However, port of Dammam ranked lowest in the ranking with RCI of 0.15. Karachi, on the other hand, ranked 5th in number due to conventional port performance. In terms of scale from 1-13, Jawaharlal Nehru (Mumbai) Port is considered to be the top-ranked port amongst its neighbouring emerging ports with an overall relative closeness index of 0.72. Whereas, the Bandar Abbas ranked lowest among the considered ports.

From the results obtained above, Jawaharlal Nehru Port ranked highest in overall competitiveness evaluation with the highest ranking in physical criteria and second highest in the throughput. However, port of Jeddah ranked second in the overall performance with better ranking in physical criteria after Jawaharlal Nehru port. Port of Jeddah ranked 4th in throughput and 10th in performance criteria. On contrary, according to Lloyd's list of top 100 ports, Jawaharlal Nehru Port ranked 2nd and Port of Jeddah ranked 4th. This difference in the results clearly indicates that throughput alone cannot be considered as a performance measure of ports. Other factors also effect the overall performance efficiency and productivity of ports.

As far as Karachi Port is concerned, it obtained 8th position in overall competitiveness with appreciable throughput and performance competitiveness. The results highlighted that the major limitation of Karachi Port amongst its competitors is its overdue infrastructure development. According to Karachi Port Trust, 2019, Karachi Port is only operating at 45% of its operational capacity. Moreover, Karachi Port ranked 83rd in world ranking due to slight increment in the container throughput rate. The deviance in the results can be ascribed to increasing the competitiveness of ports by the decision makers.

6. Conclusion

This study aims to evaluate the competitiveness of Karachi Port amongst its neighbouring emerging ports in the Persian Gulf, the Arabian Sea, and the Indian Ocean. TOPSIS augmented with entropy weight is widely used to evaluate the competitiveness of ports on the basis of the established criterion in literature. The study revealed that Lloyd's top 100 port ranking, ranked Colombo port 1st amongst other considered ports as shown in Figure 4. However, during the evaluation of overall competitiveness ranking index, Colombo Port stands at number thirteen. This results strongly suggests that throughput criteria alone cannot be reliable for ranking the ports as it ultimately effects the port's operations and business activities, especially in the developing regions. Similarly, Karachi Port ranked 11th in international ranking, however, results obtained from overall competitiveness placed Karachi Port at 7. The results also highlighted that port performance and throughput played a significant role in the overall competitiveness.

However, performance and throughput cannot be achieved without having a proper physical infrastructure.

This study is unique in the context of analysing Karachi Port and its neighbouring emerging ports using TOPSIS and entropy weight method. Moreover, no such study known to authors' knowledge has been conducted so far, that compares Lloyd's Top 100 port ranking. It is adopted by the world shipping council with the ranking attained by adding different decision-making parameters. As it is established from the results that these parameters play a pivotal role for the port, not only to identify competitive advantage over other ports but also allows the port to strategically analyse itself to compete in the region for achieving a good share in the global market.

Karachi Port increased its operational efficiency in recent years, in order to compete with its neighbouring ports. The port is in long due for an upgradation and modernization of physical infrastructure, in order to compete with its neighbouring emerging ports. The difference between the rankings highlights that the evaluation of port competitiveness considered by the decision-makers should be more comprehensive. It not only effects the global trade but also limits the business and economic development of emerging economies.

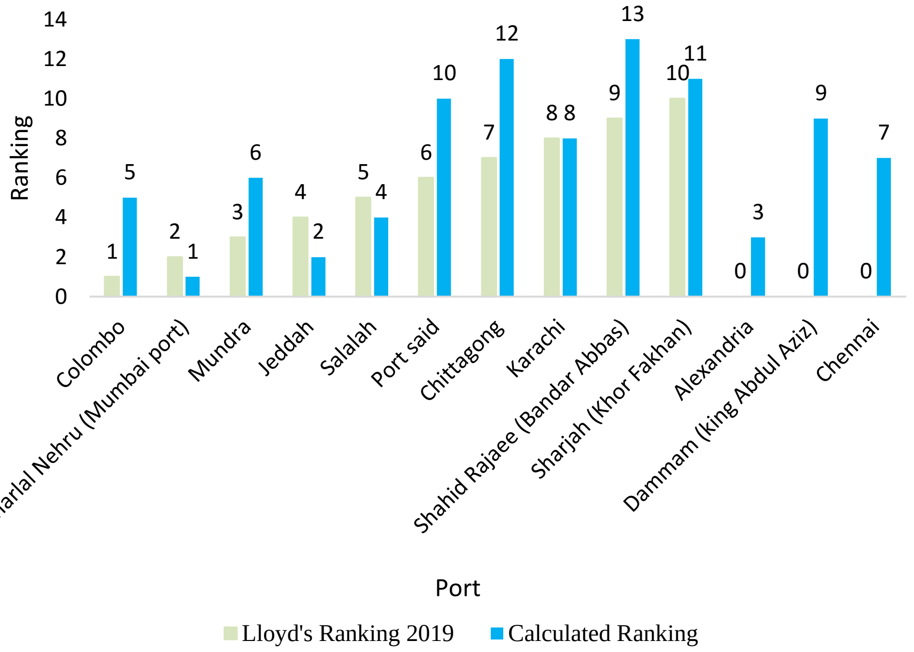

Figure 1: *Comparison of Lloyd's and Calculated Ports Ranking*

Author Contributions:

R. A. Liaqait: Literature Search and Review, Data Collection, Modelling and Manuscript Writing.
M. H. Agha: Content Planning, Literature Search and Review, Data Collection, Manuscript Writing and Editing.
T. Becker: Review, Data Collection, and Manuscript Writing.
S. S. Warsi: Modelling and Manuscript Writing

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About the Authors

Raja Awais Liaqait

Mr. Raja Awais Liaqait is the MS student of Engineering Management at Capital University of Science and Technology, Islamabad. He has his Bachelors in Mechanical Engineering from Muhammad Ali Jinnah University, Islamabad campus. His research area focuses on supply chain optimization and logistics management of complex networks.

Mujtaba Hassan Agha

Dr. Mujtaba Hassan Agha is Professor and Head of Department Operations and Supply Chain at NUST Business School, National University of Sciences and Technology, Islamabad, Pakistan. He did his PhD in Industrial Engineering from Institute National Polytechnique Toulouse (INPT), University of Toulouse (France). His teaching and research areas of interest are Production & Logistics Systems, Supply Chain Management and Energy Management.

Till Becker

Dr. Till Becker is Professor of Information Systems at the University of Applied Sciences Emden/Leer in Germany. He obtained his PhD in International Logistics from Jacobs University in Bremen, Germany. His research focuses on complex networks in manufacturing and logistics and on the ongoing digitalization in industry.

Salman Sagheer Warsi

Salman Sagheer Warsi is Assistant Professor in Department of Mechanical Engineering, Capital University of Science and Technology, Islamabad. He received his PhD in Design and Manufacturing Engineering from NUST, Pakistan and Masters in Design, Manufacture Management from University of Durham, UK. His research interests focus on sustainability analysis of manufacturing processes and systems design and Email: salman.warsi@cust.edu.pk

The Corresponding Author Professor Mujtaba Hassan Agha can be contacted at: mujtaba.agha@nbs.nust.edu.pk