PhD THESIS

IMPACT OF CONTAINER MANAGEMENT ON PORT LOGISTICS EFFICIENCY OF KARACHI PORT

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ABBREVIATIONS AND ACRONYMS

AC	Accessibility and connectivity
ACT	Fully automated container terminals
ADB	Asian Development Bank
AGV	Automatic Guided Vehicle
AI	Artificial intelligence
AVE	Average variance extracted
BAP	Berth allocation problem
BP	Berth Productivity (TEUs/year)
CAREC	Central Asia Regional Economic Cooperation
CAS	Central Asian States
CC	Custom Clearance
CEO	Chief Executive Officer
CFS	Container Freight Station
CG	Congestion
CLP	Container load plan
CMB	common method bias
CMV	Common Method Variance
COVID-19	Coronavirus
CPEC	China Pakistan Economic Corridor
CPPI	Container Port Performance Index
CR	Composite reliability
CS	Customer Satisfaction
CT	Container Terminal
DPW	Dubai Ports World
DT	Dwell Time
DV	Dependent variable
ECO	Economic Cooperation Organization
EDI	Electronic Data Interchange
EFA	Exploratory Factor Analysis
ER	Employee Reliability
EU	European Union
FBR	Federal Board of Revenue
FEU	Forty-foot equivalent unit
GDP	Gross domestic product
GM	General Manager
GoP	Government of Pakistan
GTO	Global terminal operators
HOC	Higher order constructs
HPH	Hutchison Port Holdings
HRD	Human Resources Development
HTMT	Hetrotrait-Monotrait ratio
ICT	Information and Communication Technology

IMO	International Maritime Organization
IoT	Internet of Things
IPMA	Importance Performance Map Analysis
IT	Information Technology
IV	Independent variable
IWT	Inland Waterways Transport
KICT	Karachi International Container Terminal
KPI	Key performance indicators
KPK	Khyber Pakhtunkhwa
KPT	Karachi Port Trust
LC	Logistic Capability
LM	linear regression model
LOA	Length Overall
LOC	Lower order constructs
LPI	Logistics Performance Indicators
MoMA	Ministry of Maritime Affairs
MV	Mediating variable
NHA	National Highway Authority
NIMA	National Institute of Maritime Affairs
NVOCCs	Non-Vessel Operating Common Carrier
OR	Berth Occupancy rate
PC	Port Charges
PCM	port container management
PCMMA	Management related
PCMOE	Operations related
PCMSC	Strategic capabilities
PCMSD	Strategic Direction
PD	Quay Crane productivity
PE	Port Equipment
PECY	Yard crane
PEQC	Quay crane
PERB	Reliability
PHR	Port human resource
PHRER	Employee reliability
PHRTE	Training and education
PI	Port Infrastructure
PIAC	Accessibility and connectivity
PICB	Container Berths
PICT	Pakistan International Container Terminal
PICY	Container Yard
PIFFA	Pakistan International Freight Forwarders Association
PLE	port logistic efficiency
PLS	Partial least squares
PNSC	Pakistan National Shipping Corporation
PPI	Port performance indicator
PQA	Port Qasim Authority

PS	Port services
PSA	Port of Singapore Authority
PSCC	Custom Clearance
PSDT	Dwell Time
PSSR	Service Reliability
PT	Port Technology
IT	Information technology
R&D	Karachi Dock Labour Board
RB	Equipment Reliability
RDT	Resource dependence theory
RFID	Radio Frequency Identification
RIA	Repeated indicators approach
RMG	Rail Mounted Gantry
RMSE	Root mean squared error
RTG	Rubber Tire Gantry
SAPT	South Asia Pakistan Terminal
SC	Straddle carrier
SD	Standard deviation
SE	Standard error
SEM	structural equation modelling
SPSS	Statistical Package for the Social Sciences
SR	Service Reliability
SRMR	Standardized Mean Square Residual
TC	Transfer crane
TE	Training and education
TEU	Twenty-foot equivalent unit
TOS	Terminal Operating System
TP	Container Throughput
TT	Truck Turnaround Time
UNCTAD	United Nations Conference on Trade and Development
US	United States
VAF	Variance Accounted for Calculation
VIF	Variance inflation factor
VT	Vessel turnaround time
WB	World Bank
YC	Yard Crane
YT	Yard truck
YU	Yard utilization

ABSTRACT

In recent decades, containerisation has revolutionised the international trading pattern. Increased global container trade has led to the arrival of larger ships, burdening port resources. The ship size has grown faster than the ports. Many shipping lines have formed alliances to cut costs. Pakistan's main seaport at Karachi handles about 60% national trade and has three container terminals. This study examines the relationship between port resources and logistics efficiency, with the mediating effect of container management. This will fill the research gap to examine port resources, container management, and logistics efficiency with resource dependence theory and the economic theory of the port and find the reasons for inefficient port performance. The research hypotheses were formulated through the lens of resource dependence theory and the economic theory of the port to address research questions. The study employed a positivist research paradigm and collected cross-sectional data from the respondents to test research hypotheses. The population of this study was from the port and related organizations of Pakistan, with 332 valid responses. Partial least squares structural equation modelling was used to analyze the collected data through a survey questionnaire based on a convenience sampling technique. The results revealed that port resources positively influenced port logistics efficiency directly, and when mediated by port container management. However, insignificant results were achieved when port container management mediated between port infrastructure and port logistics efficiency. The study suggests a port improvement plan that can be useful to higher management in Karachi and other ports of developing countries. The study includes limitations, prospects for future research, and recommendations.

Keywords: port container management, port resources, port logistics, port container terminal management.

CHAPTER 1

1 INTRODUCTION

This chapter sets the scope of this research work. It includes the Introduction, background, research gaps, problem statement, research questions, objectives, significance of the study, and the study's organization.

Almost 80% of worldwide trade is transported through maritime means (Bichou, 2017; Lun et al., 2023a), of which over 50% by value is transported through containers (Arvis, Rastogi, et al., 2024). Several other types of ships used for global trade include oil or LNG tankers, reefer ships, bulk cargo, and RORO ships (D. Song, 2021). In this container port-related study, the influence of port resources on logistics efficiency has been discussed. The swift increase in ship size has compelled container ports to enhance their capacity to handle bigger ships or face the threat of being marginalized (Notteboom et al., 2021). Worldwide maritime trade continues to grow, putting added burden on ports to improve their operational effectiveness, container handling ability, and logistics capacity. Contemporary ports depend on a blend of technology implementation, infrastructure capability, equipment functioning, employees, service value, charges, and container management practices to guarantee freight movement. As worldwide supply chains become further incorporated and time-sensitive, ports incapable of increasing these functions experience diminished competitiveness, greater turnaround periods, and reduced output performance.

Karachi Port, Pakistan's biggest and oldest seaport, moves most of the country's containerized cargo. Despite its strategic location and increasing container quantities, the port encounters constant challenges: bottlenecks, unpredictable container movements, obsolete systems, and a dearth of integration through operational realms. Whereas earlier reports emphasize several inadequacies, there remains inadequate empirical and theory-driven analysis clarifying how particular port constructs jointly shape Port Logistics Efficiency (PLE), and how Port Container Management (PCM) performs as a strategic mediator in this association. In view of this research gap, the current study formulated an integrated model founded on Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP) to investigate how port assets and management practices impact logistics efficiency. PCM is presented as an intervening variable to describe just how ports convert functional inputs into performance results. Through a quantitative PLS-SEM method, this study presents a structured empirical assessment of Karachi Port's operational determinants and logistics efficiency.

The article by Shahzad (2022) examines Karachi Port's efficiency challenges from the standpoint of liquid and general cargo operations, highlighting structural deficiencies, outdated technology, limited equipment, and administrative constraints as major barriers to optimal performance. In contrast, the study on container management and port logistics efficiency adopts a construct-based empirical approach, focusing specifically on how port technology, infrastructure, equipment, human resources, services, and charges impact logistics outcomes. Viewed through the lens of Resource Dependence Theory (RDT), the container management study demonstrates that strategic internal resource optimization, particularly in technology, equipment, human resources, services, and charges, reduces reliance on external factors, thereby strengthening port autonomy and resilience. From the Economic Theory of the Port (ETP) perspective, the empirical study provides stronger explanatory depth by directly linking resource utilization and service efficiency to measurable logistics performance indicators, offering more precise operational insights than the broader, policy-oriented analysis presented by Shahzad (2022). The container management study, hence, contributes construct-level evidence to the descriptive policy-focused approach by Shahzad. Moreover, the present study has analysed the survey data obtained from the local environment, through SmartPLS4, considering eight constructs, employing RDT and ETP, which is a novel work about Karachi port. The study proposes a port improvement plan, which will be generalized for use by other ports and thus contribute to the existing literature. The findings of this study will help port authorities and CT operators to improve port operations, particularly in developing countries.

1.1 Background

Maritime ports function as complicated organizations where numerous resources, such as technology, digital instruments, equipment, employees' skills, infrastructure ability, service dependability, and charges outlay, relate to define operational performance. International ports progressively depend on modern Terminal Operating Systems (TOS), digital tracking programs, automated handling equipment, and integrated container management policies to enhance efficiency.

In developing nations, conversely, resource restrictions, disintegrated systems, and governance constraints hamper such improvements. Karachi Port functions in an interim environment where transformation happens in parts instead of methodically. While infrastructure developments and concessions to International CT Operators have made progress, several challenges need to be addressed, including:

- Ineffective container movement among the ship, yard, and the gate
- Constrained real-time container visibility
- Variations in equipment reliability and workforce functioning
- Lags in dwell time and customs clearance procedure
- Conventional policies that do not encourage efficiency

Existing literature emphasizes these concerns; however, it does not empirically join them using an integrated, construct-based model founded in theory. This gap specifies an effective base for the present study. The port capabilities were determined through review of the literature, observation during port visits, and discussions with subject specialists and academia. Initially, many dimensions of these constructs were found in the literature, yet after discussion with port managers/subject experts and academia, the dimensions were shortlisted to the practical ones. A brief account of constructs used in this study, as per the literature, is described below:

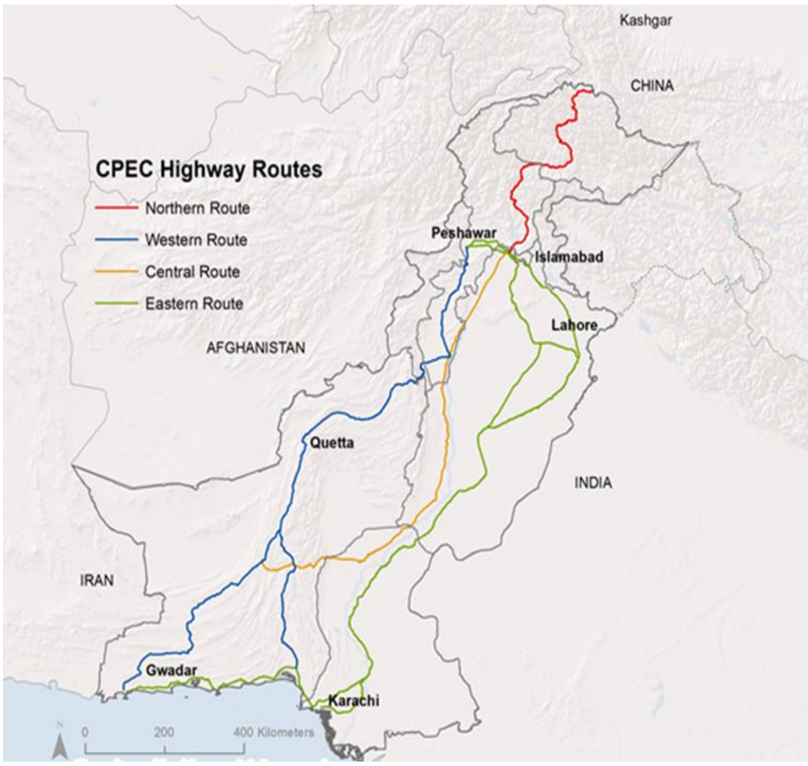
Technology plays an important role in port operations (Kosek et al., 2024). Hou et al. (2024) found that the port space cannot be added due to the city built around it. Use of modern technology, like IT, has become essential to achieve higher efficiency with existing port resources (Zhang, 2024). **Port Infrastructure**, including terminals, berths, and storage yards, is instrumental for accessibility, cargo logistics, and intermodal connectivity (Tshoopara & Mbhele, 2024). It also involves transport connections for cargo from the port, such as roads, railways, and waterways (Rodrigue & Notteboom, 2024). **Port Equipment** is vital for container movement in the terminal (L. H. Nguyen, 2024b). Steenken et al. (2004) stated that the equipment in CT helps in moving containers inside the terminal. Key equipment in CT is the quay crane, yard gantry crane, and yard truck (Shan et al., 2024). **Port Human Resources** is a basic element for port operations (Mabinga & Mwalukasa, 2024). As per Popoola et al. (2024), the workforce is employed in various roles and functions within a port, including administrative, operational, and managerial positions. Legato & Monaco, (2004). **Port Services** reflect what help a port can offer to a visiting vessel (Nikghadam et al., 2024). According to Yeo (2015), seaport services can be defined as the range of activities and functions done in a seaport to simplify the exchange of cargo and services between berth and land spaces. **Port Charges** are levied on ships and cargoes for utilizing port facilities and services during a port visit (Mthembu & Chasomeris, 2024). Yang and Chen (2016) found that port charges, transportation expenses, cargo handling costs, and port service charges are significant factors in assessing seaport efficiency (Caldas et al., 2024).

Port Container Management is an important process in CT performance. Alderton and Saieva (2013) found that the CT management system intends to regulate the move process and stowage of containers within a CT. Container management can be referred to as the systematic movement and stowage of containers within the CTs, with the best utilization of available resources (Raeesi et al., 2023). Erin Curvey (2020) stated that space limitation hampers CT expansion and limit storage at container yards, causing container management issues. **Port Logistic Efficiency** governs the movement of container cargo in and out of the port. Awah et al. (2021) found that the yearly container throughput could be considered as a main indicator to gauge a CT's efficiency. Wayne K Talley (2017) stated that a container port attains efficiency in production capacity when it increases its container throughput by using given levels of resources.

Studies reveal that CTs can improve logistics efficiency by improving resource usage through digital technologies, superior yard organization, active equipment use, trained human resources, simplified services, and motivation-based charges (Hervás-Peralta et al., 2019; Lind et al., 2018). Smart systems such as TOS, IT, IoT, and predictive analytics enhance coordination, while dwell-time-centered stacking, improved gate procedures, and truck assignment systems reduce congestion and dwell time (Bouyahia et al., 2025; Sibuea et al., 2025). Together, these integrated operational and technological methods lead to quicker ship turnaround and greater yard smoothness without increasing physical area (Oluwaferanmi, 2025).

1.2 Maritime Prospects of Karachi Port

Pakistan is not profiting from its maritime potential (Hussain, 2022). Among its three major ports (Karachi, Bin Qasim, and Gwadar), Karachi handles nearly 60% of the national trade. The traditional approach at Karachi port needs technological change. Port connectivity with rail and road needs considerable improvement. The port has a good potential for transhipment trade, which requires a strategic global outlook rather than a national one. Karachi port has the essential infrastructure and capacity to handle considerable container trade for CPEC and landlocked CAR states. The map in Figure 1.4 shows Pakistan's coast and road network. The ports of Gwadar and Karachi can be seen on the coast. Qasim Port is in the southeast of Karachi. The two major road networks connect the country's ports to the hinterland from north to south and lie on either side of the Indus River. Karachi port has the potential to become a container hub for the region, with a strategic shift from national to global trading port.



Source: Usman, 2017

Figure 1.1: Pakistan's coast and CPEC road network.

Karachi port has been compared with the selected ports to determine its performance and efficiency. For a meaningful comparison, the ports were chosen from diverse cultures in developed and developing countries. Four out of six ports rank below 20 in the world.

Table 1.1. Comparison of Karachi port with chosen World ports

Determinants		**Karachi Pakistan**	**Singapore Singapore**	**Shenzhen China**	**Hamburg Germany**	**Mundra India**	**Busan Korea**
World ranking of ports 2023		61	17	4	12	27	32
Throughput (mil TEU, 2023)		2.28	39	29.88	7.7	6.64	23.15
Designed capacity mil TEU		4.5	35	25	5.2	5	23
Terminals		KICT PICT SAPT	Tanjong Pagar Keppel Brani, Pasir Panjang	SCT CCT YICT	HHLA 1 HHLA 2 HHLA 3 HHLA 4	MICT	KBCT PNIT PNC HJNC HPNT
Infrastructure	Berth depth (m)	13-16 m	16-18 m	14-18 m	15-16.7 m	13-17 m	14-20 m
	Berth length (m)	3063 m	18276 m	13618 m	7560 m	2100 m	12500 m
	Container berths	11	60	44	23	6+3 gen	41
	Yard Area mil.m^2 (1ha=10,000m^2)	1323000 m^2 = 132.3 ha	7400000 m^2 = 740 ha	5750000 m^2 = 575 ha	1200000 m^2 = 120 ha	3150000m^2 = 315 ha	2242000 m^2 = 224.2 ha
Technology	IT	◯	●	●	●	●	●
Equipment	Quay Crane	28 9twin 20ft	204 twin 40ft	144twin 40ft	78 twin 40ft	15twin 40ft	69 twin 40ft
	Yard Crane	99	200	200	100	45	230
	Reefer plugs	1310	202,700	1400	1600	300	200
	Nautical	◯	●	●	●	●	●

Accessibility/ connectivity	Road	◐	●	●	●	●	●
	Rail	○	●	●	●	●	●
Human Resource	Managerial skill	◐	●	●	●	◐	●
	Dock labour	○	●	●	●	◐	●
Customs process		◐	●	●	●	●	●

Sources: World Shipping Council 2023; Anne Kerriou 2023; port websites[1] and UNCTAD. Compiled by the author.
Legend: Strong = ●, Moderate = ◐, Weak = ○

A comparison of the resources of five leading world ports with Karachi port in Table 1.2 reveals that it is underperforming. The table strengthens the study's rationale and highlights the research gap, showing that deficient operational resources and container-handling capabilities are key barriers to Karachi Port's efficiency.:

- Throughput of all the above ports matches or exceeds their designed capacity, whereas Karachi port is operating much below its designed capacity, hence underutilised.
- All ports, including Karachi, have sufficient dedicated container berths to dock ships.
- Karachi port handles 2.28 million TEU with 11 container berths (length 3073m). Mundra port has a throughput of 6.64 million TEU with 9 berths (length 2100m).
- Other information, including technology (IT), accessibility (road, rail, nautical), human resources, and customs, reveals a lower performance shade for Karachi port.
- Data in Table 1.2 thus reveal that Karachi port has a lower efficiency among selected ports.

The comparative assessment of Karachi Port with five leading global ports provides empirical confirmation of the central performance problem, highlighting its substantially lower efficiency relative to international standards. This disparity justifies the study's focus on operational efficiency, resource utilization, and competitiveness, while also establishing a clear research gap concerning the basic causes of Karachi Port's underperformance. Comparison reinforces the study's objectives of benchmarking performance, finding influencing factors, and proposing strategies for improvement.

Table 1.2: Comparative Analysis of the Productivity of Karachi with Global Ports

Efficiency	**Karachi Pakistan**	**Singapore Singapore**	**Shenzhen China**	**Hamburg Germany**	**Mundra India**	**Busan Korea**	**Industry Average**	
							Drewry 2014	**Elentably 2015**
TEU/meter quay	7,18	2,003	1,887	1,155	2,105	1,733	1,072	1,000
TEU/terminal hectare	16,629	47,297	44,695	72,750	110,500	96,610	24,791	20,000
TEU/quay crane/year	78,571	171,569	173,611	111,923	294,666	313,913	123,489	Traditional 120,000 Automatic 160,000

Source: Compiled by author with literature support, UNCTAD, various port websites, and Wikipedia.

In Table 1.2, a comparison of port productivity in three areas: TEU/meter quay, TEU/terminal hectare, and TEU/quay crane/year has been done for Karachi port with five other

[1] https://www.statista.com/statistics/913398/container-throughput-worldwide/

global ports from Asia and Europe. Two Industry benchmarks, Drewry 2014 and Elentably 2015, have been taken from the literature as reference. It may be observed that the productivity values of Karachi port in all three categories are less than the other ports, and on average, 20% to 35% less than the benchmark values. This establishes that Karachi port's productivity is much lower than the world industry average, which needs to be improved.

Container Port Performance Index (CPPI) 2023. The CPPI 2023 was developed based on vessels' time in port and actual port performance. The ranking of 405 world container ports has been compared based on region, throughput, ship calls, and ship size so that ports with similar credentials can be compared. The summary of the ranking for Karachi port is mentioned in Table 1.4 below. As per CPPI 2023, among West, Central, and South Asia, Karachi port ranks 56, whereas the overall world ranking of Karachi port is shown as 61. Karachi Port's positioning in the CPPI ranking is 56 in Asia and 61 globally, reflecting clear operational limitations in areas such as technology, infrastructure, equipment, services, and container handling efficiency. This performance gap aligns closely with the constructs investigated in this study, thereby substantiating the research questions and objectives. The CPPI results not only refine the articulation of the research problem but also reinforce the rationale for examining resource dependence and container management mechanisms, ultimately underscoring the research gap this study seeks to address.

Table 1.3: CPPI 2023 Ranking of Karachi container port

Weight	Area						Ranking
Region	West, Central, and South Asia (Saudi Arabia to Bangladesh)						56
Throughput	Medium Ports (throughput between 0.5 mil. and 4.0 mil. TEU per Year)						56
Ship calls and size	Total Calls	<1,500	1,501−5,000	5,001−8,500	8,501−13,500	>13,500	56
	306	-	122	83	57	54	
Overall	World ranking of Karachi port as per CPPI 2023						61

Source: World Bank CPPI 2023.

Logistics Performance Index (LPI). As per Figure 1.5, Pakistan is performing poorly in LPI, ranking 122 among 160 countries in 2018, down from 68 rank in 2007. This large decline since 2007 is caused by low logistic parameters, due to delays in customs clearance, tracking/tracing, port connectivity, and inefficient port resources (NFLP, 2020; WB, 2023[2]). Pakistan was not endorsed as part of LPI in 2023 due to the provision of deficient data to the publishing authority in Germany. This shows a lack of commitment by the concerned officials to secure national maritime interests.

[2] https://lpi.worldbank.org/about

Pakistan's steep decline in the Logistics Performance Index reflects major logistics inefficiencies linked to weak port technology, infrastructure, and operational resources. These shortcomings align directly with the constructs of this study, reinforcing the relevance of its research questions. The LPI evidence highlights a clear research gap in understanding how resource capabilities and container management influence port logistics efficiency.

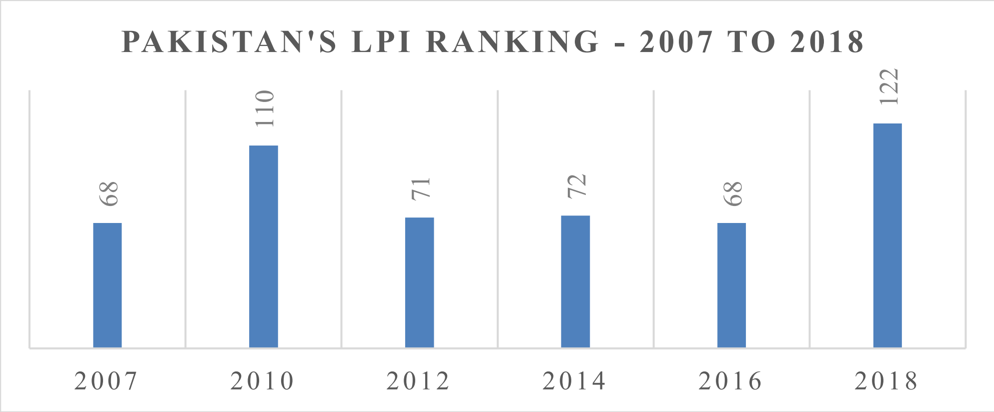


Figure 1.2: Pakistan's LPI Ranking 2007 to 2018.

Source: https://lpi.worldbank.org/about.

1.3 Research Gaps

1.3.1 Theoretical Gap

Regardless of wide-ranging studies on port efficiency and terminal performance, there is a substantial theoretical gap in understanding how port operational resources impact its logistics efficiency, directly and through container management, within the combined analytical lens of Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP). Prevailing studies classically examine resource variables like port technology, infrastructure, equipment, human resources, services, and charges in isolation, or in smaller groups, without integrating them into a unified explanatory framework that accounts for inter-organizational power dynamics (as highlighted by RDT) and cost-productivity relationships (as per ETP). Also, though container management is generally identified as an important operational function, its role in mediating how operational resources translate into logistics efficiency remains theoretically underdeveloped. No preceding research has systematically conceptualized container management as a mechanism that decreases resource dependence, optimizes operational costs, and improves throughput efficacy concurrently, mainly inside the legacy-port context of developing countries. Consequently, the interaction among resource dependence, operational cost structures, and container-handling capabilities has not been sufficiently theorized in port logistics literature, leaving unexplained the paths through which resource constraints shape logistics efficiency outcomes. This research addresses this theoretical gap by integrating RDT and ETP to develop a more comprehensive clarification of how operational resources, independently and jointly, affect logistics efficiency through the mediating role of container management in the case of Karachi Port

1.3.2 Methodological Gap

While port efficiency research has considerably grown, an evident methodological gap persists in how operational resources are empirically associated with logistics efficiency, directly and through container management, in a theoretically informed model. Most studies depend on high-level efficiency metrics like DEA, SFA, or frontier benchmarking without investigating the micro-level operational drivers (technology, equipment, human resources, services, charges) via multivariate causal modelling (Guo & Yang, 2025). Besides, most studies seldom integrate Resource Dependence Theory (RDT) or the Economic Theory of the Port (ETP) into empirical PLS-SEM frameworks, leading to restricted methodological rigor in capturing interdependencies, mediation effects (T. N. M. Nguyen, 2024). The mediating role of container management is nearly missing from quantitative port-efficiency studies, where container handling is mostly considered as a performance indicator rather than a transformative operational mechanism (Alzate et al., 2024). Also, empirical studies excessively focus on modern ports in developed countries (Baafi, 2024), while legacy ports in developing contexts remain under-represented (Mohite & Mathew, 2025) in SEM-PLS studies, regardless of having more intricate resource dependence patterns. No preceding study has developed or tested an integrated structural model that simultaneously evaluates direct and mediated paths from port operational resources to logistics efficiency using RDT and ETP theories based methodology (Q. Li et al., 2022). This study fills this methodological gap by applying SEM-PLS to quantify resource-capability influences on logistics efficiency via the mediating mechanism of container management at Karachi Port.

In a study regarding the impact of supply chain management on port performance and competitiveness for container shipping, the input was obtained from senior, middle, and junior managers, as they were knowledgeable about the company's internal and external processes (Hsu & Huynh, 2023). Another study by Loh (2015) about the role of ports in supply chain disruption management the input from managerial respondents from the port authority, port users, and port operators, as they had appropriate insight into port affairs. Yet due to fewer respondents, analyses could not be done according to the respondents' geographical locations and organizational sizes. Likewise, a few studies used smaller sample sizes (Baştuğ et al., 2022). To address such concerns, this study involved all three management tiers of the organization (i.e., top, middle, and lower management) as respondents in data collection through a survey.

1.3.3 Practical Contextual Gap

Although several research studies have been conducted on port/CT activities. However, their port operational practices were mainly limited to certain areas like operations, management, supply chain logistics, etc. The term ‘empty container management’ has been extensively used in research (Gusah et al., 2019; Legros et al., 2019; Xie et al., 2017). However, the term ‘container management’ has been rarely used (Giubilato et al., 2019; Hulten, 1997; Lee & Song, 2017; H. Li et al., 2022).

Although a few research studies on port/CT operations and logistics practices have been written in the context of Karachi port, the intervening variables involving container management have not been used. Also, the combination of variables involving container management in the presence of independent variables such as port technology, port infrastructure, port equipment, port human resources, port services, and port charges, with an output variable of port logistic efficiency, remains unused. There is a considerable difference between Pakistan's and Western countries' cultures, working environments, and fiscal conditions (Syed et al., 2025). Previous research has revealed that a country's culture may substantially influence the direction and intensity of the relationship among container port operations, logistics, and management constructs (Göçer et al., 2022). Yet, the preceding research findings cannot be generalized to other economies, cultures, and geographic locations.

Former studies about container management practices influencing port logistics efficiency and port resources were mostly limited to empty container management (D. Song, 2021), ECR strategies via dry ports (Castrellon et al., 2023), seaport competitiveness (Tijan et al., 2022), the worldwide attractiveness of container ports as per shipping lines (Kaliszewski et al., 2020). While most of the studies suggested exploring sectors including port/CT competitiveness or repositioning strategies, the improvement can lead to better operational performance and higher productivity by using fewer traditional means. These resources might include less conventional means such as training, leadership/management, information systems, and other resources that rejuvenate existing assets of the port towards increased capacity by various means at less cost and intricacy (Russell et al., 2022). It was identified that the container port/terminal might need to be investigated concerning container management practices, port logistic efficiency, and port resources, by exploring operational inefficiencies and management skills, and filling the gap, as there is a lack of literature in these areas (Russell et al., 2022).

Kajuna (2024) found that appropriate management practices will result in improved CT throughput, efficiency, and strategic operational performance. There is a relative lack of managerial competence in CTs (Notteboom & Rodrigue, 2023a). As per Shah (2021), the following areas in Karachi Port CT need to be explored and fill the research gap in the literature. The major areas are stranded containers due to customs clearance delays, operational and logistics inefficiencies, excessive charges, dock labour issues, poor rail and road infrastructure within the port, port-hinterland rail-road connectivity, training of KPT officials, and updated technologies. The World Bank assesses countries' logistic performance on six dimensions: customs, infrastructure, competitive charges, competent logistics services, capability to track and trace, and timeliness of shipments. The above cannot be achieved without competent management with strategic capabilities and direction. Sumbal et al. (2024) found that a performance gap exists in the logistics systems in Pakistan for infrastructure. Main challenges are inefficiencies of the government sector (e.g., KPT), minimal use of information and computer technology, and incompetent employees.

In the study by da Silva and Ensslin (2024), most research emphasizes on assessment of past data to evaluate and match port performance. They hung on to inert procedures, usually unbending to port alterations. They used a broad measurement system that might not reflect the explicit features of the examined ports. Besides, they did not urge the involvement of managers and stakeholders in the process of port efficiency performance analysis. The analysis of various port resources contributing to its performance can assess the aspects for the manager/decision-maker, in multifaceted, inconsistent, and ambiguous situations, like the container port (Fri et al., 2021).

1.4 Problem Domain

The container throughput at Karachi port has gradually improved (Zohaib et al., 2024). Although Karachi port has improved in ship-shore container handling, a few operational inefficiencies and bottlenecks increase the time and cost of container handling and enhance the ship's time in port (Baig et al., 2024). Higher container dwell time reduces port storage capacity, affecting throughput. Poor port efficiency and higher charges deter shipping lines from selecting the port (Saini & Lerher, 2024). The main problem areas for inefficient functioning of Karachi port are related to Port Technology, Infrastructure, Equipment, Human Resources, Services, Charges, Container Management, and Logistics Efficiency (Jaffry & Zia; Sumbal et al., 2024).

Despite its vital role in Pakistan's trade system, Karachi Port continues to face longer ship turnaround times, restricted container handling capacity, and operational bottlenecks, leading to inefficiencies that limit logistics performance (Sumbal et al., 2024). While these shortcomings are acknowledged in industry reports, academic literature lacks a comprehensive, empirical examination of the specific operational and strategic variables influencing the port's logistics efficiency (Q. Li et al., 2022). Existing container port studies tend to be descriptive, focusing on single or a few issues such as congestion, equipment shortages, or technology upgradation, without providing a unified theoretical framework or quantitative model (Wan et al., 2018). Moreover, there is insufficient understanding of how port resources, such as technology, infrastructure, equipment, human resources, services, and charges, relate to and translate into logistics outcomes, and what mechanisms influence this transformation (Su et al., 2024).

No empirical study has applied either Resource Dependence Theory (RDT) or the Economic Theory of the Port (ETP) to examine the operational determinants of Karachi Port, indicating a clear gap in the port research literature. While RDT suggests that ports rely on resource effectiveness to reduce operational uncertainty, it has been theoretically used to analyse port supply chain relationships and logistics interactions (Denktas-Sakar & Karatas-Cetin, 2012; Van et al., 2017), and ETP emphasizes efficiency-driven resource allocation, providing a theoretical framework to understand port performance (Van et al., 2017). As such, no empirical application of these theories, particularly to Karachi Port, could be found in the literature.

A critical missing element in the literature is the role of Port Container Management (PCM), the strategic, managerial, and operational processes governing container handling. Although PCM has been recognized globally as a core determinant of efficiency, its mediating role between port resources and logistics efficiency remains untested in the context of Karachi Port. Thus, the core problem is the absence of an empirical, theory-driven model explaining how port operational constructs influence logistics efficiency through the mediating function of container management. This research addresses that gap through a structured quantitative analysis using PLS-SEM

To ensure coherence and focus, the problem statement of this study has been refined to link with the research questions and objectives. The operational inefficiencies and performance gaps at Karachi Port are clear, particularly in port technology, infrastructure, equipment, human resources, services, and charges. The problem statement establishes the rationale for investigating their impact on port logistics efficiency. This alignment ensures that each research question and objective emerges logically from the identified problem, providing a clear direction for assessing the direct and mediated effects of port resource capabilities on container management. Consequently, the study maintains a consistent, structured framework, demonstrating that addressing the defined problem will generate insights to improve logistics performance and bridge the existing research gap.

The recent decisions for interventions by Pakistan's major container terminals address the core problems of connectivity, capacity, obsolete infrastructure, and operational inefficiencies (The News, 10 Feb 2025). Yet, progress in development work is likely to take more time due to investment delays because of political instability and security risk (Bukhari et al., 2024); (Freyt Consol, 2 June 2025). KGTL's planned and ongoing dredging at East Wharf will deepen the channel to improve accessibility and connectivity for 13,000 TEU post-Panamax ships. Hutchison Ports' US$1 billion investment targets modernization through remote-controlled quay cranes, automated RTGs, electric trucks, and digitized gate systems, confronting efficiency and bottlenecks. Corresponding improvements, like advanced digitalization at SAPTL, better road connectivity, installation of modern handling equipment, and major dredging initiatives, collectively enhance throughput capacity, decrease congestion, and uplift Pakistan's terminals toward global operational standards.

1.5 Problem Statement

Based on the discussion in the problem domain, past research is fragmented, focusing on isolated issues such as technology adoption, human resources, and port services, without integrating them into a unified model centered on Container Management as a mediating mechanism. The lack of theory-driven empirical evidence weakens strategic decision-making for port authorities. Although Karachi Port plays a central role in Pakistan's trade logistics, its operational efficiency remains significantly lower than that of comparable international ports. Existing studies and government reports highlight issues such as equipment unreliability, outdated technology, long dwell time, inconsistent human resource capabilities, high port charges, and service delays. However, these descriptions fail to address a core theoretical and empirical gap. **Thus, the central problem is the absence of an integrated, theory-driven empirical assessment of how port resources and operations influence logistics efficiency through container management at Karachi Port.** From the perspective of Resource Dependence Theory (RDT), ports rely on resources such as equipment, technology, skilled workforce, efficient services, and cost structures to achieve operational performance. The economic theory of the port (ETP) further suggests that ports must allocate these resources efficiently to maximize productivity and competitiveness. Yet no empirical study in Pakistan examines whether these resource inputs, when coordinated through effective container management, generate measurable improvements in logistics efficiency.

1.6 Significance of the Study

1.6.1 Theoretical Significance

This study offers an innovative theoretical contribution by integrating Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP) into an integrated empirical model. By presenting Port Container Management (PCM) as a mediating construct, the research stretches both theories, displaying that *in what manner* resource environments, managerial competences, and operational processes are in cooperative form. This adds to port management's literature by transferring attention from detached factors to a universal, resource-oriented context. The study evaluates the container handling capacity of Karachi port and identifies the bottlenecks hampering port operations. The study has the novelty of examining port resources and their relationship with container management and port logistics efficiency. Pertinent theories such as RDT and ETP have been employed.

1.6.2 Empirical Significance

This investigation is the first comprehensive PLS-SEM research assessing port logistics efficiency by means of several constructs: technology, infrastructure, equipment, human resources, services, charges, container management, and efficiency, within the framework of Karachi Port. The discoveries create empirical evidence for a developing nation’s port settings, filling a gap where preceding studies are largely conceptual or centered on progressive ports. By using primary data collected from managerial employees and logistics professionals in the local maritime environment related to Karachi Port, the study fills a critical empirical void and generates statistically validated insights that can be generalized across container terminal operations in developing countries with comparable institutional and infrastructural features. Such a comprehensive empirical study, having multiple constructs related to port resources, mediated by container management, and resulting in logistics efficiency, with data collected through a survey in the local maritime environment of Karachi port and data analysis done using PLS-SEM, is not found in the literature. Hence, this work has the novelty of being the first comprehensive study on Karachi port efficiency using PLS-SEM.

1.6.3 Practical Significance

The outcomes of this study offer actionable awareness for port strategy-makers, container terminal operators, port authority officials, and shipping firm managers. To comprehend the way PCM intervenes with operational factors, it can funnel developments in digitalization, container tracking, equipment repairs, employee planning, and service improvement. The results advocate evidence-based policies to augment Karachi Port's competitiveness, curtail ship turnaround times, and reinforce national logistics performance. Enhanced managerial skills can augment CT performance. The study proposes a port improvement plan for Karachi Port, which can be generalized for use by other compatible ports in developing countries, and hence contributes to the existing literature. The findings of this study provide insight for policymakers to improve port operations, particularly in developing countries.

1.7 Research Questions

RQ.1. Does port technology, infrastructure, equipment, human resources, services, and charges positively impact post logistics efficiency at Karachi port?

RQ.2. Do port technology, infrastructure, equipment, human resources, services, and charges have a positive impact on port container management?

RQ.3. Does port container management positively impact port logistics efficiency?

RQ.4. Does port technology, infrastructure, equipment, human resources, services, and charges have a positive impact on port logistic efficiency when mediated by port container management?

1.8 Research Objectives

Wider objective is to improve port container management to enhance port logistics efficiency.

RO1: To determine which port resource capabilities impact logistics.

RO2: To assess how port resources (technology, infrastructure, equipment, human resources, services, and charges), dimensions influence Karachi Port's logistics performance.

RO3: To examine how port resource capabilities shape container management effectiveness.

RO4: To evaluate the impact of port technology, infrastructure, equipment, human resources, services, and charges on port logistics efficiency.

RO5: To validate an integrated RDT and ETP port performance model within the Karachi Port operational environment.

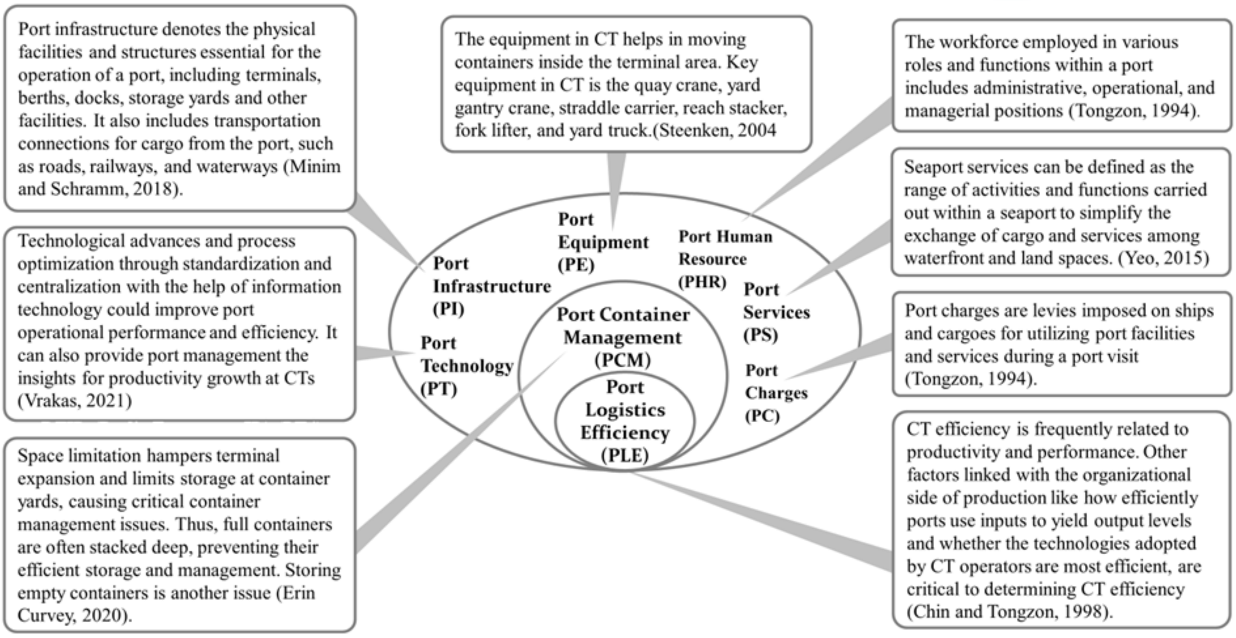
RO6: To determine the extent to which resource capabilities indirectly influence logistics efficiency through enhanced container management.

1.9 Scope

The study is focused on Karachi Port and limited to container terminal operations; external macro factors are not directly considered. Survey data and PLS-SEM have been used for quantitative analysis. RDT and ETP have been employed. It examines Port Logistics Efficiency (PLE), with port resources (PT, PI, PE, PHR, PS, PC) as independent variables and Port Container Management (PCM) as a mediator.

1.10 Constructs and their Definitions

Under mentioned figure shows constructs of the study and their definitions from the literature:



Source: Compiled by the author by adapting from various research studies in the literature

Figure 1.3: Port Performance related constructs and their definitions.

1.11 Organization of Thesis

This study follows a five-chapter structure. The current chapter comprises of introduction, background, research gaps, problem statement, research questions, research objectives, significance of the study, and scope. Chapter two pertains to a detailed review of the literature on variables of interest by appraising the supporting theories and formulating the research model. Theoretical bases are provided to rationalize and hypothesize proposed relationships among constructs. Measurement items and hypothesis development. Chapter three entails the research methodology (i.e., population sampling technique, sampling size, etc). The statistical tools and software choices are distributed along with the instrument design. Chapter four entails data analysis and discussion. To conclude, chapter five discusses the key findings of this study and draws statistical inferences in line with research objectives, the study's implications, contribution, conclusion, and future research direction.

Chapter Summary

This chapter introduces the study, covers background, research gaps, problem statement, significance of the study, research questions, research objectives, scope, and structure of the research. The next chapter reviews the literature on these constructs.

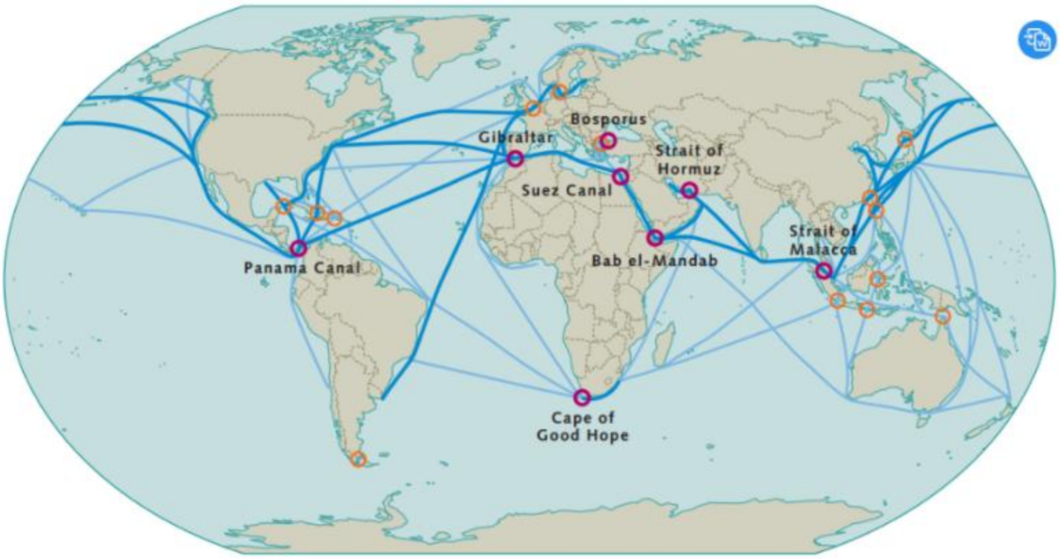
CHAPTER 2

2 LITERATURE REVIEW

This chapter, covering the literature review, focuses on port technology, port infrastructure, port equipment, port human resources, port services, port charges, port container management, and port logistic efficiency. In addition, a few key related areas like seaports, container terminals, automated ports, and traditional ports are also briefly discussed at the start of the chapter to offer a better insight to the readers. Given the gap analysis in chapter one and the literature review, research hypotheses have been proposed based on the theoretical support derived from the underpinning theories. The supporting theories form the basis for a relationship among the variables of interest in the theoretical model. This chapter concludes with the supporting theories which provide justification and rationale for using the theories and developing of the research model.

2.1 Maritime Developments

International trade is dominated by maritime means. Ports and CTs connect countries via global shipping routes. Ports and shipping lines collaborate to economize maritime logistics. The constant increase of global container trade and its management in ports makes it a natural choice for research. A world map showing the main maritime trade routes and bottlenecks is shown:



Source: Dr Jean-Paul Rodrigue, 2017
Figure 2.1: World Maritime Shipping Routes and Bottlenecks

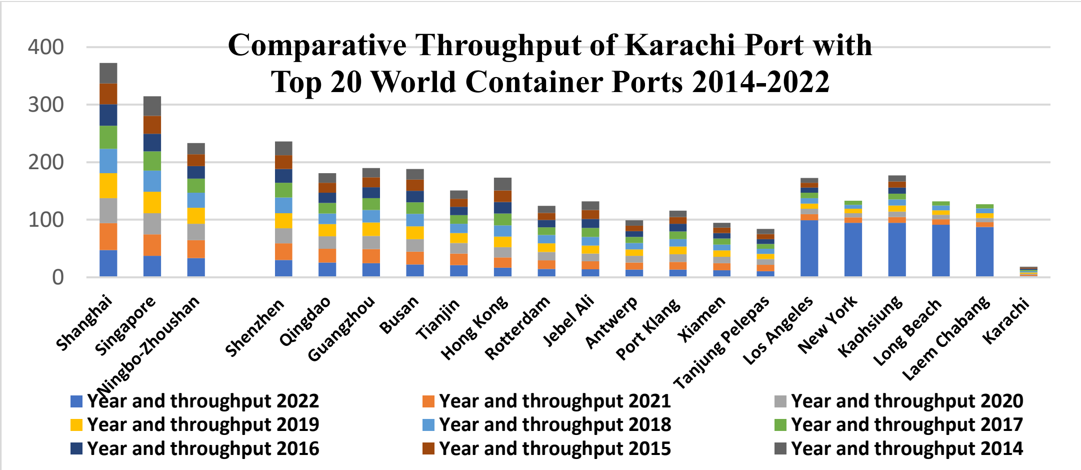
The data in Table 2.1 shows the throughput of the top twenty world ports compared to Karachi port, whereas Figure 2.2 shows its graphical form. The highest-performing port, 'Shanghai', has 20.5 times higher throughput than Karachi port, whereas the lowest-performing port, 'Laem Chabang', is also 3.8 times ahead than Karachi port. World throughput data show that leading ports like Shanghai and Singapore handle over 30 to 47M TEUs annually, while Karachi Port handles only about 2.3M TEUs, ranking 83rd worldwide. This long-term gap (2014–2022) shows Karachi's slow capacity growth and operational inefficiencies. This evidence directly supports the research gap and justifies investigating how port resources and container management influence Karachi's logistics efficiency. Karachi port is operational and improving, yet it needs dredging, modernized equipment, and operational coordination for better working. The assessment indicates that Karachi Port plays a national gateway function, whereas Laem Chabang works as a regional hub port with much higher efficiency and connectivity. This brief analysis reveals that Karachi port needs to improve berth and channel depth for bigger ships, transform equipment mainly QCs and RTGs to enhance moves per hour. increase terminal capacity, improve automation with advanced terminal operating systems (TOS), improve yard division, and computerized gate processes. Finally, improve port-hinterland connectivity. Comparing Karachi Port with the world's leading container ports emphasizes its significant performance gap and lesser operational efficiency, regardless of its strategic location. This benchmark underscores deficiencies in port resources and container management, justifying the study's research questions and objectives. It also classifies an obvious research gap, the lack of empirical analysis describing Karachi Port's underperformance, and encourages the investigation of factors impacting logistics efficiency and the mediating role of container management.

Table 2.1: World's Top Twenty container ports by throughput and Karachi port

World Ranking	**Country**	**Port**	**Year and throughput**								
			2022	2021	2020	2019	2018	2017	2016	2015	2014
1.	China	Shanghai	47.30	47.03	43.5	43.30	42.01	40.23	37.13	36.54	35.29
2.	Singapore	Singapore	37.29	37.49	36.6	37.20	36.6	33.67	30.90	30.92	33.87
3.	China	Ningbo-Zhoushan	33.35	31.07	28.72	27.49	26.35	24.61	21.60	20.63	19.45
4.	China	Shenzhen	30.04	28.77	26.55	25.77	27.74	25.21	23.97	24.20	24.03
5.	China	Qingdao	25.67	23.71	22.00	21.01	18.26	18.3	18.01	17.47	16.62
6.	China	Guangzhou	24.60	24.18	23.19	23.23	21.87	20.37	18.85	17.22	16.16
7.	South Korea	Busan	22.07	22.71	21.59	21.99	21.66	20.49	19.85	19.45	18.65
8.	China	Tianjin	21.02	20.27	18.35	17.30	16	15.07	14.49	14.11	14.05
9.	SAR China	Hong Kong	16.57	17.8	17.95	18.30	19.6	20.76	19.81	20.07	22.23
10.	Netherlands	Rotterdam	14.46	15.3	14.35	14.82	14.51	13.73	12.38	12.23	12.30

11.	UAE	Jebel Ali	13.97	13.74	13.5	14.11	14.95	15.37	15.73	15.60	15.25
12.	Belgium	Antwerp	13.50	12.02	12.04	11.10	11.1	10.45	10.04	9.65	8.98
13.	Malaysia	Port Klang	13.22	13.72	13.24	13.58	12.32	13.73	13.20	11.89	10.95
14.	China	Xiamen	12.43	12.05	11.41	11.12	10	10.38	9.61	9.18	8.57
15.	Malaysia	Tanjung Pelepas	10.51	11.2	9.85	9.10	8.96	8.38	8.28	9.10	8.50
16.	USA	Los Angeles	9.91	10.68	9.2	9.30	9.46	9.43	8.86	8.16	8.33
17.	USA	New York	9.49	9.0	7.59	7.40	7.2	6.71	-	-	-
18.	Taiwan	Kaohsiung	9.49	9.86	9.62	10.42	10.45	10.27	10.46	10.26	10.59
19.	USA	Long Beach	9.13	9.38	8.11	7.63	8.09	7.54	-	-	-
20.	Thailand	Laem Chabang	8.74	8.34	7.55	8.10	8.07	7.78	-	-	3.22
83.	Pakistan	Karachi	2.30	2.21	1.90	1.90	2.20	2.25	2.11	1.95	1.85

Source: www.worldshipping.org/top-50-ports; World Shipping Council 2023; Anne Kerriou 2023. Compiled by author



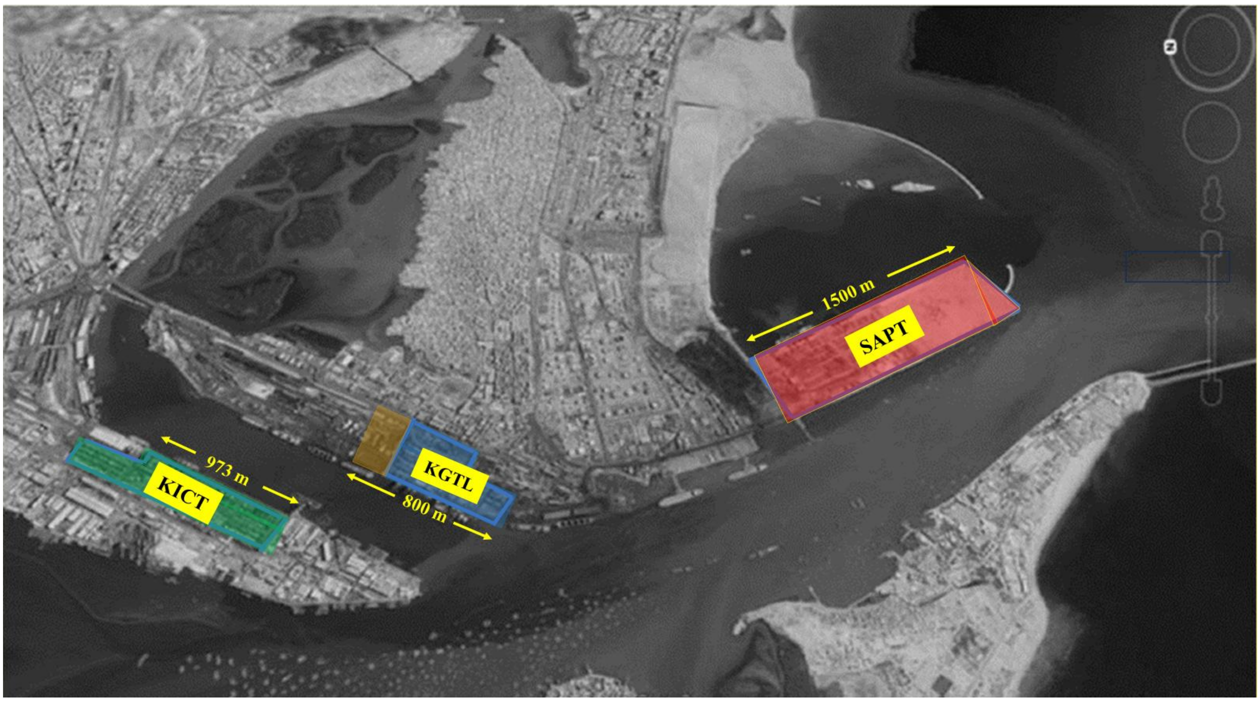
Source: Prepared by the author with data in Table 2.1

Figure 2.2: Comparison of Karachi Port with the Top 20 World Ports.

Pakistan has 1046 km of coastline along the Arabian Sea (Hafiz, 2018). It is situated in South Asia, bounded by India to the east, Afghanistan to the west, Iran to the southwest, and China to the northeast. The Wakhan Corridor of Afghanistan barely separates it from the landlocked Central Asian Republics (CARs). Pakistan's strategic location, due to its proximity to world maritime trade routes, the Persian Gulf, landlocked CARs, and China, makes Karachi port the right choice to become a regional hub for maritime trade (Durrani et al., 2017; Rahman et al., 2024). Pakistan has three major and five minor seaports. The major ports are Karachi, Bin Qasim, and Gwadar, whereas minor ports are Keti Bandar, Ormara, Pasni, Gidiani, and Jiwani, used for fishing activities. Ormara also has a naval base (Kardon et al., 2020). About 95% of national trade is handled by maritime means, i.e., Karachi port (60%), Bin Qasim port (35%), and Gwadar Port is still under development

(Rahman et al., 2024; Sajjad et al., 2015). Bin Qasim port is located 40 km east of Karachi, while Gwadar is situated 460 km west of Karachi and is still under development (Husnain, 2021).

Regarding container terminals at Karachi port, in 1998 Karachi Port Trust (KPT) signed an agreement with Hutchison Port Holdings (HPH) to lease five berths (26 to 30) 973 meters long, for 23 years, and named it Karachi International CT, KICT, with a total area of 26.3 hectares and 12.5 meters depth. In 2002, four berths (6 to 9) were leased for 21 years to International CT Services (ICTS), having an overall length of 600 meters, 21 hectares area, and 13.5 meters depth, and the terminal was named Pakistan International Container Terminal, PICT. This agreement was completed in June 2023, and a new agreement with one additional berth with an overall 800-meter length has been signed for 50 years with Abu Dhabi ports, and renamed as Karachi Gateway Terminal Ltd, KGTL. In 2016, a newly developed infrastructure for a deep-water port was leased to HPH and named South Asia Pakistan Terminal (SAPT). It has four berths (SAPT-1 to 4) of overall 1500 meters length, 85 hectares area, and 16 meters depth. Two berths are in use while two are under development by HPH. An image of KICT, KGTL, and SAPT at Karachi port, along with the total berth length, is shown in Figure 1.3.



Source: Google Maps and the author's deliberation

Figure 2.3: Karachi port CTs, storage space, and berth dimensions.

Figure 2.3 shows an aerial view of Karachi port container terminals (CTs), storage space, and berth dimensions. The South Asia Pakistan Terminal (SAPT), shown in red colour, has a berth length of 1500 meters, depth of 16 meters, and a capacity to handle 3 million TEU per annum. It is suitable for handling large ships. Karachi International Container Terminal (KICT), shown in green colour, has with 13-meter draft and a capacity to handle 0.7 million TEU per annum. Karachi Gateway Terminal (KGTL), formerly PICT, shown in blue colour, with a capacity to handle 0.7 million TEU per annum. The SAPT frequently handles ships up to 13600 TEU capacity, while KGTL and KICT dock ships of up to 7000 TEU capacity.

About 8,000 uncleared containers due to customs objections have been stranded at KGTL, KICT, and SAPT for a decade, resulting in a lack of container storage capacity at CTs (Karachi port visit 2021). The non-disposal of stranded containers can be attributed to a lack of strategic direction and indecision by KPT and customs management. Stranded containers reduce the terminal storage capacity and hinder the container management process and port logistics efficiency.

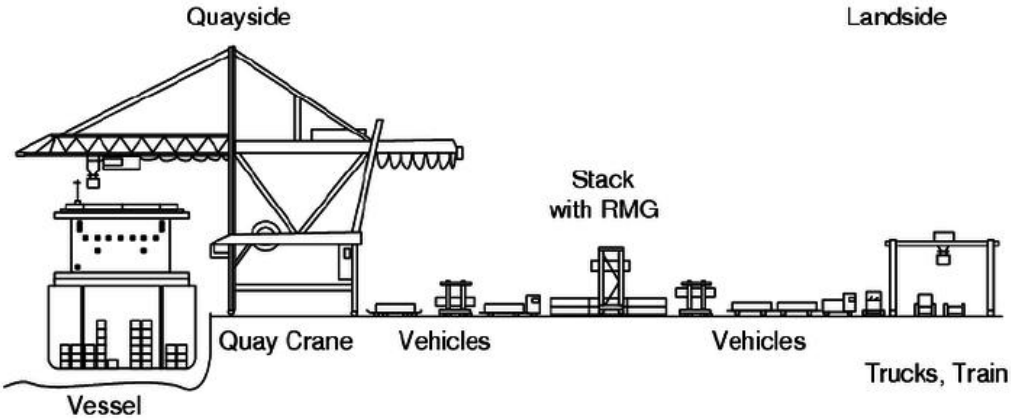
2.2 Overview of Seaports and Container Terminals

2.2.1 Seaports

In his study, Wang et al. (2021) found that seaports are highly valuable national assets as they act as a gateway to global maritime trade and hinterland development (de Almeida Rodrigues et al., 2024). A large port may contain many terminals, but a place where small vessels offload their cargo may be just a port (Rodrigue & Notteboom, 2024). Seaports connect countries to world trade and help boost economic growth (Ayesu et al., 2023; W. Li et al., 2023). A seaport is the border of land and ocean or a linked channel that offers facilities to maritime ships and cargo, along with multimodal freight dispersal and logistic movements (Liu et al., 2024); (Ducruet & Notteboom, 2023). Seaports are port facilities where goods are transferred between waterways or land-based transportation systems. (Knatz & Chambers, 2022; Shobayo, 2023). Seaports can also be defined as places where cargo is transferred to and from waterways and onto the coast. They mainly serve as transport points in the supply chain, where logistical activities can occur (Oni et al., 2023; Wayne K Talley, 2017). Brancaccio et al. (2024) found that ports have durable structures engineered to last for extended periods, making them significant investments compared to the equipment they operate.

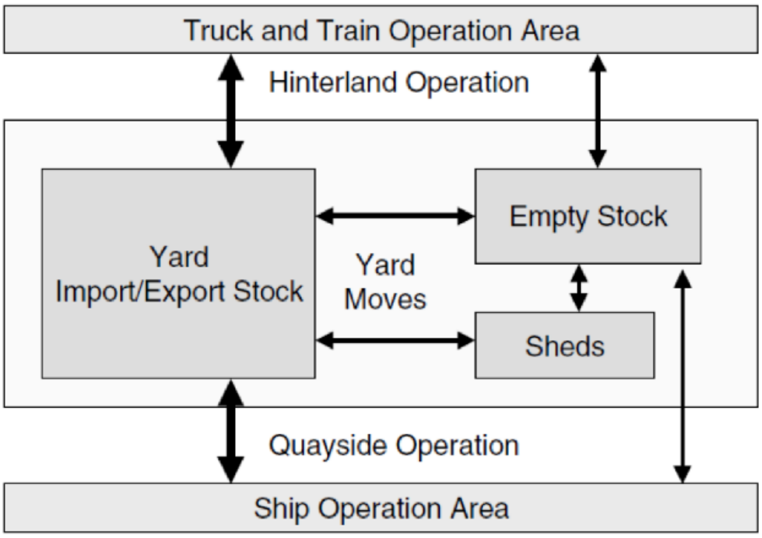
2.2.2 Container Terminal (CT)

In his study, Shan et al. (2024) found that CTs are generally categorized by the installed quay cranes, yard cranes, and storage capacity. The CTs worldwide utilize labour-intensive or automated quay cranes (Kim, 2024). A CT characterizes a complicated system with extremely dynamic interaction among different handling, transport, and storage units (Liu et al., 2024). Bechtsis et al. (2017) found that transfer between the wharf and stowage area can be done by yard trucks (YTs), automatic guided vehicles (AGVs), or other yard equipment. The same equipment can be reused for landside activities (Liu et al., 2024); (Kyaw, 2024). The containers have standardized dimensions worldwide, and can be moved alike by ship, rail, or road (Kaliszewski et al., 2020). Figures 2.1 and 2.2 related to transport flow in the CT are shown below:



Source: Steenken 2004

Figure 2.4: Operation area of a CT and transport flow



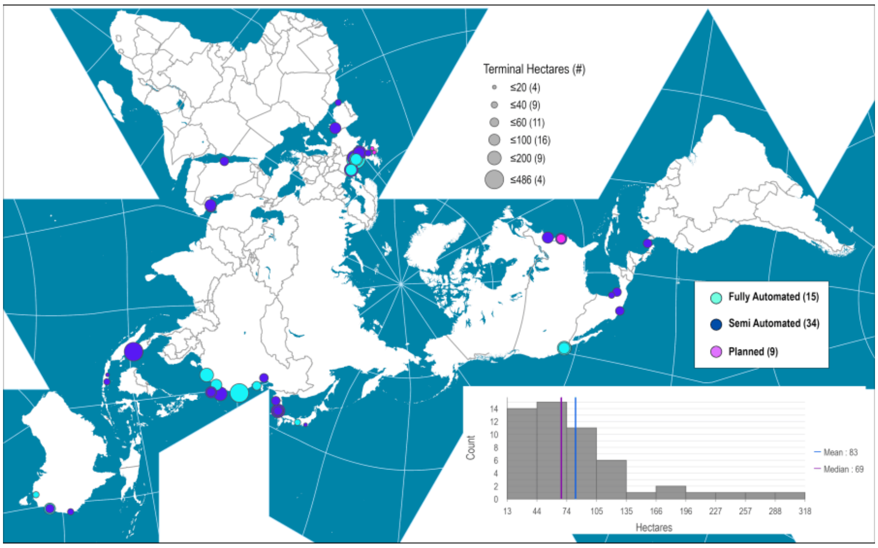
Source: Henesey 2006.

Figure 2.5: Container Terminal System.

As per Kim and Lee (2015); (Kim & Lee, 2014), the choice of equipment to be utilized in a CT depends on various considerations. Area limitations, usable terminal area, cost-effectiveness, and past practices play a significant role (D. Zhang et al., 2024). AGVs and programmed yard cranes could be chosen for a new CT if labour costs are high. Historical and cultural aspects may be considered if CTs are to be restructured (Naeem et al., 2023). In addition to the two stated categories, used in the EU and Asia, another kind, common in the USA and Canada, is the on-chassis arrangement, where the containers are stowed on a chassis, rather than placed over one another (Stewart & Rust, 2022). This scheme overcomes the dearth of stowage cranes but is more area-oriented.

2.2.3 Automated CTs

A study by Drewry Maritime Research (2018b) surveyed forty-one modern container ports. Among them, eleven were fully automated, twenty-six were semi-automated, and four ports were in the development phase. Results revealed that only about 3% of world ports were automated, while 97% of ports were still functioning traditionally. Among them, 1% were completely automated, whereas 2% were semi-automated. In their study, Brooks and Faust (2018) found that Asia has four times higher container output than Europe and that automation enabled ships to load and unload containers quickly at ports.



Source: Rodrigue (2022).
Figure 2.6: Completely and Semi-Automated CTs Total Hectares 2020

Notteboom et al. (2022) stated that terminal automation is a rapidly growing phenomenon. Yet the level of automation may vary among terminals. Burigana (2022) found that about 55 CTs worldwide were either entirely or partly automated as of mid-2020. Since there are about 750 active CTs worldwide, it represents 7.3% of all terminals, but 12.2% of the entire worldwide CTs in terms of hectares. Whereas the average CT size was 51.7 hectares, it was 85.5 hectares for completely automated CTs and 69.9 hectares for semi-automated CTs, emphasizing the scale tendency for automation.

2.2.4 Comparison of Traditional CT with Automated CT

The utilisation of automation technologies helps improve the quay cranes and yard performance for traditional CTs (Yu et al., 2022). Yet, capital investment for traditional CTs, no matter whether the induction of modern equipment or the construction of a new ACT, must be deliberated before a decision (Notteboom et al., 2022). For traditional CTs, yard space management can be divided into four sub-areas, including storage strategy planning, storage space allocation, location assignment, and re-marshalling (Yu et al., 2022). For traditional CTs, yard layouts based on Straddle Carriers, Rail-Mounted Gantry cranes, and Rubber-Tired Gantry cranes are usually used (Majoral et al., 2024). For ACTs in operation, most automation equipment is transformed from traditional equipment with an automated control system. As a result, the traditional yard layout continues to be fit for most ACTs (Majoral et al., 2024). Like the traditional CTs, a key objective of the storage strategy planning for ACT is to reduce the extra movements (D.-P. Song, 2021).

For traditional CTs, import and export containers are always stored in different blocks; thus, most terminal managers prefer to focus on coordinating the space management with yard crane scheduling to avoid re-marshalling costs (Y. Wang et al., 2024). For a few semi-automated CTs, the traditional QC is still employed to work with other automated equipment. Thus, research based on traditional QC scheduling still inspires ACT's management (Yu et al., 2022). For ACT, the containers belonging to the same group do not have to be allocated adjacent bays compared with traditional terminals (Yu et al., 2023). Relating to the traditional yard crane scheduling, the generation of handling sequence for AYC in ACT should further coordinate the plan of other subsystems, such as the stowage plan (Gao et al., 2022; Yu et al., 2022). In traditional CTs, the sub-block in Yard has proven to be a suitable clustering unit. However, for ACT, which clustering unit is better still needs validation (Yu et al., 2022). Secondly, the mixed storage of import and export containers in the same block cannot be avoided for a perpendicular yard, which is seldom discussed in traditional CTs, where the stacks are parallel to the berth (Kim, 2024).

The South Asian container ports improved their performance between 2000 and 2017 (Yang & Yip, 2019). The post-pandemic environment has changed the dynamics of maritime container trade, with escalating shipment costs, obstacles at sea, and supply chain congestion (Chua et al., 2022). The port authorities can be instrumental in enhancing the performance and efficiency of CTs, though they seem helpless in case of factors like trade flows, customs clearance, local transport, and the dock labour union (Dappe & Suarez-Aleman, 2016).

The word improvement has been frequently used in this study pertaining to the port's functioning. Hence, its meaning is explained for clarity and better understanding of the readers. According to the Merriam-Webster dictionary, the word 'improvement' means 'to enhance in value or quality; that is make better' or 'the act or process of improving'. As per Merriam-Webster thesaurus, the word 'improvement' also means increase, enhancement, refinement, or innovation. Conversely, as per Merriam-Webster dictionary, word optimization can be defined as an act, process, or methodology of making something (such as a design, system, or decision) as perfect, functional, or effective as possible. Specifically, mathematical procedures (such as finding the maximum of a function) are involved. As per Merriam-Webster Thesaurus, optimisation means 'improvement', whereas 'optimize' means 'to improve'.

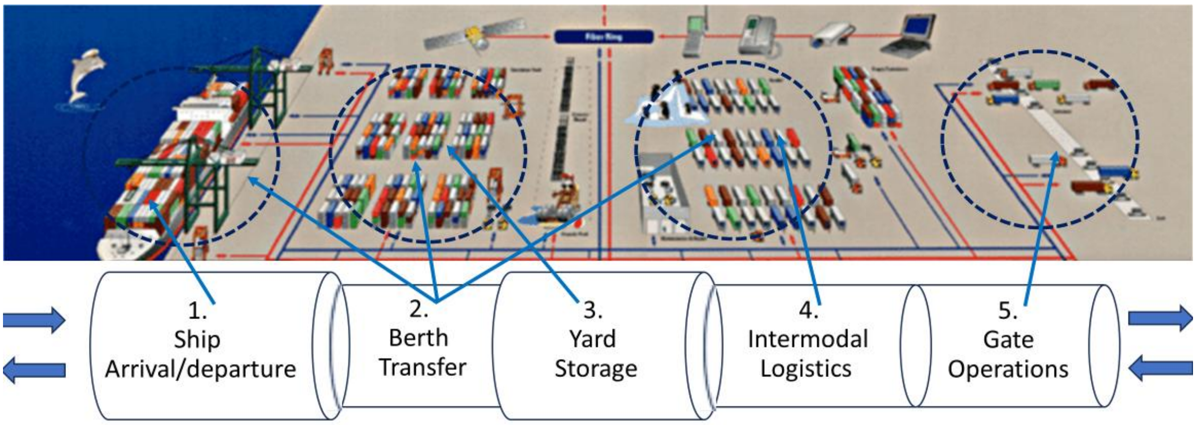
Most studies referring to port optimization are found in engineering, mathematical, or simulation journals, though less work is available in the management realm. This study uses the term improvement as it endeavours to find the effects of container management to improve port performance/efficiency, without using engineering, mathematical, or simulation techniques. As over 90% of the world's ports are traditional (non-automated), their performance and output would depend upon the level of management of their port resources. The broad port planning for incoming ships can be done with the help of Terminal Operating System (TOS) at CTs, yet the port manager's skills and competencies can make the difference among ports by better resource utilization to further improve their container management process.

2.2.5 Container Terminal Management

Gharehgozli et al. (2017) stated that CT is part of a seaport where container ships dock to disembark and embark containers. CTs have various segments like oceanside, landside, stacking, and internal transportation areas. Due to the high demand for containerized trade, container vessels are expected to spend the minimum time in port for cargo transfer. Swift handling of containers from the vessel to the wharf is done with the help of well-defined port procedures, supporting infrastructure, specialized equipment, port services, stakeholder communication, and a trained workforce. As per Gharehgozli et al. (2016a), container management equipment contains quay cranes (QCs), yard cranes (YCs), automated guided vehicles (AGVs), straddle carriers (SCs), and so on, which are utilized to transfer containers from vessels to freight barges, trucks, and trains. Pallis et al. (2015) claimed that a modern CT may cost nearly $ 1 billion, while payback could take 15 to 30 years. According to Gharehgozli et al. (2016b), QCs handle containers from vessels berthed along the quay, and the container's stowage location rests on the vessel's loading order. As per research, Ding and Chou (2015) discovered that heavier containers are loaded first, to guarantee the vessel's stability, while containers to be unloaded at the next seaport are loaded in the end.

As per Felício et al. (2015) the terms seaport, port, and CT are interchangeably used in the research literature; an effort is made to explain the terminology (Petering, 2015). A seaport is a place where cargo may be transported through maritime shipping. The rail, road vehicles, and inland waterways linked the seaports with the hinterland. The primary purpose of CT management is the preparation, regulation, and efficiency of port operations. Terminal managers often hesitate to adopt modern technology. Yet they must try to minimize the ship's time in port to achieve customer satisfaction, or else affect the terminal choice by shipping companies.

In his study, Chargui et al. (2021a) stated that to decrease a vessel's time in port, CT managers work hard to enhance the output of QC moves per hour, which is considered an attribute of CT performance. The intricacy of CT operations requires the management to carefully allocate port assets (Hsu et al., 2023). Due to obsolete practices, CT management is often split, with different administrations handling similar tasks in a terminal, amounting to duplication (Aggarwal et al., 2021). During the visit to Karachi port and a discussion with CT managers between 2019 to 2024, it was learnt that the CT management faced severe challenges from dock labour, congestion, poor infrastructure, rail-road connectivity, customs delays, and space problems due stranded containers.



Source: Authors deliberation, adapted from Henesey, 2006.

Figure 2.7: The Container Terminal Subsystems

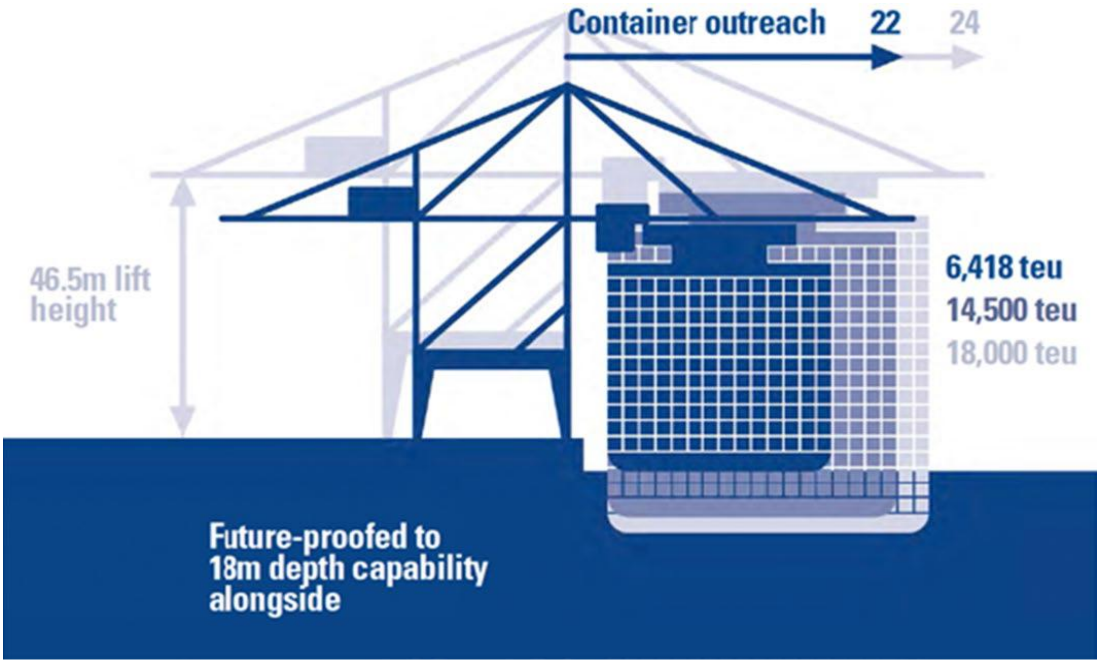
Figure 2.7 portrays an overview of CT's five key segments: distinguished when working together. The efficiency of one segment influences the working of the other. These are:

- **Ship Arrival/Departure**. Container handling from vessel to jetty. Quay cranes embark/disembark containers from vessels to the marshalling area (Zhao et al., 2020b).

- **Berth Transfer**. Handling of containers from the jetty to the yard storage area, intermodal transfer within the yard, from yard to gate, and the other way around. Trucks, Straddle Carriers, and AGVs work in this segment (Hirata et al., 2022).
- **Yard Storage**. It is the area where containers are brought for storage and stowed above one another. Yard gantry or straddle carriers lift the containers for stowage (Shan et al., 2024).
- **Intermodal Logistics**. Movement of cargo in the same loading unit or road conveyance, which consecutively utilizes two or more modes of transport (rail, road, inland waterway, or sea) without handling the cargo themselves in changing modes (Pencheva et al., 2022).
- **Gate operations**. The terminal gate performs as a crossing point for the CT with other means of transportation, like trains or Trucks (Singh, 2022).

2.2.6 Quay Crane and Berth Planning

In his research, Kim et al. (2021) stated that upon vessel arrival, decisions are made for berth allocation, berthing time, and assigning QCs for container handling with the least terminal cost and delay (Bierwirth & Meisel, 2015). The key dilemma is the berth allocation problem (BAP). Ideal berth allocation is complex due to spatial limits like draft, vessel size, crane outreach, distance among berths, and container stacking area (Martínez Ruiz, 2020).



Source: Gharehgozli, 2019.

Figure 2.8: Quay cranes outreach and container ship size

2.2.7 Global Terminal Operators

A total of 21 global terminal operators performs various activities for the movement of containers related to maritime and land transport. Terminal operators play a key role in container management at the port. The top seven terminal operators handled 40% of the global container trade in 2023. The leading global terminal operators are shown in Table 2.1.

Table 2.2: Top six world terminal operators, throughput, 2018 and 2023.

Ranking	Terminal Operator	2018 (million TEU)	2023 (million TEU)
1.	PSA International	60.3	62.6
2.	China COSCO Shipping	46.1	52.9
3.	China Merchant Ports	35.1	50.6
4.	APM terminals	42.8	48.8
5.	DP world	44.2	46.5
6.	Hutchison Ports	46.7	45.1
7.	Adani, AD Ports, Hapag-Lloyd	-	8.2

Source: Drewry Maritime Research, Global CT Operators Annual Review 2019 and 2024.

Shipping alliances. Ge et al. (2021) found that container ship size grew steadily till the early 2000s and then on much faster to reduce per container cost. However, the Ship size grew faster than the ports (Ge et al., 2021). Many shipping lines formed shipping alliances to enhance outreach (Ichimura et al., 2022). In their research, C. Zhao et al. (2024) found that big shipping alliances are central to regulating the dynamics of container trade by influencing the decision of shipping companies to do business with a CT, which could change its fate. As per Yau et al. (2020) port authorities face challenges due to growing ship size, as upgradation of infrastructure and port equipment is quite costly. Nduna (2022) found that port authorities readily offer CTs to reputed terminal operators on concession agreements for 20 to 25 years. Wahyuni et al. (2020) found that the agreement is usually based on the concept that the port authority undertakes basic development, while the terminal operator invests in the terminal equipment and its operationalisation. This practice has led to inter-terminal competition and networking with shipping alliances. In their study, Herrera et al. (2017) found that shifting of vessel by an alliance to another terminal operator in the same port can levy setback to the terminal operator and expose it to exploitation. Molavi et al. (2020) stated that ports must upgrade wisely and achieve efficiency level suitable for operations. (Langenus et al., 2022); (Ju, 2024) found that it is important for port management to maintain strategic relations with stakeholders such as shipping alliances for a better future.

In 2025 the four major shipping alliances MSC, GEMINI, Ocean Alliance, and Premier Alliance, cumulatively control more than 84% of the world container capacity on major east-west maritime trade routes linking Asia, EU, and the USA. These alliances have recently realigned owing to ups and downs in the shipping industry, COVID-19, and the US-China trade conflict. The alliance partners for 2025 are shown in Figure 2.9.

Source: Shipping companies. https://market-insights.upply.com

Figure 2.9: Strategic container shipping alliances 2025

2.2.8 Port productivity and efficiency

Port efficiency and terminal productivity are two important attributes of the existing market. Innovation in port technology presents various operational solutions, like automation, to expand terminal productivity. Though such solutions offer enhanced outputs (e.g., moves per hour), excessive fixed charges, managerial challenges, and some laws are obstacles that hinder their initiation. Changing situations can affect terminals' output in several ways (Ghiara, 2021). Wang and Cullinane (2015) stated that port productivity and efficiency are key ideas in economics for performance measurement and are used interchangeably. Efficiency is a key idea in economics and is fixated on the cost-effective use of assets for production (Beecher, 2020; Velenturf, 2021). Economic efficiency is considered as the attainment of moving TEUs at the least possible price (Castellano, 2020). Notteboom et al. (2022) found that alterations in the arrangement of the port structure have changed the nature of port procedures. Wayne K Talley (2017) stated that larger ports have greater efficiency. On the contrary, Rajasekar and Deo (2018) found that port size is not the main reason and does not affect efficiency. Munim et al. (2019) found that port efficiency has improved by privatizing terminals. In their research, Wang and Cullinane (2015) found that examining the efficiency of dissimilar container ports is essential to ascertain the efficiency of a port.

2.3 Variables Definition and Operationalization

The following research variables deduced from a review of the literature are described below:

2.3.1 Port Technology (PT)

As per Fill and Härer (2018), technology can be defined as the applied implementation of knowledge, particularly in a specific domain; for instance, maritime port and CT technology, medical technology, car fuel-saving technology, information storage technologies, educational technology, etc. According to with a rising demand for container trade worldwide, ships have grown in size to carry more containers. Chiganga (2015) stated that the growth in ship size has necessitated the upgradation of ports to handle larger ships, more space for container stowage, automation of processes, addressing congestion, and improving port-hinterland connectivity. Monios (2016) stated that it may not be possible to increase port space significantly due to the city built around it. Therefore, to achieve large-scale container handling efficiency in the existing port infrastructure and space, the adoption of new technology or innovation has become essential. However, challenges like the huge costs of port modernisation, skilled HR, and port-hinterland connectivity, limit its adoption at times. Wolf et al. (2019) revealed that tall rack-type auto systems can save up to 90% land space by storing containers up to 50 levels, but at a high cost.

Table 2.3: Conceptualization of Port Technology (PT) in literature

Author	**Definition**
(Vrakas, Chan, Thai, et al., 2021).	Technological development and process optimization through standardization and centralization with the help of information technology could improve port operational performance and efficiency. It can also provide port management insights for productivity growth at CTs.
Fill and Härer (2018); Jun, Lee, and Choi (2018)	Technology can be considered as the applied application of knowledge.
Aprilianty and Evander (2017)	Sound contemporary equipment with an integrated IT system has a close link with seaport facilities and efficiency. IT practices are now essential due to competition among seaport services and management to improve transparency, efficiency, reliability, and safety in seaport processes.
Ab Hamid, 2017	Electronic data interchange (EDI) is an inter-organizational information system (for example, between a ship at sea and a port).

In his study, Beškovnik (2008) found that innovative ideas to improve the processes of maritime CT are often studied in conjunction with technology to improve terminal capacity and output. Adabere et al. (2021) found that IT has a positive direct effect on port operational efficiency

(OE) and an indirect effect on port OE through organizational culture (OC). In their research, Aprilianty and Evander (2017) discovered that an integrated IT system has an association with seaport facilities and efficiency. The management of maritime CT is a complicated process that includes numerous financial and operational decisions. The management, with the help of terminal managers, must develop and implement quickly adoptable improvement strategies and solutions to improve CT productivity by adopting new technologies. In their research, Cimino, Palumbo et al. (2017) found that smart Information and Communication Technology (ICT) permit a coordinated interaction of important dissimilar features, customers, and infrastructures while abiding by the state policy. In their study about smart ports, Yang et al. (2018) found that the Internet of Things (IoT) can be considered a vital technical uprising linked to smart port applications. In their study about smart city-port linkage, Ferretti and Schiavone (2016) found IoT to be an important technical linkage with smart urban areas and modern port operations. IoT is an arrangement of devices that enables items to trade information. Javed, Afzal, Sharif, and Kim (2018) specified that IoT is a vital link for smart port operations.

As per Dawn, 26 July 2024[3], in a meeting at the Ministry of Maritime Affairs (MoMA), it was concluded that the infrastructure and lack of digitization were the key challenges at Karachi port. Chairman KPT highlighted the critical problems at Karachi port, including delayed container cargo clearance due to bottlenecks in the customs clearance process. Need to develop existing infrastructure to world standard, adopt digital solutions and automation to improve efficiency. To clear the backlog of uncollected containers, leading to reduced port capacity, inefficient container movement, and congestion in the port. The need to improve communication and coordination by KPT with stakeholders to enhance performance. Simplification of regulatory procedures for smooth port operations, cuts transaction time and cost. KPT's high operational costs related to CTs are to be reduced. Workforce issues must be resolved to improve productivity and operational efficiency.

In a study about the future of efficient CTs, Krause (2020) discovered that the demand for operational efficiency in existing CTs is likely to further rise and the traditional automation methods will subside due to the massive pressure of cost reduction. The use of intelligent autonomous vehicles and artificial intelligence (AI) based operational ideas is providing an ultimate means to attain hidden operational performance in Ports. In their study about container identification, Kadir et al. (2016) found that the practical implementation of RFID for container identification is being tested. As per Medina et al. (2019), the use of devices like ultrasonic, radar, laser, IT, and RFID can

[3] Dawn, 26 July 2024

be used to gather information, and to transform the seaport into a 'smart port'. Y. Yang et al. (2018) found that RFID improves the traceability, identification, and tracking of containers, thus reducing human error, cost, and processing time and improving the efficiency of CT's cargo management. Kadir et al. (2016) found that the adoption of technology can reduce the ecological and environmental impact of port operations. Goh (2010) revealed that the usage of electric-driven cranes and equipment to move containers inside the port will reduce unwanted gas releases and noise during port operations. Salient dimensions are:

Information Technology (IT): The IT system has gained importance in seaport operations, management, administration, container movements, and an organized maritime transport process. With modernization, seaports have implemented the use of IT, which helps them obtain and improve the accuracy of data (Sadiq et al., 2021). IT systems and control software: logistics control in large CTs is an extremely complex task, which needs real-time decisions on matching handling tasks with the conforming equipment units and the provision of thorough data regarding each independent container. Diverse means of software and IT support, and the usage of sophisticated improvement tools, are considerably important for CT operations (Tsolakis et al., 2022). The majority of ports have systems for exchanging information between different agents involved in the supply chain. The most useful functions of a port communications system are the ability to automatically extract the information required by customs authorities from private port operators. It also helps ports to resolve various issues, like the identification of personnel, vessels, and trucks, and tracking containers in the port (Kapkaeva et al., 2021). Port development involves innovative technological solutions, mainly information technology systems, particularly for integration and communication, such as sensors, RFID, Internet of Things, etc (Bessid et al., 2020). CTs should be able to handle large ships within the shortest time possible and at competitive rates. Hence, terminal operators, shipping lines, and port authorities are investing in new technologies to improve container handling and operational efficiency (Gharehgozli et al., 2016b).

In his study about IT support to transport, Mondragon et al. (2012) stated that IT-supported multimodal carriage and cargo handling means are adopted for the efficient delivery of goods. Service novelty is a real way to enhance port efficiency. In the study about IT and ports, Aprilianty and Evander (2017) found that sound contemporary equipment with an integrated IT system is closely linked with seaport facilities and efficiency. IT practices are now essential due to competition among seaports in their services and management to improve transparency, efficiency, reliability, and safety in seaport processes. Provision of accurate data facilities and analysis to sustain viability and fulfil regulatory needs (Aprilianty & Evander, 2017). Terminal management is considered a key determinant when assessing service quality regarding providing fluent services to shipping lines, including processes and harmonization between government organisations, application of IT and EDI, education credentials, and professional skills of port employees (Pham and Yeo, 2019).

Electronic Data Exchange (EDI): EDI is a valued tool to process and improve import and export operations at seaports (Ab Hamid et al., 2017). The information flows around freight transfer at ports, and the engagement of stakeholders drives the use of technology for the secure exchange of maritime shipping paperwork. EDI allows efficient management of information and benefits the logistics chain stakeholders by applying this communication system (de Almeida Rodrigues et al., 2023). As per Paik (2022), deficient transparency and flexibility result in extended shipping time, degraded services, resource wastage, and higher costs. This task can be improved by using Electronic Data Interchange (EDI) in the modern Port Information Systems to improve port operations.

Radio Frequency Identification (RFID): Kolarovszki et al. (2016) discovered that container identification by RFID is being studied to improve container tracking and identification. Kosiek et al. (2021) found that the application of RFID in CTs has significantly improved the efficiency of the port's cargo management system. Yang et al. (2018) found that RFID has improved the traceability, identification, and tracking of containers in ports. It interfaces with IoT and reduces operational costs and processing time. It allows identification and tracking of containers at terminals and gates, and cuts the expenditure of container management, manhours, equipment, labour, and energy. Reducing truck waiting time at the port entrance cuts environmental pollution. It also helps in container identification/tracking, better security, fewer human mistakes, and reduced cost.

Internet of Things (IoT) As per a study, Yang et al. (2018) found that IoT is described as a system of items together with sensors and embedded schemes that can link with the internet and allow actual items to obtain and exchange information. In their study, Javed et al. (2018) found that IoT is a valuable linkage for smart port operations. Chaudhary and Tomar (2019) revealed that IoT is viewed as a vital technical uprising linked with smart urban areas, brilliant processing plants, and contemporary port operations. Adhya (2016) explained that IoT contains detection devices associated with the web and empowers physical items to gather and trade data. Padayachee and Mukomana (2019) stated that a seaport is a fully automated port where gadgets are linked through IoT, but are quite costly. Devices like inertial, ultrasonic, radar, imaging, IoT, and RFID sensors are used to gather information to transform the seaport into a 'smart port' (Kosiek et al., 2021). As per the study by Acciaro et al. (2018) a range of technological, Internet of Things (IoT) based solutions were proposed that can be applied to improve logistics and transport services in Le Havre port. Cil et al. (2022) found that the Internet of Things (IoT) enabled real-time monitoring in container ports.

Ports and terminals have arrived in a fifth phase of development characterized by their digital conversion and configuration with Industry 4.0 practices. IoT and detecting solutions, cybersecurity, horizontal and vertical system integration, cloud computing, big data, business analytics, augmented reality, and simulation and modelling are the pillars of Industry 4.0. Some are mature enough in the maritime realm, yet others remain in their early phases and are hence weakly reported in the scientific literature (de la Peña Zarzuelo et al., 2020).

5G. In his research on the 5G network, Li et al. (2018) discovered that it is considered the 5th generation cellular network that offers broadband access. It gives quicker access and interfaces with the evolving IoT concept for use with apps of varying speeds, safety, and capacity. It can sustain a million devices within 500 meters compared to 4G, which could only support about 10% of that. In his research, Chandra (2020) discovered that several key ports in the world have been operating for extended periods. They now face the challenge of aging infrastructure and network limitations in a more dynamic situation than earlier. Emerging technologies like 5G bring future-generation connectivity and IoT capabilities with the potential to transform toward integrated port operations. Yet, this new wireless interconnectivity model also brings along many risks, like exposure to electronic radiation and higher installation costs.

Laser. In his research Kosiek et al. (2021); Yang et al. (2018) found that laser technology is an important part of a smart or automated port. The laser helps in the accurate positioning of containers, and their handling equipment performs safer functioning of amenities and reduces human resource costs (Kathirvel et al., 2024). In today's difficult environment, nearly all CTs confront challenges linked to monitoring access management and specifying spaces in yard areas for embarking and disembarking containers. A key aim for logistics firms is to guarantee timely and complete delivery, which relates to improved customer satisfaction and enhanced profitability (Mindell & Reynolds, 2023).

Table 2.4: Compilation of Port Technology (PT) from literature

Port Technology (PT)							
Sr. #	Author (s)	Information Technology (PTIT)	Radio Frequency Identification (RFID)	Electronic Data Indicators (EDI)	Internet of Things (IoT)	5G	Laser
1.	Beškovnik (2008)	●					
2.	Cimino, Palumbo et al. (2017)	●					
3.	Krause (2020)	●					
4.	Medina et al. (2019)	●	●				●
5.	Adabere et al. (2021)	●					
6.	(Sadiq et al., 2021).	●					
7.	(Tsolakis et al., 2022)	●					
8.	Mondragon et al. (2012)	●					
9.	(Aprilianty & Evander, 2017)	●					
10.	(Pham and Yeo, 2019).	●		●			
11.	Bessid et al., 2020	●					
12.	Kapkaeva et al., 2021	●	●		●		
13.	Vrakas, Chan, Thai, (2021)	●					
14.	Fill and Härer (2018)	●					
15.	Chiganga (2015)	●	●		●		
16.	Monios (2016)	●	●		●		●
17.	Park 2015	●					
18.	Gharehgozli. (2016)	●					
19.	Iris and Lam (2019	●					
20.	ha2017	●					
21.	Raza et al., 2020	●					
22.	(Ab Hamid et al., 2017)			●			
23.	(de Almeida Rodrigues et al., 2023)			●			
24.	(Paik, 2022)			●			
25.	Kadir et al. (2016)		●				
26.	Kolarovszki et al. (2016)		●				
27.	Yang et al. (2018)		●		●		●
28.	Ferretti and Schiavone (2016).				●		
29.	Javed, Afzal, Sharif, and Kim (2018)				●		
30.	Chaudhary and Tomar (2019)				●		
31.	Adhya (2016)				●		
32.	Padayachee and Mukomana (2019)				●		
35.	(Kosiek et al., 2021)		●		●		
40	Acciaro et al. (2018)				●		
41	Cil et al. (2022)				●		
42	(Rajan et al., 2024)				●		
43	(Almansor et al., 2025).				●		
44	(de la Peña Zarzuelo et al., 2020)				●		
45	(Dalaklis et al., 2022)						
46	(Basulo-Ribeiro et al., 2024)		●				
47	Li et al. (2018)					●	

48	Chandra (2020)					●	
49	(Sordello, 2021);				●	●	
50	(Esenogho et al., 2022)				●	●	
51	Kosiek et al. (2021)						●
53	(Kathirvel et al., 2024)						●
54	(Mindell & Reynolds, 2023)						●

Table 2.5: Port Technology (PT) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual Studies	Gap Notes
IT / ICT	20	6	14	Limited applied studies in the Karachi Port context
RFID	7	2	5	Mostly early-stage; few real port deployments
EDI	8	3	5	Focus on Europe/Asia; developing ports are underrepresented
IoT	10	3	7	Few empirical tests; limited performance metrics
5G	2	0	2	Early-stage; no operational validation in ports
Laser	5	1	4	Mostly lab-based; not port-specific

Narrative Summary for Port Technology (PT)

The bibliometric mapping of Port Technology (PT) shows that most research concentrates on integrated IT systems (PTIT), with moderate attention to technologies like RFID, IoT, and EDI, while emerging tools such as 5G and laser-based systems remain underexplored. The mapping also highlights clusters of authors working on specific PT themes and reveals limited studies integrating multiple technologies, especially in developing port contexts like Karachi. This literature synthesis demonstrates that PT is central to improving operational efficiency but lacks empirical validation in emerging markets. These gaps justify the present research, which aims to assess PT adoption, barriers, and its influence on container management and logistics efficiency at Karachi Port.

2.3.2 Port Infrastructure (PI)

Table 2.6: Conceptualization of Port Infrastructure (PI) in literature

Author	Definition
(Munim & Schramm, 2018; Yang & Ge, 2020)	Port infrastructure denotes the physical facilities and structures essential for the operation of a port, including terminals, berths, docks, storage yards, and other facilities. It also includes transportation connections for cargo from the port, such as roads, railways, and waterways.

(Wayne K Talley, 2017)	Port infrastructure discusses the physical facilities and structures necessary for port operations including terminals, berths, docks, storage yards, and other facilities. It also includes transportation connections for cargo from the port, such as roads, railways, and waterways. Channel length, width, depth, breakwater, and turning radius are also part of port infrastructure.
Mansouri, 2010	Port Infrastructure includes all long-term static capital investments (nautical entrance, locks, berths, gates, port authority buildings, etc.)
Acciaro et al. (2014)	Port infrastructure shows positive effects on port efficiency and is linked to global connectivity. Seaport infrastructure is assessed by the amount and quality of existing substructures (seawall, depth alongside, terminal area, gates).
Chu and Huang (2005)	The volume limit of a CT will be a lesser limit of its storage area, quayside, or entrance gates.
Clark, 2004	Inefficient ports also enhance handling charges, which is a component of shipping charges. Sequentially, factors describing variations in port efficiency contain undue regulations, incidents of organized crime, and the overall state of national infrastructure.

In their study, Suykens and Van de Voorde (1998) observed that a maritime container port infrastructure supports the socio-economic progress of the region. Suitable infrastructure is also essential for effective container management operations, to avoid overcrowding, improve trade growth, and achieve better connectivity for large container vessels. Appropriate port-hinterland connectivity is important to achieve the best results. Development of port-hinterland connectivity has gained importance due to the need to enhance throughput owing to increased containerized trade. Yet higher cost restricts the quick development of port infrastructure, which usually occurs in phases. Meanwhile the increased trade results in instances of congestion, even in developed countries.

Cullinane and Khanna (1999) found that container port activities are impacted by the frequency of ship visits of differing dimensions. Container ships above 15000 TEUs are now common but can only enter larger hub ports. Hence container movements converge on limited larger seaports, affecting berths, quay crane, yard crane and port-hinterland connectivity, causing congestion and ecological issues (Yap & Lam, 2013). In his study Baird (2006) stated that the likely growth of transshipment due to mega ships inspire container ports to manage larger throughput due to appropriate berth and yard infrastructure, thus becoming more reliable in container movements.

In their study, Tongzon and Heng (2005) found that usually, infrastructure is separated into bodily and soft essentials. Bodily structures comprise operational facilities like wharves, cranes, yard stowage areas, tugs, and road-rail linkage (Cidell, 2021). Soft structures denote the workforce involved. All-out placement of both kinds will help cut ship turnaround time, thus enhancing terminal stowage capacity. Growth in container ship size and capacity, is faster than the growth in port infrastructure and connectivity. In the absence of appropriate rail and road connectivity, the efficiency of container port operations is likely to deteriorate owing to congestion and unplanned operational interruptions.

In his study, Acciaro et al. (2014) stated that port infrastructure shows positive effects on port efficiency and is linked to the economic progress of the region and global connectivity. Seaport infrastructure is assessed by the amount and quality of existing substructures, such as seawall, depth alongside, terminal area, and gates (Lai, 2024). As per Wayne K Talley (2017), channel length, width, depth, breakwater, and turning radius are also included in port infrastructure. Chu and Huang (2005) analysed that the volume limit of a CT will be the lesser of its storage area, quayside, or entrance gates. Alavi et al. (2018) specified that the competitiveness of seaports vastly hinges on their working efficiency, particularly in logistic practices and supply chain linkages. As per the study by Song and Van Geenhuizen (2014), several authors have revealed that port infrastructure investment generally shows a positive effect on port efficiency. The examination has shown that the difference is linked to the attractiveness of the seaport, fiscal growth, worldwide connectivity, and the impact of contiguous areas. In another study by Suárez-Alemán et al. (2016), results reveal that drivers of port efficiency exhibited a rising tendency for port efficiency in emerging areas, as it improved from 51 to 61% between 2000 and 2010. The study also found that the enhanced shipping connectivity and the availability of road and rail transportation reduce dwell time and increase port efficiency in emerging areas.

Clark (2004) highlighted the significance of transport expenses and infrastructure to describe trade. Enhancing port efficiency from the 25th to 75th percentile decreases shipping costs by 12%. Inferior ports are comparable to being 60% farther away from markets. Inefficient ports also enhance handling charges, which are part of the shipping cost. Consecutively, factors describing variations in port efficiency involve unnecessary regulations, the occurrence of organized offenses, and general condition of the national infrastructure. Reduction in country inadequacies, related to transport charges, indicates an expansion in mutual trade. Salient dimensions are described below:

As per Dawn, 26 July 2024[4], in a meeting at Ministry of Maritime Affairs (MoMA), it was concluded that the infrastructure and lack of digitization were the key challenges at Karachi port.

[4] Dawn, 26 July 2024

Chairman KPT highlighted the critical problems at Karachi port, delayed container cargo clearance due to bottlenecks in the customs clearance process. Need to develop existing infrastructure to world standard, adopt digital solutions and automation to improve efficiency. To clear backlog of uncollected containers, leading to reduced port capacity, inefficient container movement, and congestion in the port. The need to improve communication and coordination by KPT with stakeholders to enhance performance. Simplification of regulatory procedures for smooth port operations cuts transaction time and cost. KPT's high operational costs related to CTs are to be reduced. Workforce issues must be resolved to improve productivity and operational efficiency.

Accessibility and Connectivity (AC) Accessibility is an important factor in the assessment of international containerized transportation systems. The output level in any container port is substantially correlated with its accessibility (T. Zhang et al., 2024). Usually, accessibility is gauged as the quality of nautical connections that join seaports, without considering the port's characteristics (Liu & Wang, 2023). Contrary to earlier studies, it also mentions internal accessibility of the port, combining the Liner Shipping Connectivity Index with factors like container ships' time at port, maximum berth depth, and number of containers per quay crane (QC) or per yard area, by studying Mediterranean container ports for throughput in the last decade (Fancello et al., 2023). The results can help identify the potential elements to improve container port accessibility and provide decision-makers the useful knowledge to implement management strategies. Future studies may explore additional indicators like road and/or rail, and inland water accessibility (Breuer et al., 2022)

Baştuğ et al. (2022), found that negligible consideration has been given to the accessibility of individual container ports related to the wider marine container transport system. A diverse valuation of port attractiveness comprising quantitative factors (like port prices, inland logistic charges, and relative efficiency estimations) with a formulated index estimating accessibility measures for individual container ports was therefore studied.

Container Berth (CB) The number of berths and their entire length is an indicator of port capacity, which is more pertinent to CTs. Dissimilar container ships with diverse numbers of containers reach ports, each container needing a single service. To ascertain the required number of container berths, a technique considering the container handling capacity per berth per year is adopted (Grubisic et al., 2020).

A leading planning problem in container transshipment operations is the berth allocation to vessels calling at the terminal regularly. The berth location is used as an important input to yard storage, employees, and equipment allocation plans (Kizilay & Eliiyi, 2021). The problem is further aggravated by deviations in the ship arrival time, leading to last-minute changes in resource planning and terminal operations. Port Managers handle this problem by keeping (capacity) cushion in their operative strategy and providing added resources if required (Notteboom et al., 2022). In his study Imai, (2001) found that, although the public berth system might not be appropriate for maximum container ports, it offers greater cost-effectiveness in Japanese seaports. The berth allocation to visiting ships is an important factor for effective public berthing. To attain an appropriate solution with minimum computational application, the author developed a heuristic procedure by conducting many computational tests, displaying that the suggested algorithm is adjustable to real-life applications. The study solved problems of 5, 7, and 10 berths, containing data on 25 and 50 ships, generating 6 prototype problems.

The problem of allocating berths to vessels in CTs is denoted as the berth allocation planning issue (Ursavas, 2022). Results exhibited that in a moderate load setting, the proposed berthing system can assign space to most of the visiting ships upon arrival, with most ships allocated the preferred berthing location (Kizilay & Eliiyi, 2021). The coastal berthing capability determines the globally accepted performance factor of a CT. The berthing capability governs the number and dimension of visiting ships, and the need for stowage space and available prime movers, etc (Günther, 2006). A restricting feature for many seaports is the accessibility of suitable berth space for container vessels. Because of the continued increase in the dimensions of container ships, added options for berth availability can benefit the port management. Berth length (in meters) is thus considered a key determinant of port efficiency (Imai, Sun et al. 2005). Carlo et al. (2015) found that the maximum depth at a container berth (in meters), determines the deepest draft ship that can be docked there. On the other hand, Xu et al. (2012) found that berth assignment to ships at a CT is constrained by water depth and tidal conditions (i.e., maximum vessel draft restriction).

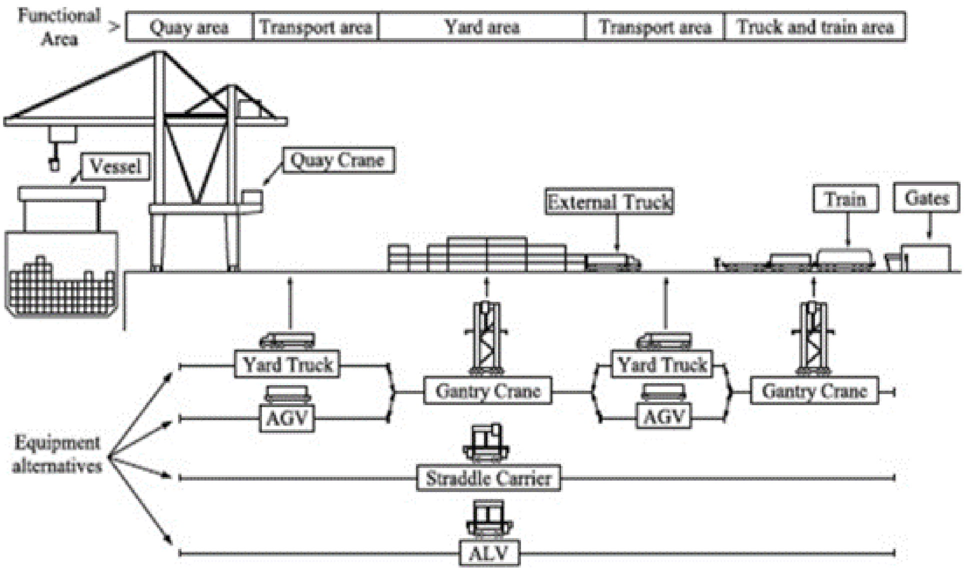
Container Yard (CY) As per UNCTAD (2016), a restricting aspect in several ports is the availability of land area for container management. A bigger terminal land area is important for being able to handle large container vessels carrying greater volumes of TEUs. In their study about the storage capacity of a CT, Günther and Kim (2006b) found that the highest container circulation that can be handled at a container yard in a particular situation is the terminal capacity. Chen et al. (2015) found that it is the capacity limit of a CT and will be the lesser limit of the terminal storage area, quayside, or entrance capacity of the seaport. The container yard is the key to coordinating several sub-systems in a CT. Effective allocation of yard space can have a critical effect on the production expense, output, and handling efficiency of CT (Luo & Wu, 2020). In the present era modern technology development, like artificial intelligence, big data, and more technologies are applied to ACTs, while digitization and automation are the unavoidable trends of yard management (Wang et al., 2019). In their study, Zaerpour et al. (2019) discussed a vertical storage capacity expansion tower for ports having land limitations. The storage towers up to 50 levels high will occupy less ground space.

For a port to compete in the global market, it is essential to improve yard management of ACTs, which can reduce energy consumption (Budiyanto et al., 2021), reduce production safety risks (Sahin & Soylu, 2020), conserve human resources (Caballini & Paolucci, 2020), and work more proficiently (Yue et al., 2021). Currently, the study on container yards is usually about traditional CTs (Günther & Kim, 2006a), and the research on ACT yards is still in the early stages. Many ACT management strategies are devised to improve yard space utilization and operational efficiency. The yard outline can be primarily bifurcated into two forms. One CY layout is perpendicular to the berth, whereas the other CY layout is parallel to the berth (Hu et al., 2016). Currently majority of the recently constructed ACT yards have implemented the perpendicular layout.

During CT operation, the container yard plays a central role in its wholesome performance, as it links the berth and hinterland, operating as a cushion to store containers (Yu et al., 2022). Whatever the kind of CT, yard management is always the key to coordinating various handling systems, which has a notable effect on the production charge, throughput, and handling efficiency of the terminal (Yu et al., 2022); (Raeesi, 2023). The problems of port operations have moved from the quayside to the yard area with the developments of quayside equipment and technologies in ACT (Wang, 2024). New technologies of the ACT have brought modifications in yard utilization, equipment process, and stacking means, hence offering better yard management (Kizilay, 2021). A well-designed yard planning considering equipment allocation is the best means to increase productivity (Nguyen, 2024). Operational planning to integrate stowage distribution and equipment assignment allocation is likewise a feasible step for yard management (Kizilay, 2021). Generally, the study on container yards is significant for the operational improvement of an ACT, but there is a need to clearly define the main management problems in the existing literature, for practical and theoretical analysis and classification of yard management (Yu et al., 2022).

Congestion Infrastructure is required for efficient freight operations (Holguín-Veras et al., 2018). Chinedum (2018) found that suitable infrastructure is required to avoid port congestion, short-term trade development, and ocean container liner connectivity. Suykens and Van de Voorde (1998) found that infrastructure is required to be accompanied by efficient hinterland transportation linkages if the seaport must use its abilities. It is difficult to develop port capacity and overcome congestion even in a modern terminal (Dowgiewicz, 2022). There is a requirement for a continuous and coordinated struggle to increase container capacity at terminals. CT operations are influenced by the frequency of ship visits and the growing change of increasing ship size (Pujats et al., 2024). Mega container ships of 16000 TEUs are becoming common, which can only proceed to hub ports (Jungen et al., 2021). Vessels are growing with increased container capacity (Huang et al., 2022). Inter-modality is vital for quick transportation. In the absence of connections, the efficiency of CT operations may be curtailed because of congestion and delays (Tongzon & Heng, 2005).

Figure 2.10: The container management process at a CT



Source: link.springers.com

Table 2.7: Compilation of Port Infrastructure (PI) in the literature

Port infrastructure (PI)				
Sr #	**Author (s)**	**Accessibility and Connectivity (PIAC)**	**Container Berth (PICB)**	**Container Yard (PICY)**
1.	Yang & Ge, 2020)	●		
2.	(Munim & Schramm, 2018	●		
3.	Mansouri, 2010	●		
4.	Clark, 2004	●		
5.	Cullinane and Khanna (1999)	●	●	●
6.	(Yap & Lam, 2013).	●	●	●
7.	Baird (2006)		●	●
8.	Tongzon and Heng (2005)	●	●	●
9.	Acciaro (2014)	●	●	●
10.	Talley (2017)	●		

11.	Chu and Huang (2005)	●	●	●
12.	Van Geenhuizen (2014)	●		
13.	Saurez-Aleman (2016)	●		
14.	Cherniaieva, 2023	●		
15.	Liu & Wang, 2023	●		
16.	Fancello et al., 2023	●		
17.	Zhang et al., 2024	●		
18.	Baştuğ et al. (2022)	●		
19.	W. Li et al., 2023	●		
20.	Steenken et al. (2004)	●	●	
21.	rmt2018		●	
22.	Merk2012		●	
23.	Cullinane2010		●	●
24.	Bichou2013		●	●
25.	Munisamy2011		●	
26.	Gamassa2017		●	●
27.	Wanke2011		●	●
28.	Zahran2017		●	
29.	Rubem2015		●	
30.	Ursavas, 2022		●	
31.	Hlali2018		●	●
32.	Liu 2008		●	
33.	Cullinane2006		●	●
34.	Park2015		●	●
35.	rajeshkar2018		●	
36.	ducruet2007		●	●
37.	kaisar2013		●	●
38.	kalgora2019		●	
39.	tongzon2001		●	
40.	beuren2016		●	
41.	naguyen 2018		●	
42.	Grubisic et al., 2020		●	
43.	Kizilay & Eliiyi, 2021		●	●
44.	Notteboom et al., 2022		●	●
45.	Imai, (2001)		●	
46.	Ursavas, 2022		●	
47.	Günther, 2006		●	●
48.	Imai, Sun et al 2005		●	
49.	Carlo et al. (2015)		●	
50.	Xu et al. (2012)		●	
51.	UNCTAD (2016)			●
52.	Luo & Wu, 2020			●
53.	Wang et al., 2019			●
54.	Zaerpour et al. (2019)			●
55.	Chen et al. (2015)			●
56.	Sahin & Soylu, 2020			●
57.	Yue et al., 2021			●
58.	Hu et al., 2016			●

59.	Yu et al., 2022			●
60.	Raeesi, 2023			●
61.	Nguyen, 2024			●
62.	Wang, 2024			●

Table 2.8: Port Infrastructure (PI) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual/ Simulation	Key Gaps Identified
PIAC	19	6	13	Most studies focus on connectivity; limited integration with berth/yard performance; and few smart/digital PI metrics
PICB	44	18	26	Predominantly conceptual/simulation; few empirical studies across multiple regions; limited holistic automation and equipment inclusion
PICY	21	7	14	Narrow variable sets; lacking operational connectivity integration; limited digital/ automation measures

Comments:

1. Most research is conceptual or simulation-based, highlighting a gap in empirical validation.
2. PIAC studies focus heavily on regional or hinterland connectivity; yard/berth performance is underexplored.
3. PICB/PICY studies often ignore digitalization, smart-port technologies, and operational relations with PIAC.
4. Integrated PI models among PIAC, PICB, and PICY dimensions are scarce.

Narrative Summary for Port Infrastructure (PI)

This analysis establishes Port Infrastructure (PI) as a core variable in the study, defining it through three key dimensions: Accessibility & Connectivity (PIAC), Container Berth (PICB), and Container Yard (PICY). The purpose of including PI is to quantify how physical capacity and bottlenecks directly impact container logistics performance at Karachi Port and to integrate infrastructure into a holistic performance model that interacts with managerial and operational practices. PI is highly relevant because it directly addresses Karachi Port's documented challenges, such as berth draft restrictions, yard congestion, and weak hinterland links. Its inclusion fills a critical gap in the literature, which lacks empirical studies on infrastructure in developing countries, contexts as South Asia. Key insights from the literature synthesis reveal that:

2.3.3 Port Equipment (PE)

Table 2.9: Conceptualization of Port Equipment (PE) in literature

Author	Definition
Steenken et al. (2004)	The equipment in CT helps in moving containers inside the terminal area. Key equipment in CT is the quay crane, yard gantry crane, straddle carrier, reach stacker, fork lifter, and yard truck.
Bichou (2014)	Port equipment refers to the machinery, tools, and devices used in port operations and activities for the handling, loading, unloading, and storage of cargo.
Nooramin et al. (2012)	Container lifting equipment exists in various forms like straddle carriers, reach stackers, forklifts, quay cranes, rail-mounted gantries, and rubber tire gantries, for the movement of containers at the terminals.
Rodrigue (2022) (Kizilay & Eliiyi, 2021)	A CT depends on a range of intermodal equipment for operations, including quay cranes, yard cranes, and straddle carriers. The choice of equipment and reliability is linked to investment, volume, stacking intensity, and productivity. Trend of ACTs has led to replacement of manual equipment.
Gharehgozli et al. (2016a)	Manual container handling cranes can be automated with the use of technology, to enhance productivity and reduce operational cost.
Iris and Lam (2019)	Automatic cranes/equipment enhance port efficiency and reduce cost.

In their research, Steenken et al. (2004) found that the equipment in CT helps in moving containers inside the terminal premises. Key equipment in CT is the quay crane, yard gantry crane, reach stacker, straddle carrier, fork lifter, and yard trucks. The main work of a CT is ship docking, disembarking/embarking containers, and their stowage in the yard area. In their study Nooramin et al. (2012) discovered that container elevating equipment is available in various forms such as straddle carriers, reach stackers, forklift trucks, empty container handlers, Quay cranes, rail mounted gantry cranes and rubber tire gantry cranes, for movement of containers at the terminals. The main job of a CT is to achieve ship docking, incoming container disembarkation, outgoing container embarkation, and stowage ability. Such goals can be attained by employing appropriate container-elevating equipment in the port (Cisternas, 2022). Rail-mounted gantry crane is more suitable for rigorous container handling due to its excessive use in the container stowage area. RMG cranes elevate huge cargoes with their composite cabling arrangement and strong gantry frame.

The rubber tire gantry crane is mobile and utilized for container elevating and piling in container stowage yards. In comparison to various yard equipment RTG is the most useful crane due to its mobility. In their study, Zeng and Yang (2009) stated that ship arrival and ship handling time are improved by integrated quayside operation models. For QCs allocated to high-priority ships, Meisel (2009) offered the idea of limited time brackets, combined in the scheduling problem. Iris et al. (2015) found that individual cranes will provide service to a specific ship in a specified period. Automatic cranes and container handling equipment enhance port efficiency. Gharehgozli et al. (2016a) specified that manual container handling cranes can be automated with the use of technology, to enhance productivity and reduce operational cost. In their research, Dinu et al. (2017) found that ship handling time was improved by integrated quayside operations. Iris and Lam (2019) in their study discovered that automatic cranes and equipment enhance port efficiency and help in the reduction of cost. The next step could be conversion to a smart port, though it may result in job reduction at the port. Salient dimensions are:

Quay Crane (QC) In his research Wayne K Talley (2017) stated that QC is also named STS, (ship to shore crane) which is a huge quay crane in container ports, used to embark and disembark containers to/from container vessels. QCs are usually categorized by their hoisting capability and the vessel size they can handle. For instance, a Panamax crane can serve vessels of 12 to 13 container rows, a post-Panamax crane can attend vessels equal to 18 rows and a Super-Post Panamax crane can handle vessels of 22 rows and above. In their work, Dejan et al. (2013) discovered that contemporary QCs with a hoisting capacity of two, 20-foot containers at a time will be valued at 65 tonnes. QCs capable of lifting six, 20-foot containers at a time are being studied.

In his study, Imai, (2008) found that QCs were among the main terminal equipment utilized to move containers. This indicates that inefficient QC service could become a choke point for quick ship handling operations. Therefore, a terminal is required to make available a maximum number of cranes to service a particular vessel. Yet, when there is a variation in ship calling rate, this turns out to be an expensive and uneconomical investment, as the cost of each crane is high. Hence, a competitive CT requires maximizing the operational efficiency of its smaller number of cranes.

In a CT, QCs are the key equipment engaged in the main events. As per the bottleneck principle, the output rate of QCs is associated with employee productivity and the employed yard trucks. The effective management of marine logistics operations at CTs increases the performance of international supply chains. A vital problem in CT operations is the planning of QCs, which is affected by the output rate of QCs. This output rate rests on the kind of task to be accomplished by QCs on a particular ship (Chargui et al., 2021b). QC is an important asset at a CT. If numerous ships dock concurrently with a CT, the QC Assignment Problem (QCAP) increases. The number of QCs to serve a ship concurrently is often limited by a minimum number (agreed among the ship and CT operator) and a technically permissible maximum number. The QC to ship task can be altered during the container handling process of a vessel (Meisel, 2009).

Rodrigue, (2022) found that a QC is dedicatedly utilized to embark and disembark cargo on container vessels and is available in various dimensions based on the vessel class they can assist. Whereas a Panamax crane can service vessels up to 13 across, a post-Panamax reaches up to 16 across. The modern QCs named Ultra Post Panamax can serve the modern 24,000 TEU containerships, that are 24 across. The newest cranes can lift over 150 tons of cargo at a time Most QCs can now perform twin lifts, whereas triple lifting in one move has also been tested for the new cranes.

Yard Crane (YC) In their research, Steenken et al. (2004) stated that a rubber Tire Gantry (RTG) is a portable crane utilized for piling containers inside the yard stowage areas or when maximum stowage concentration in the container stack is anticipated. Rail-mounted Gantry (RMG) moves on rails to handle a 20 or 40-foot container in the yard area. The container is elevated by a spreader equipped with wires. These are intended for exhaustive container piling because of automation. Compared to RTG, the RMG is more rewarding as it is electrically powered, pollution-free, low noise, can handle bigger volumes, and enjoys faster freight transfer ability.

Energy efficiency in ports is mainly related to investments in modern equipment. Port activities are categorized by the number of moves of the terminal container handling equipment, which consists of RTG cranes, reach stackers, yard trucks, and forklifts, and this procedure is quite energy (fuel) intensive. The main possibility to reduce costs and emissions in seaports is the usage of electrical energy instead of diesel in RTG cranes. Diesel-driven RTG cranes are commonly used in most world seaports and consume considerable fuel. The diesel-powered RTG crane has the advantage of moving freely through the CT as needed by everyday port operations. Electrification of RTG cranes offers improved performance compared to diesel-fuelled RTG, saving around 82% energy, cutting 50% noise, and reducing CO2 emissions. The payback time on investment for the conversion of diesel-driven RTG into electric is about 2.5 years.

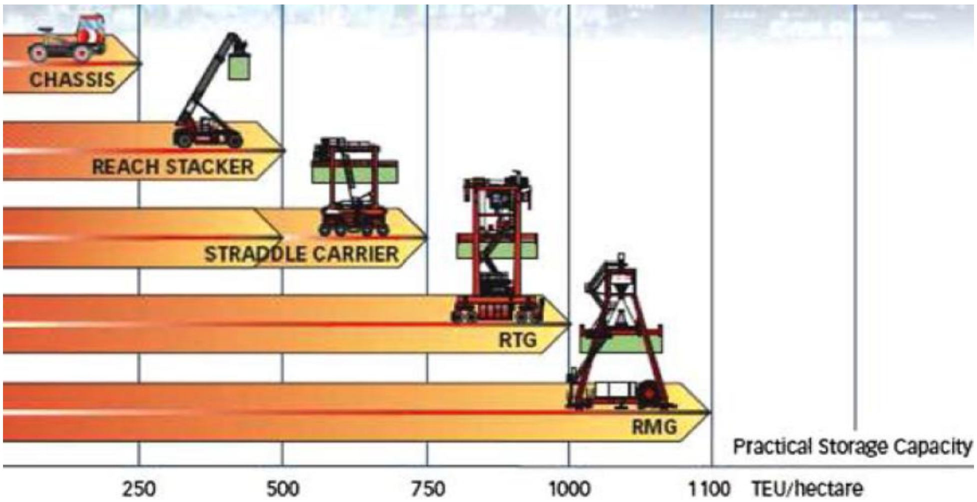
Existing ports require significant alteration, and the cost of grid and rail for the installation of electrified RTG cranes. As per Ding (2021), governments must frame apt regulations or offer incentives to inspire terminal operators to electrify existing RTGs and other handling equipment. In his research, Rodrigue (2022) found that RTG is an important intermodal equipment used for embarking and disembarking from trucks and rail terminals. RTGs can work across four rail tracks or six container rows and can manage to stack up to 1,000 TEU per hectare. It can serve up to 9 trucks per hour, which includes 30 to 40 container moves due to container reshuffling within their stacks. RTGs are costly but have lower working costs and are suitable for normal container yard operations. As per Rodrigues (2022), a Rail-mounted gantry (RMG) is a fixed intermodal equipment that is commonly used for intermodal operations across 6 to 10 rail tracks, or 8 to 12 containers. Whereas these are usually used at CTs for operations across huge container stacks, a novel intermodal rail terminal progressively relies on RMGs for intermodal operations across a sequence of rail tracks.

Equipment Reliability (RB) Forecast of non-operational time and lifespan data for QCs and YCs in CT is critical to determine scheduled maintenance plans (Meric, 2024). The enhanced international container trade has led to the development of large hub ports, endeavouring to achieve efficient container management to minimise ship turnaround times. The two main challenges of seaports are customer satisfaction by moving containers efficiently and managing the growing demand without the expenses of infrastructure or equipment. Important seaport equipment, i.e., QC, needs to be reliable, which performs as the ship-berth interface (Cisternas, 2022).

Most studies about port operations emphasise the operation of ships and the quay (Kizilay & Eliiyi, 2021). Results show that handling equipment must be assigned to the berth, with a focus on operational planning and reliability (Soriguera et al., 2006). The reliability of seaport equipment is vital for port logistics efficiency (Q. Li et al., 2022) (Kammoun & Abdennadher, 2022). The reliable performance of port equipment, such as quay cranes (QC), rubber-tyred gantry (RTG) cranes, and yard trucks (YT), is important to maintain efficient port operations and to curtail cargo delays (Canbulat, 2021). Equipment breakdowns can interrupt terminal activities, increase functioning rates, and negatively impact a port's service status and effectiveness (Ohagwu, 2024). Moreover, freight firms are interested in utilizing ports that show enhanced equipment readiness and service reliability (Baştuğ et al., 2022).

Numerous variables influence the reliability of port equipment, involving maintenance attitudes, equipment age, ecological disclosure and the operators competence (Chuah et al., 2023). Moreover, the proficiency of equipment operators plays a key role, as inexperienced workers can quicken wear, leading to repeated interruptions (Kiogora, 2023). Automation decreases human faults and increases operational strength but also claims superior redundancy and strong cyber protection arrangements (Anayat, 2024). Malfunctions in automated systems can result in added problems, emphasizing the significance of sophisticated protective approaches (Xu et al., 2024). Excessive investment expenses for digitized observation solutions, challenges aligning former equipment with contemporary technologies, confrontation to transformation amongst port workers, and dearth of homogeneity among equipment producers are common challenges (Brunila et al., 2021; Norheim, 2024). To ensure balanced container port equipment reliability needs strategic planning, cooperation amongst shareholders, and fiscal agreement (Song, 2021; O'Connor, 2023).

Other Yard Equipment Czermański et al. (2021) stated that yard equipment like yard truck, reach stackers, straddle carriers, RTGs, RMGs, forklifters, help container management in CT. The selection of equipment and its combination is linked to numerous factors like investment, capacity, stacking concentration, and throughput. Important yard equipment is shown at Figure 2.8.



Source: (Stahlbock & Voß, 2008b).

Figure 2.11: Important container yard equipment and its stacking capacity.

Table 2.10: Compilation of Port Equipment (PE) in literature

Port Equipment (PE)				
Sr. #	**Author (s)**	**Quay Crane (PEQC)**	**Yard Crane (PEYC)**	**Equipment Reliability (PERB)**
1.	Nyema2014	●		
2.	Merk2012	●	●	
3.	Cullinane2010	●		●
4.	Munisamy2011	●	●	
5.	Kammoun2018		●	
6.	Sharma2009	●		●
7.	Gamassa2017	●		
8.	Zahran2017			●
9.	Cullinane2006	●	●	●
10.	Park2015		●	
11.	Bichou2014	●	●	●
12.	Nooramin. (2012)	●	●	
13.	Kizilay & Eliiyi, 2021	●	●	●
14.	Gharehgozli. (2016)	●	●	

15.	Iris and Lam (2019	●	●	
16.	rajeshkar2018	●	●	●
17.	Fancello et al., 2023	●		
18.	Kalgora2019	●		
19.	Tongzon2001	●		
20.	Vacca2007	●	●	
21.	Naguyen 2018			●
22.	Meric, 2024			●
23.	Kizilay & Eliiyi, 2021			●
24.	Soriguera et al., 2006			●
25.	Cisternas, 2022			●
26.	Q. Li 2022			●
27.	Kammoun & Abdennadher, 2022			●
28.	(Zaoudi et al., 2023	●	●	
29.	Iris and Lam (2019)	●	●	
30.	Steenken et al. (2004)	●	●	

Source: From Literature

Table 2.11: Port Equipment (PE) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual/ Simulation	Key Gaps Identified
PEQC	14	6	8	Focused on quay crane; limited integration with yard cranes & reliability; mostly Europe or simulation-based; lacks Pakistan-specific data
PEYC	12	5	7	Yard crane performance studied separately; limited combination with quay crane & reliability; context-specific studies
PERB	5	2	3	Mostly conceptual/simulation; limited field measurements; reliability often isolated from crane performance

Comments:

1. Many studies focus on one or two PE dimensions, rather than the full construct (PEQC + PEYC + PERB).
2. Many studies are simulation-based or conceptual, with limited empirical validation in operational ports, especially in developing countries.
3. There is a clear gap in empirical studies integrating all three dimensions in real operational contexts, such as Karachi Port.
4. Older studies (e.g., Steenken 2004; Tongzon 2001) lack modern digital/automation contexts.

Narrative Summary for Port Equipment (PE)

The purpose of reviewing Port Equipment (PE) literature is to consolidate evidence on how quay cranes (PEQC), yard cranes (PEYC), and equipment reliability (PERB) impact port logistics efficiency, particularly in terms of vessel turnaround time and container handling. Key insights reveal that quay cranes are the most critical factor for ship-to-shore productivity, yard cranes are essential for smooth container flow in the yard, and equipment reliability is a major factor in preventing operational bottlenecks. This research is directly relevant to the study of Karachi Port, as it addresses a significant gap in the existing literature, which is heavily focused on advanced ports and simulation models. The review justifies the present study by highlighting the lack of empirical evidence on the combined impact of these equipment dimensions and the unique equipment challenges, such as maintenance deficiencies and aging fleets, faced by developing-country ports like Karachi.

2.3.4 Port Human Resources (PHR)

In their study, Phan et al. (2021) found that the main aim of port administration is human resource development (HRD) to further develop port service quality and logistic procedures (Q. Li et al., 2022). In his research, Ball (2017) found that care needs to be taken from the enrolment stage to select apt persons with qualities and capacity to learn and develop skills at the container port in a multi-tasking environment. Meletiou (2006) identified important dimensions of HR as the worker's skill, obligation and faithfulness, training and education, and workers' productivity per TEU. In his work, Thai (2012) discovered that skilled, trained, and educated HR can perform better in CT, as they can learn and operate modern equipment and complex processes efficiently.

Autsadee et al. (2023) found that HR Development (HRD) is an essential issue at CTs which affects its performance. Improvement of the HR in handling equipment is vital as they play a key role in determining port productivity. Nearly, 80% of training schemes for fresh employees the on-the-job training, while for others the training system comprises theory and practice of using the equipment. About 20 employees handle one QC at the berth to embark and disembark containers. In that about 15 employees operate loading/unloading equipment, while the rest oversee the employees (Burgstahler, 2023). The calculation of required employees at the seaport to achieve the best possible embarkation and disembarkation can be used from the expected number of employees per gang and the number of berths times the number of QCs.

As per Dawn, 26 July 2024[5] Chairman KPT highlighted the critical problems at Karachi port, including clearing the backlog of uncollected containers, leading to reduced port capacity, inefficient container movement, and port congestion. The need to improve communication and coordination by KPT with stakeholders to enhance performance was also stressed. Workforce issues must be resolved to improve productivity and operational efficiency. Safa (2017) found that effective HR management brings skill, talent, and productivity to the seaport. Talent acquisition challenges and professional training to align strategic HR with enduring targets of seaport operation and management. Port managers can influence their HR by concentrating on opportunities and solutions.

Table 2.12: Conceptualization of Port Human Resource (HR) in Literature

Author	Definition
Popoola et al. (2024) Tongzon, (1994) Slack and Frémont (2005) Marlow and Casaca (2003)	The workforce employed in various roles and functions within a port includes administrative, operational, and managerial positions.
Legato & Monaco, (2004)	Employee performance is the mainstay of CT output and efficiency. CT managers directly impact CT performance and productivity as they strategize the use of resources.
Boardman et al. (2017); (CTAD, 2018)	The HR employed at the port is also measured for cost and benefit analysis.

As per Deresky (2017), ports, being big organizations with large numbers of employees, need appropriate handling of their human capital. Buchanan and Huczynski (2019) found that the culture of communication and consultation by managers with stakeholders before making important decisions can enhance the level of employee motivation, creativity, and loyalty. Sun et al. (2015) found that the periodic review meetings, assessment cycles, and provision of feedback for remedial actions also keep the employees satisfied. A robust retention policy may be important to curtail turnover intention. As per Boardman et al. (2017), the HR employed at the port is also measured for cost and benefit analysis. For example, tons of freight per employee, revenue collected per employee, labour costs per employee, training costs, and wages (CTAD, 2018). During various visits to KPT and Karachi Port between 2019 to 2023, it was observed that the norm to refer to workers in the decision-making process did not happen in KPT, and the managers did not usually consult employees before making key decisions. This showed a lack of manager and workers' connection and reliability.

[5] Dawn, 26 July 2024

Sony and Naik (2020) argued that organizational effectiveness is attained through the integrated improvement of both social and technical systems, mainly relevant to the marine industry, where the integration of automation technologies intersects with complex human factors. Hence, the role and skill of port managers are vital for the efficient working of the CT. As per Popoola et al. (2024); and Baum-Talmor and Kitada (2022), the integration of automated systems in port operations has substantially improved operational efficiency, reduced human error, and enhanced safety. The study offers the positive implications of automation, arguing that it permits a more streamlined workflow and improved resource allocation. However, the study also acknowledges the complexities inherent in this technological transition, particularly its implications for workforce training and management. Salient HR dimensions are:

Employee Reliability (PHRER) Dunn (2024) found that facets persuading port workers' obligation and faithfulness contain age and gender. Roh et al. (2025) found that a port worker's commitment and reliability are generally linked to a progressive container port and good management. The study proposes that managers may also apply some influence on the commitment and reliability of their employees, which might subsequently influence the container port's working (Susanto et al., 2024).

Arvis, Ulybina, et al. (2024) found that the majority of World Bank KPIs for container ports concentrate on the areas of reliability, quality, and time goods. Hui et al. (2019) found that constant employee engagement can be a challenge when extending or applying organizational transformation in ports. Boakye (2024) found that a top-down management approach reinforced by robust leadership and persistent communication helps achieve effective change management (Rousseau & Ten Have, 2022). Communication can help improve bonding between port management for workers' engagement and reliability (Yinusa & Ogoun, 2024).

In their research, Rios and Maçada (2006) found that the average TEUs handled by an employee per year (total TEUs moved divided by the number of employees) converted to financial effect when compared to the cost incurred on an individual's wages and training. HR pricing could be useful for CT managers to evaluate the expected expense compared to output. The expense on port employees would also be the expense incurred for the output. Wayne K Talley (2017), while comparing two container ports of different capacities, found that the estimated expense on employees (supervisory, administrative, operators, upkeep, and services) for the bigger container port was less, mainly for the upkeep of container moving equipment and container movements. The working price per TEU for the expense of employees and the time spent on a TEU would also be assigned to the container. As per Legato & Monaco, 2004, managers inside CTs have a direct impact on CT performance and productivity as they strategize and achieve the resources used.

Training and Education (PHRTE) Meletiou (2006) in his research found that due care is needed at the time of induction to select apt individuals, with appropriate education and ability. Diverse technology, processes, infrastructure, communication, transportation, and IT require educated employees with growth capacity. As per Legato & Monaco, 2004, the best choice, division, and training of workers at CTs play a critical role in attaining a high level of output at CTs. Yang et al. (2009) found that in the last few decades, the container port industry has looked at innovation in technology to promote automation, improve throughput, and reduce reliance on human involvement. Othman, El Gazzar, et al. (2022) found that the development of HR includes improvement in quality of education and training skills. The training for safety, security, maritime environment, lifting equipment, cargo coordinator, planner, employees, and health safety can help adapt sustainable smart ports. As per UNCTAD (2023) the port managers must receive dedicated training to improve their knowledge and leadership skills, for driving digital and decarbonization transformations.

Safa et al. (2018) found that efficient HR management brings skill, ability, and productivity to seaports. Management at modern ports faces unique challenges to obtain quality intake and ensure their professional training, aligns with the strategic objectives of port operations. Port managers can best influence their HR by concentrating on their professional training and education needs. Robust training is needed to meet novel and complex demands for skilled workers. Ngoc and Tien (2023) found that the present era has a trend of automation, data exchange, and adoption of technology to increase productivity. Automation is replacing manual labour at seaports and is slowly splitting the job market into low-tech and high-tech fragments (Brynjolfsson et al., 2008). Hence, CT employees need to be furnished with knowledge, education, and skills to meet the market needs (Grant, 1996); (Fernando & Wickramasinghe, 2024; Mahoney & Kor, 2015). As container ports are being continuously modernized with automated equipment and processes, more skilled managers and workers are essential. Unskilled employees are at risk of losing their jobs (Ahmad & Zamir, 2018; Esser et al., 2020).

Bennett and Graham (2019) argued for a re-evaluation of maritime education and training curricula to include advanced automation systems management, cyber security, and remote operation skills. In their study, Mallam, Nazir, and Sharma (2020) claimed that port workers perceive the impact of automation on job security, work satisfaction, and team dynamics. Their findings suggest that while automation can enhance operational efficiency and safety, it also raises concerns about reduced human oversight, potential job losses, and the erosion of team cohesion. The study calls for measures to address these concerns, including transparent communication strategies, employee's involvement in automation transition process, and creation of support systems for affected workers. Moros-Daza and Jubiz-Diaz (2024) found that the impact of automation on maritime workforce is intense and multifaceted. they also explored the socio-economic implications of automation, highlighting a shift in the skill sets required from maritime workers. With prevalent automation, there is a growing demand for technical skills to manage and maintain automated systems, at the expense of traditional maritime skills (Sharma, 2023). The transition towards developing technologies pose significant challenges for workforce management, necessitating strategic planning to mitigate the risks of job displacement and skills obsolescence (Emma, 2024).

A substantial worry of port stakeholders is whether existing training is enough to groom and develop the required skills of the potential port workforce (Agbaba, 2020; Esser et al., 2020). Upcoming studies ought to concentrate on developing innovative and right training and education programs corresponding to the requirements of the industry. These vigorous programs must cater to technological and soft skills to train potential experts to manage unique conditions and challenges (Bottalico, 2021). These skills involve business assessment, port operation/administration, maritime law, innovation, communication, joint effort, leadership, critical reasoning, and problem-solving (Nalupa, 2022). Baraza (2021) found that there is a positive relationship between HR performance and port logistic efficiency. Q. Li et al. (2022) discovered that a positive and significant relationship exists among HR performance, port logistics integration and port performance. Othman, El Gazzar, et al. (2022) revealed that skilled, trained, and educated HR contributes to refining port performance.

Table 2.13: Compilation of Port Human Resource (HR) in Literature

Human Resource (HR)			
S #	Author (s)	Training and Education (PHRTE)	Employee Reliability (PHRER)
1.	ha2017	●	
2.	Mwendapole, 2021		●
3.	KESİKTAŞ, 2021		●
4.	Popoola 2024		●
5.	Slack and Frémont (2005)		●
6.	Brown 2011		●
7.	Kruk and Donner 2009		●
8.	Hui 2019		●
9.	Wayne K Talley 2017		●
10.	Rios and Maçada (2006)		●
11.	Legato & Monaco, 2004	●	●
12.	Meletiou (2006)	●	

13.	Yang et al. (2009)	●	
14.	Safa et al. (2018)	●	
15.	Esser et al., 2020	●	
16.	Sharma, 2023	●	
17.	Nalupa, 2022	●	
18.	Q. Li 2022	●	
19.	Othman, El Gazzar 2022	●	
20.	Bottalico, 2021	●	
21.	Ridwan & Pambudi, 2023	●	
22.	Steenken et al. (2004)	●	
23.	Baraza (2021)	●	
24.	Agbaba, 2022	●	
25.	Bennett and Graham (2019)		●
26.	Mallam, Nazir, and Sharma (2020)		●
27.	Moros-Daza and Jubiz-Diaz (2024)		●
28.	(Emma, 2024)	●	
29.	UNCTAD (2023)	●	
30.	(Fernando & Wickramasinghe, 2024	●	●
31.	Mahoney & Kor, 2015)	●	
32.	Ahmad & Zamir, 2018	●	
33.	Dunn (2024)		●
34.	Roh et al. (2025).		●
35.	(Susanto et al., 2024)		●
36.	Arvis, Ulybina, et al. (2024)		●
37.	Boakye (2024)	●	●
38.	(Rousseau & Ten Have, 2022).		●
39.	(Yinusa & Ogoun, 2024)		●
40.	Ngoc and Tien (2023)	●	
41.	(Brynjolfsson et al., 2008)	●	
42.	(Grant, 1996)	●	
43.	Phan et al. (2021)	●	●
44.	Ball (2017)		●
45.	Thai (2012)	●	●
46.	Autsadee et al. (2023)		●
47.	(Burgstahler, 2023).	●	
48.	Buchanan and Huczynski (2019)	●	
49.	Deresky (2017)		●
50.	Boardman et al. (2017)		●
51.	Sun et al. (2015)	●	●
52.	Sony and Naik (2020)	●	
53.	Baum-Talmor and Kitada (2022	●	
54.	Tongzon, (1994)	●	
55.	Dawn, 26 July 2024	●	●
56.	Marlow and Casaca (2003)		●
57.	(CTAD, 2018)	●	●

Source: based on literature

Table 2.14: Port Human Resources (PHR) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual/ Other	Key Gaps Identified
PHRTE	6	2	4	Most studies are conceptual or geographically limited; lack integration with port logistics/ technology; no Pakistan-specific evidence
PHRER	6	3	3	Limited operational measurement; mostly developed country contexts; lack of Karachi Port data
Combined PHRTE + PHRER	4	1	3	Minimal empirical studies integrating both training and reliability; no testing in Pakistan ports

Comments:

1. Training & Education is often studied separately from Employee Reliability, though the combined effects are important for port operational efficiency.
2. Many studies are conceptual or limited in scope; only a few provide field-based empirical evidence.
3. There is a significant gap in Pakistan-specific empirical studies, especially in integrating HR constructs with port technology and logistics efficiency.

Narrative Summary for Port Human Resources (PHR)

This review synthesizes literature on Port Human Resources (PHR) to establish its role in port logistics efficiency, focusing on two dimensions: Training & Education (PHRTE) and Employee Reliability (PHRER). The analysis reveals a clear consensus: training improves operational competence and technology adoption, while reliability reduces errors and ensures workflow continuity. However, the review identifies critical gaps that justify the present study. Existing research is predominantly focused on developed economies and lacks quantitative analysis on how HR interacts with other factors like technology and infrastructure. Therefore, this study aims to fill these gaps by providing an empirical, Karachi-specific assessment of how human resource capabilities collectively impact port performance, offering actionable insights for the local workforce and policy development.

2.3.5 Port Services (PS)

Flor and Defilippi (2003) found that seaport services indicate the value of port amenities, and allow their comparison with other ports. Branch (2008) stated that advanced seaports need to satisfy their customers' requirements through reliability of services, safety, use of IT in processes, and prompt response to clients. Other significant features of service dependability are equipment availability, receptiveness to client needs, occurrence of container damage, security, service postponement, and vessel waiting period CS. In his research, Yeo et al. (2015) stated that service indicators gauge the value of amenities offered to clients, such as vessel proprietors, shipping lines, terminal operators, and transporters. UNCTAD (2012) has stated that the prime customers of a container port are the shipping liners and alliances. They see the value of the facility offered to them as; total charges per port call and the period of stay at port.

Table 2.15: Conceptualization of Port Services (PS) in literature

Author	Definition
Yeo (2015)	Seaport services can be described as the range of activities and functions carried out within a seaport to simplify the exchange of cargo and services among waterfront and land spaces.
Bichou and Gray (2005)	Port services can be defined as the range of activities and functions carried out within a seaport to enable the interchange of cargo and services involving maritime and land spaces.
Thai (2016)	Service quality reflects the general performance offered to clients in port premises.
Wayne K Talley (2017)	Port services may also include vessel tie-up, container handling, stowage, shifting, ship repair, and dry dock.

In their work, Dooms et al. (2019) found that progressive ports need to fulfil their client's needs and expectations. As per Thai (2016), service quality reflects the general performance offered to clients on port premises. Swee et al. (2019) stated that the seaport service quality primarily touches on customer satisfaction, faithfulness, and reputation. In his work on service quality management, Yeo et al. (2015) described that consistency of service quality, cargo safety, and security, use of IT in operations, swift reply to port client queries, and better service performance are considered important for service quality management. In another study, Wayne K Talley (2017) stated that port services may also include vessel tie-up, container handling, stowage, shifting, ship repair and dry dock. Chang and Thai (2016) deduced the result that service quality along with port facilities can enhance customer satisfaction. In his research Ha et al. (2017) concluded that the university-government-industry linkage can help further improve port efficiency by using their input for common objectives. Pakistani ports could gain from the Chinese experience of providing port services to a variety of ships. Dimensions of port services are described below:

Service Reliability (PSSR) In the study by Hemalatha et al. (2018) it was learned that the worth of services being given is consistently measured to improve service quality. The excellence of offered facilities in a container port is noteworthy for creating interest for fresh clients and retaining the current ones. A vital aspect of service reliability is the readiness of equipment or machinery to facilitate the visiting ship for the container management activity at the terminal as per the agreed schedule. Ensuring the placement of the required equipment at the port may be a prime responsibility of the port operations manager. UNCLAD (2016) concluded that the ship waiting time phase is envisioned from the time of the preliminary process at the seaport to the time of achievement of the berthing process, before commencing cargo operation. In their study regarding cargo safety Brooks and Schellinck (2015) concluded that seaport managers wanting to facilitate the requirements of valuable freight proprietors must consider the aspects of the seaport's customer service delivery, being of grave significance. Seaports and ships are exposed to greater risks due to fast-changing situations and increased trade (Notteboom & Siu Lee Lam, 2014). There has been a rise in incidents of natural calamities (Botta & Koźluk, 2014; EMDAT, 2015). Financial loss linked to such calamities has enhanced (EMDAT, 2015). Maritime segments are more susceptible to economic loss due to earthquakes; tsunamis, hurricanes, cyclones and floods (Goda & Song, 2016). Nguyen and Tran (2019) found that unreliability of the seaport services results in the dissatisfaction of the customers; this is because any failure in the seaport operation results in disruption of freight movement and logistics processes.

Custom Clearance (PSCC) The influence on operations of the customs clearance process at seaports and carriage is well recognized Branch (2013)(Clark, Dollar, and Micco 2004), and a key benefit of the dry port is the possible accumulation of containers and custom check is outside the marine port (Roso 2008). The dry port was defined as an Inland Clearance Depot, (UNECE 1998) particularly containing customs check facilities. The service areas are described as internal intermodal terminals devoted to the movement and stowage of containers in custom shipment. There is a growing cognizance about the importance of customs check period efficiency to help international trade. The import clearance procedures commence much before the ship arrives and are thus not linked to dwell time. Hence, containership arrival is not firmly linked to cargo dwell time. Thus far, most paperwork is still done after the ship arrives in several developing ports despite trade simplification (UNCTAD, 2003). Clark and Bernard (2022) found that improvement in the efficiency of customs services by avoiding duplication of clearance procedures and by increasing cooperation among stakeholders can contribute to smoothen the trade process, particularly in developing countries.

Customs inspection and container dwell time are deeply related. Transport logistics and customs service in global communication obtains extraordinary importance in the prevailing situation (Prokudin et al., 2022). Custom clearance facility must be offered necessary support to accomplish its legal obligations for trade facilitation and collection of import tax with ease (Mogbojuri, 2020). All the objects imported in a country must be Custom cleared. Goods are exported and imported from one country to another through supply chain. Transportation and shipping of cargo occur via land routes, air, and water. Yet, to ensure a comprehensive lawful and moral cargo shipment, custom clearance is essential (Gupta et al., 2023). As per (Matsudaira, 2022), the digitization of Customs processes lead to time and cost savings due to reduced need to prepare, handle, store and deliver customs. It also cuts dwell time and enhances customer satisfaction.

During visits to Karachi port, it was learned that many non-customs-cleared containers were lying abandoned at various CTs. This affects service reliability and customer satisfaction and questions the customs clearance process. Shah (2021) stated that thousands of empty and laden containers lay abandoned in the CTs, where ground slots and space were occupied by them, generating inefficiencies by increasing congestion and dwell time. The newspaper Nation reported on 3 March 2023, that several containers (6000-8000 TEUs) are stranded in Karachi port for years, due to non-custom clearance, thus occupying precious port stowage space. The disposal of stranded containers is pending due to the incompetence of customs and KPT management (Manager KGTL, 2023). Shah (2021) argued that abandoned containers lying at the terminals raise the question of why they should be retained when customs regulations agree to the auction of uncleared cargo at the terminal after 20 days, which can even generate revenue for customs. About 1,500 laden containers have been stranded at KICT since 2014, and 3600 containers at PICT and SAPT await auction. Yet the customs and KPT management appear to disregard the problem, showing a lack of strategic capabilities, strategic direction, and management skills.

Container Dwell Time (PSDT) Rodrigue and Notteboom (2009) in their study stated that the container dwell (or residing) period is calculated in days for which the container stays in the yard stowage area of the port upon disembarkation from a ship, and is regarded as an important standard of a CT's efficiency. It significantly affects the managing capability of a CT. Dwell period is inversely related to yard capacity. For example, if the average dwell period is curtailed from 11 to 10 days, the yearly storage ability will be enhanced by 10%. Usually, the dwell periods span between 4 to 7 days contingent on the seaport, whether the container is incoming or outgoing from the port. In their research, Mandal et al. (2016) defined dwell time as the usual period (in days) a container spends in the yard of a port.

De Armas Jacomino et al. (2021) found that ideal stacking of import containers in a terminal reduces the reshuffles during unloading operations, thus reducing idle crane moves, operation time, and fuel use. The crane traveling distance is also important (Zhen et al., 2013). Containers are kept in stacks to save storage space. Only containers at the top are accessible by yard cranes, while others cause a reshuffle. Dwell time of a container is measured in days, it will stay in yard (Maldonado et al., 2019). Mostly, the actual dwell time is unknown, and CT operators estimate it through expertise or algorithms (Kim & Yi, 2021; Kourounioti & Polydoropoulou, 2017; Luo et al., 2011).

Aminatou et al. (2018) in their study found dwell time as the usual extent of period a container passes at a container yard. Curtailing dwell periods is vital for a port because it enhances transport efficiency and cuts expenses. Container dwell time is a worthy dimension in evaluating the operational efficiency of a CT. It is, however, not frequently used for international benchmarking, like ship turnaround time, productivity, etc. About 3 to 4 days denote the average dwell time (Gordon, 2003). In terminal operations, there exists a straight association between dwell time and yard occupancy. There is a requirement to assess the standard dwell time, beyond which the efficiency of the CT is undesirable. It is customary to have a free duration in which a container could stay in a yard without demurrage charges (Huynh, 2006). From a transportation viewpoint, CTs are just an intermodal node in international transportation chains. (UNCTAD, 2003). In 2015, Singapore port's dwell period was 1.5 days, whereas for Indonesia it was 3.5 days (Syafaaruddin, 2015).

Customer Satisfaction (PSCS) Failure or unavailability of seaport services can meaningfully impact port clientele, shipping companies, and cargo proprietors, and outcome in their discontent. Port service quality is a five-factor construct, and its management, image, and social responsibility factors have a noteworthy positive impact on customer satisfaction (Yeo, 2015); (Karakasnaki et al., 2023). The unreliability of seaport services can affect seaport clients due to their discontentment (Jiang & Panichakarn, 2024). found that seaport administrators must gauge client satisfaction and validate funds to ensure excellence in seaport services (Haris et al., 2023); Lai et al. (1995). Nguyen and Tran (2019) found that unreliability of the seaport services results in the dissatisfaction of the customers; this is because any failure in the seaport operation results in disruption of freight movement, dwell time, and logistics processes.

The primary challenge faced by firms nowadays is how to attract new customers and retain existing ones. The difference between customer expectations about the performance of the company and customer assessments of actual performance provides a customer perception of service quality.

This difference arises due to a gap between customer expectations and reality of the service received. This gap exists as a result of not fulfilling customer expectations (Budiana et al., 2023).

Table 2.16: Compilation of Port Services (PS) in literature

Port Services (PS)					
S #	Author (s)	Dwell Time (PSDT)	Custom Clearance (PSCC)	Service Reliability (PSSR)	Customer Satisfaction (PSCS)
1.	Dooms 2019				●
2.	Branch (2008)			●	●
3.	Nyema2014	●			
4.	rmt2018	●			
5.	Swee 2019				●
6.	Liu2008				●
7.	Branch (2008)			●	●
8.	ha2017	●		●	●
9.	Nguyen and Tran 2019			●	●
10.	Brooks and Schellinck 2015			●	
11.	Branch (2013)		●		
12.	Chang and Thai (2016)				●
13.	Roso 2008		●		
14.	Prokudin 2022	●	●		
15.	Mogbojuri, 2020		●		
16.	Matsudaira, 2022	●			
17.	Gupta 2023	●			
18.	De Armas Jacomino 2021	●			
19.	Kim & Yi, 2021	●			
20.	Maldonado 2019	●			
21.	Kourounioti & Polydoropoulou, 2017	●			
22.	Hemalatha 2018			●	
23.	Clark & Bernard, 2022		●		
24.	Prokudin, 2022	●	●		
25.	Mogbojuri, 2020		●		
26.	Gupta et al., 2023		●		
27.	Matsudaira, 2022	●	●		●
28.	Syafaaruddin, 2015	●	●	●	●
29.	Haris et al., 2023				●
30.	Nguyen and Tran (2019)	●		●	●
31.	Jiang & Panichakarn, 2024			●	●
32.	Karakasnaki et al., 2023			●	●
33.	Budiana 2023				●
34.	Steenken et al. (2004)	●	●		●
35.	Orieno et al., 2024	●			
36.	Zając et al., 2023	●			
37.	UNCTAD (2011)			●	

Table 2.17: Port Services (PS) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual/ Other	Key Gaps Identified
PSDT	5	3	2	Often studied separately, integration with other service dimensions is lacking; limited Pakistan-specific evidence
PSCC	4	2	2	Few empirical studies, mostly regional, lack container-specific analysis
PSSR	5	3	2	Focus on general service reliability; limited linkage with container operations and customer satisfaction in emerging ports
PSCS	5	3	2	Customer satisfaction is often isolated; insufficient empirical testing in Pakistan ports
Combined PS Dimensions	4	2	2	Multi-dimensional analysis exists, but is region-specific; empirical validation is needed for Karachi Port

Comments:

1. Service dimensions are frequently studied individually, with few multi-dimensional studies.
2. Empirical evidence is limited in emerging/developing port contexts, particularly Karachi Port.
3. Integration gaps exist. Few studies link dwell time, customs, service reliability, and customer satisfaction to container logistics efficiency.

Narrative Summary for Port Services (PS)

The Port Services (PS) variable captures the performance of key service-related dimensions, dwell time, customs clearance, service reliability, and customer satisfaction, shifting analysis from physical assets to process efficiency. Literature shows that delays and unreliable services increase logistics costs and reduce competitiveness, while digitalization and streamlined procedures enhance efficiency; however, studies typically examine these aspects separately and rarely explore PS's mediating role. For Karachi Port, PS is central to understanding how service quality shapes logistics efficiency and throughput, offering critical insights for reforms such as customs digitalization. Major research gaps remain, including the absence of integrated, multi-dimensional PS models and limited empirical evidence from developing countries. This study addresses these gaps by evaluating PS holistically and empirically testing its influence on Karachi Port's performance.

2.3.6 Port Charges (PC)

In his study, Tongzon (1995) found that port charges are significant factors for port efficiency, which usually relate to ship docking, cargo handling, and auxiliary services. Yet, shippers are more worried about unintended charges related to unplanned delays, loss of business share, harm to client self-assurance, and missed opportunities owing to poor service. Port charges account for a very low share of the total cost of global trading. Peters (2001) stated that the overall charges imposed on seaport customers are a component of old-style port payment; for instance, port charges, container stowage, container moves, vessel stevedoring, and supplementary costs incurred in extended port stoppages. Apart from service value and time costs, port charges are a key factor that influences the need for port services (Dasgupta & Ghosh, 2000; Gardner et al., 2006).

Table 2.18: Conceptualization of Port Charges (PC) in Literature

Author	Definition
Tongzon1994 Tchang (2020)	Port charges are levies imposed on ships and cargoes for utilizing port facilities and services during a port visit.
Meersman et al. (2015)	Port charges are levies imposed on ships and cargoes for utilizing port facilities and services during a port visit
Wayne K Talley (2017)	Port charges may also include pilot, tug, wharf, dock, line handling, crane rent, and containers transferred on or off the vessel.
Yang and Chen (2016)	Port charges, transportation expenses, cargo handling costs, and seaport service charges are significant factors to assess seaport efficiency.
(Baştuğ et al., 2022)	Port costs refer to direct port costs, such as port dues, storage and stevedoring, container handling, drayage services, and premiums for peak periods; and indirect costs that occur during lengthy port stays.

In their study, Hassan and Gurning (2020) found that terminal efficiency can be imitated in the goods rates charged by shipping firms, the turnaround time of vessels, and container dwell time. The longer a vessel stays at berth, the greater the cost a vessel will have to pay. This can be passed on to shippers regarding greater freight charges and longer container dwell time, thus decreasing the attractiveness of the hub at a port (Musso & Sciomachen, 2020). Indicators of terminal efficiency are regarded as two main groups, that is: operational efficiency and customer-oriented measures. Initial actions deal with investment and workforce output, along with asset usage rates. The second set comprises direct charges, vessel waiting time, minimizing delays in local transport, and reliability.

Meersman et al. (2003) in their research found that transport, cargo handling at the port, transshipment, and shore service costs are the key components of port charges. On the other hand, in their study, Yang and Chen (2016) stated that usually, port charges, transportation expenses, cargo handling costs, and seaport service charges are significant elements to assess seaport efficiency. Kavirathna et al. (2018) in their study clarified that transshipment charges are an important component of port cost, where feeder and hub association have a close link. Wayne K Talley (2017) elaborated that port charges may also include pilot, tug, wharf, dock, line handling, and rental for cranes and containers moved on or off the ship. Yet, if a seaport has bottlenecks and frequent delays, but reduces port charges, it will remain an inefficient port. Tongzon (2009) found that higher port charges may deter shipping lines from choosing another port, given a choice. Besides, the frequency of ship visits is a key determinant of port efficiency. Wayne K Talley (2017) found that total revenue from port is the entire income meant for port service charges and associated facilities delivered to outsourced firms.

Alderton and Saieva (2013) in their research on overall service charges stated that there were eleven types of port costs, prices, and revenues. The overall service cost is the income obtained by the Port Authority, for delivery of pilotage, tugs, towing, wharf, dock, line handling, cranes facilities, containers moved on or off the ship, logistics for the ship, shore services (electric power, telephone line, fuel, water), repair/maintenance. Jansson and Shneerson (1982) in their study on port economics found it is the amount received by the Port Authority on income related to the delivery of container handling facilities and amenities. Trujillo and Nombela (1999) stated that freight handling charges are the most significant as they are about 70 to 90% of entire seaport charges, depending upon the quantum of cargo (Marcucci et al., 2023).

Heilig and Voß (2017) found that ancillary services charges were the overall amount received by the Port Authority on income linked to facilitating the ships. There are several local tariffs levied on inbound ships visiting a port, for maintaining channel deepness, navigation markers, beacon lights. These are usually called wharfage dues imposed on ship dimensions/gross tonnage. Fung et al. (2003) stated that, prior to the launch of terminal handling charges (THCs), traditional freight rates included both ocean freight charges and terminal charges at ports. After initiation of THCs in 1991, the freight rate has become a ‘port-to-port’ cost which only accounts for the sea leg, whereas the onshore costs of using the CTs are charged independently as THCs (Kombo, 2015).

The port charges play an important role in attracting shipping lines and a factor in port efficiency (J. Wang et al., 2024). Port charges normally relate to vessel berthing, cargo handling, and supplementary services. (Kaliszewski, 2020). The attractiveness of a CT is its capability to present its services in a better way than its local and overseas contestants (Kaliszewski, 2020). Tongzon (2009) discovered that about 75% of cargo forwarders opt to pick a shipping company before selecting a seaport to be used by the shipping company. Hence, ports ought to concentrate more on the shipping companies instead of other seaport clients as the port selection is normally decided by the shipping companies (Yeo, 2024).

Table 2.19: Compilation of Port Charges (PC) in Literature

Port Charges (PC)		
Sr. #	**Author (s)**	**Services Cost (PCSC)**
1.	Parolaetal, 2016	●
2.	Gharehgozli. (2016)	●
3.	Iris and Lam (2019	●
4.	Ha 2017	●
5.	Fung et al. (2003)	●
6.	Heilig and Voß (2017)	●
7.	Kaliszewski, 2020	●
8.	Tongzon (2009)	●
9.	Trujillo and Nombela (1999)	●
10.	Alderton and Saieva (2013)	●
11.	Wayne K Talley (2017)	●
12.	Kavirathna 2018	●
13.	Musso & Sciomachen, 2020	●
14.	Meersman 2015	●
15.	Yang and Chen (2016)	●
16.	Hassan and Gurning (2020)	●
17.	Tchang (2020)	●
18.	Gardner et al., 2006	●
19.	Baştuğ et al., 2022	●
20.	Mthembu & Chasomeris, 2024	●
21.	Caldas et al., 2024	●
22.	Raza et al., 2020	●
23.	Zając et al., 2023	●
24.	Kombo 2015	●
25.	Vrakas, Chan and Thai (2021)	●
26.	Maure (2018)	●
27.	Yeo, 2024	●
28.	J Wang 2024	●

Table 2.20: Port Charges (PC) Bibliometric Analysis

Dimension	Total Studies	Empirical Studies	Conceptual / Other	Key Gaps Identified
PCSC	12	6	6	Many studies focus on Europe or Asia; pre-digitalization context; limited quantitative modeling; insufficient analysis linking charges to container logistics, port services, and technology; Pakistan-specific evidence is missing.

Comments:

1. Most studies analyze port charges in isolation, without considering their interaction with port technology (PT), infrastructure (PI), and equipment (PE).
2. Empirical validation is limited, especially for Karachi Port or other developing ports.
3. Several studies are conceptual or historical, highlighting the need for current data and integration with operational indicators like container throughput, dwell time, and logistics efficiency.

Narrative Summary for Port Charges (PC)

The Port Charges (PC) variable, specifically through the dimension of Service Cost (PCSC), is included in this study because it is a key factor in a port's economic competitiveness and directly influences shipping lines' choice of port. For Karachi Port, operating in a highly competitive regional market, analysing PC is essential to understand if its costs align with the service quality it provides. The literature reveals a consistent "cost-efficiency trade-off," where higher charges must be justified by superior productivity, and highlights a trend towards innovative, performance-based pricing models. However, significant research gaps justify this study's focus. These include a lack of research on dynamic pricing models, limited evidence from developing-country ports like those in South Asia, and a failure in existing studies to integrate port charges with other operational factors like human resources and equipment. By incorporating PC into its framework, this study addresses these gaps and aims to provide a holistic, empirical analysis of how port charges interact with other operational and managerial constructs to influence the overall logistics efficiency of Karachi Port.

2.3.7 Port Container Management (PCM)

The CTs handle different categories of containers, such as laden, empty, reefer, non-standard size, twenty-foot equivalent unit (TEU), or forty-foot equivalent unit (FEU) (Naiker, 2018). Among them, the ‘laden’ and ‘empty’ containers form the core groups, as together they cover all the containers (Abdelshafie et al., 2022; Lee & Song, 2017). On the other hand, though literature considerably discusses the terminology ‘empty container management’, it rarely discusses ‘laden container management’ (Song, 2021). Moreover, very few studies refer to ‘container management’ as a terminology covering both ‘laden’ and ‘empty’ containers (Abdelshafie et al., 2022; Numa-Navarro et al., 2023).

Standard terminology or taxonomy referring to both ‘laden’ and ‘empty’ containers being managed at the CT has rarely been used in literature as a standard term. Hence, various authors have used diverse terminologies as per their understanding and suitability in the context of their study. With this background, a modest analysis based on a literature review has been done, which provides a rationale for using ‘container management’ as a standard terminology for referring to the movement of all containers during CT operations in this study. The term ‘container management’ is hence recommended for use while referring to different types of containers handled at the CTs /port.

Table 2.21: Conceptualization of Port Container Management (PCM) in literature

Author	Definition
Erin Curvey, 2020	Space limitation hampers terminal expansion and limits storage at container yards, causing critical container management issues. Full containers are often stacked deep, preventing their efficient storage and handling. Storing empty containers is another issue.
(L. H. Nguyen, 2024a; Song & Panayides, 2012)	It is the strategic management, systematic planning, coordination, and control of container activities, aimed at ensuring efficient and effective handling, storage, and movement of containers within a port
Kim (2019)	To satisfy customers by reducing the ship's time in port, by managing increased productivity of existing terminal resources.
Alderton and Saieva (2013)	The CT management system intends to regulate the moving process and stowage of containers inside a CT. Container management can thus be referred to as the ‘systematic movement and stowage of containers within the CT’s sea and land boundary, with best utilization of available resources, and space.
Huang, 2016	Develop strategies to improve terminal efficiency, throughput, and customer satisfaction.

The increasing complexity of CT operations requires its management to decide resource allocation and the sequence and timing of processes. CT management is often fragmented due to traditional practices, with different segments handling specific tasks in the terminal (Filom, Amiri, Razavi, et al., 2022). Many CT managers often face such difficulties, which are supported by research articles by the following authors (Mar-Ortiz et al., 2020). In his study, Hulten (1997) observed that there is substantial research on the container management aspect, which does not reflect the broad viewpoint of container logistics. Regarding the complexity of CT management, many authors have paid more attention to separate sub-systems, while limited studies have looked at the entire CT system as one function. As per Henesey (2006), the introduction of CT management tools may enable to measurement and categorization of the features defining performance in the CT system, which may help in creating vigorous policies and improved management methods.

On the contrary, a study by Tongzon (1995) revealed that tendering of combinatorial improvement techniques had little success in analysing and increasing the performance of CTs (G. Zhao et al., 2024); (Kombo, 2015). The complexity of CT operations needs complicated models; thus, the consequent models are extremely tough or consume undue time to resolve issues (Liang et al., 2024). Tongzon (1995) found that because of such causes, separate planning is usually done and practiced. The drawback of this method is that it only offers approximate outcomes and needs to be complemented with the knowledge of expert planners, which has become rare to find. Huang, (2016) suggested developing strategies to improve terminal efficiency, throughput, and customer satisfaction. The overview of a typical CT management model, when bifurcated yet segments are linked at the macro level may be able to gauge and classify the characteristics describing the working of the CT system, which may help to formulate dynamic strategies and improved management approaches. Tongzon (1995) also found that the combinative improvement technique registered little success in improving CT efficiency.

Due to the popularity of container trade, the container ship size has grown manifold in the past two decades, putting pressure on ports (de la Peña Zarzuelo et al., 2020). Hence, several ports have capitalized to upgrade their infrastructure, equipment, technology, HR, and services to dock bigger ships and handle more TEUs. A study of the literature revealed that increased container movement can only be managed with the automation of CTs. Yet despite technological advancements and the intent to modernize CTs, worldwide automation of terminals has only partially been achieved due to the cost-benefit ratio (Raeesi et al., 2023). Popoola et al. (2024) argued about the ramifications of automation for workforce management in maritime container ports, offering a conceptual outline to steer through this increasing pattern.

Automation, regarded as the integration of advanced technologies like artificial intelligence (AI), robotics, and the Internet of Things (IoT), assures improved efficiency, safety, and ecological sustainability (Brynjolfsson et al., 2014). Yet, these technological developments also present substantial challenges for workforce management, demanding a re-evaluation of traditional employment models and skill sets (Ford, 2015). The automation in the maritime sector, for operational procedures, has implications for labour demand, with a likely shift to technologically skilled workers (Tijan et al., 2021). In their study (Sony and Nail, 2020) explain that the proposed conceptual framework is driven by the socio-technical systems theory, which suggests that organizational effectiveness is achieved through the integrated improvement of both social and technical systems. This perspective is mainly pertinent to the maritime industry, where the integration of automation technologies intersects with complex human factors. Hence, port management with its skills plays a key role in managing the port employees.

Critical analysis of literature. The literature on container management has been critically synthesized and related to prior studies to categorise research gaps and limitations. The literature discloses a complex area referring to several operational, technological, and strategic areas of port management. A critical analysis identifies key ideas needing additional study. Implementing **automation technologies**, in cranes and yard trucks, helps improve port efficiency. While automation can cut operational costs from 15% to 35%, it poses high costs, needs skilled technical managers, and opposition from labour unions because of job uncertainty (Bender, 2024). The above factors highlight the intricacy of port automation and the requirement for detailed planning and stakeholder engagement (Financial Times, 2025). Latest studies stress **sustainability** and greening the CTs and ports by improving methods. Employing micro-grids, solar systems, wind turbines, and modifying yard equipment are strategies to cut gas emissions and pollution. Though such measures improve environmental sustainability, their application has a high cost, and understanding between stakeholders (Lalla-Ruiz et al., 2024). Automation can perform faster container moves with quick turnaround times and reduced power use, but incur higher costs (Durlik et al., 2024).

Successful port management requires traversing complicated interactions with several **stakeholders**, like CT operators, port clients, port authorities, and logistic firms. Disputes may develop due to varying concerns, like infrastructure redesigning choices affecting diverse participants in different ways (Durlik et al., 2024). Efficient container handling has caused **security** weaknesses. Studies highlight the requirement for detailed measures to check cargo robbery and smuggling, evaluating the balance between operational efficacy and security procedures (Zhao et al., 2017). Port bottlenecks pose a serious concern, aggravated by occurrences like COVID-19, which can be resolved by **operational planning**. Studies reveal that bottlenecks can be dealt with by increasing port efficiency, promoting cooperation between CT operators, shipping companies, and inland transporters. Also, combining planning problems through several stages and logistics routes is encouraged to improve operations. Yet, achieving such incorporation is difficult as it is complicated to coordinate with various stakeholders and methods (Lalla-Ruiz et al., 2024). The trend of port automation demands competent employees to handle modern equipment. Literature stresses persistent training and education for the **capacity building of workers**. Yet there is a strain between technical progress and workers due to job uncertainty, which needs delicate handling to balance labour relations and operational efficiency. Re-skilling courses and fair transition policies may also be considered (Wiseman 2025); (Financial Times 2025).

Concerning **port resources**, the literature implies several factors like technology, infrastructure, equipment, human resources, services, and charges that jointly impact port performance and effectiveness. Their critical analysis shows the aspects for further research. Strong **port infrastructure** is important for port efficiency and capability. Investing in infrastructure, such as channel dredging, are understood to curtail logistics cost and increase security, hence improving port effectiveness. Yet such infrastructural spending can differ in area wise and need cautious evaluation to support wider financial and ecological ideas (Wagner et al., 2022). The implementation of **modern technologies**, involving automation and digitalization, has altered port operations. Studies emphasize that employing technologies can enhance knowledge, enable smart decision-making, and foster multi-stakeholder cooperation within ports (Klar, 2023). Yet the combination of such technologies requires major financing and presents interoperability challenges and employees' adjustment. The efficient management of **human resources** is essential for port effectiveness. Related studies emphasize the significance of resolving workforce deficiencies and executing training to increase workforce expertise. Apart from this, there is a requirement for more empirical research on the effect of human resource practices on port performance, predominantly in the circumstances of technical developments (Heliyon, 2024).

The effectiveness of **port services**, involving container management and logistics, influences overall port operations. Studies show that the maritime logistics system stresses the intricacy of port operations. However, the vibrant international trade demands constant change and novelty in service delivery (Sunitiyoso et al., 2022). **Port charges** policies greatly impact port attractiveness and profit-making. A critical review of port charges literature shows that there is a dearth of agreement on a standardized charges system. This ambiguity creates ripples and demands further research to develop a fair and able port charges framework (Sunitiyoso et al., 2022). **Sustainability** has developed as an inherent aspect of port resource management. The literature stresses the need to balance functional effectiveness with green obligation. The ideas of green port approaches are gaining popularity, but their execution frequently faces barriers linked to finance, regulatory compliance, and stakeholder orientation (Lim et al., 2019). **To conclude**, the literature highlights the complexity of port resource management. Studies reveal a sizable advancement in understanding the port resources separately. There is a requirement for combined approaches that study their inter-dependencies. Future research must focus on developing a wholesome model that combines these dimensions to improve port operation in the growing worldwide trade environment.

Earlier studies regarding Karachi Port operations gave a worthy understanding of different attributes of port efficacy and container management. Yet, these studies show some restraints that require further study regarding the influence of container management on the port's logistic efficiency. Shahzad (2022) tried to find the main factors concerning the general port efficiency of Karachi Port and recommended methods to moderate delays. This study took a wider look at port efficiency factors, but did not investigate intensely the peculiar role of container management practices and their influence on logistic efficiency. Jaffry (2024) studied the issues regarding moving container freight from the industrial area to Karachi Port, stressing on the problems like truck-rail inclination and complications in the customs process. The study has discussed about supply chain, but did not systematically evaluate the customs procedures and logistics processes, thereby limiting the evaluation about how container management in the port effects logistic efficiency. The study evaluated ships output at Qasim International Container Terminal (QICT) and identified operational gaps and capacity improvements. However, this work largely focused on relative productivity assessment of shipping facilities and not the wider effects of container management practices on the ports logistic efficiency (Afzal & Zohaib, 2012). The above limitations emphasize a research gap regarding the broad evaluation of container management practices and their direct influence on the logistic efficiency of Karachi Port. Resolving this gap is important to make strategies to improve container handling methods, cut ship turnaround times, and increase the port's general functioning in the local and international maritime realm.

2.3.7.1 Automated and Traditional CTs

A study by Drewry Maritime Research (2018b) surveyed 41 most modern container ports. Among them, 11 were fully automated, 26 were semi-automated, and 4 ports were still in the development phase. Results revealed that only about 3% of world ports were automated, while 97% of ports were still functioning manually. Out of them, 1% were fully automated while 2% were semi-automated. (Brooks & Faust, 2018) found that Asia has four times higher container output than Europe and that automation enabled ships to load and unload containers swiftly at ports. In his research, Rodrigue (2022) found that terminal automation was rapidly growing. As of mid-2020, 55 CTs around the world were either fully or partially automated. Since there are about 750 CTs in the world, it represents 7.3% of all terminals, but 12.2% of the global footprint in hectares. While the average CT size was 51.7 hectares, it was 85.5 hectares for fully automated terminals and 69.9

hectares for semi-automated terminals. (Drewry Shipping Consultants, 2019; (Notteboom et al., 2022). The semi- and fully automated CTs need competent professional managers to supervise the employees and for prompt decisions to solve emerging problems. Automated terminals though have high productivity due to modern equipment and technology, yet they cannot function well without the support of competent managers (Böse, 2011).

When planning for container port modernization, certain varying factors that may influence its expected output may also be considered. These could be location, nautical connectivity, rail-road connectivity, trade volume, shipping lines interest, transshipment, storage space, political stability, port authority's vision, security environment, dock labour, skill level of port employees, etc. Developing countries may face funding issues for capital projects.

In traditional CT, workforce planning is crucial to operating the terminal with skilled labourers. Two problems must be solved first: the Provision of workforce capacity, and the Scheduling of labour tasks. It is decided on the workforce capacity that is needed to handle the workload of a terminal within a period. The labour to operate the equipment needs to be determined. A basic constraint is to respect the dynamic availability of the workforce. Legato and Monaco (2004) gave an approach to the design of an apt shift system for a CT. Agreements between labour unions and terminal management restricted the likely decisions. Kim (2024) found that individual operators had been assigned to QCs, YCs, and yard trucks, considering allocated work and the workers' skills.

Concerning seaward processes, automatic procedures have not become common practice. Besides, associated employees are rarely studied in academic papers. Operating a quay crane needs a team of workers, termed a gang. This team comprises a crane operator, workers to lash containers, a supervisor to manage the activities, and a few drivers for yard trucks for container movement in the terminal. As the quay crane is normally worked for a full shift, high employment of crewed quay cranes is important for port managers, apart from service value. On this aspect, Meisel and Bierwirth (2006) proposed a method to curtail the crewed quay crane shifts in a collective berth allocation and quay crane allocation problem. Yet, when the workforce price is the lone objective, a decline in service quality is perceived. A joint objective of both domains permits an equilibrium involving the worth of the terminal and its customer satisfaction.

Table 2.22: Considerations

Options	Consideration	Recommendation
Option 1	Invest heavily and extensively in modernizing the port.	
Option 2	Invest modestly and make essential modifications only.	

Option 3	Invest minimum and focus on improved productivity from existing resources, through innovative managerial skills.	Option 3 is considered more feasible. Iyer 2021 has also recommended.

It may be unwise to invest heavily in port modernization without undertaking an in-depth feasibility study, considering several factors influencing port performance. The work required to improve the port's berthing, container handling, storage capacity, and intermodal connectivity should be ascertained. Thus, in the absence of a detailed study, options 1 and 2 may not be preferred options. Option 3, involving minimum outlays and focusing on the improvement of existing resources, processes, and development of advanced managerial skills, will be the preferred option. As per the literature, partially automated container ports having good stowage capacity can achieve compatible throughput compared to semi-automated container ports by best resource utilization and developing innovative managerial skills (Knatz et al., 2023; Kugler et al., 2021; Majoral et al., 2023; Peemdechachai, 2020).

2.3.7.2 CT Management

The foremost aim of CT management is to prepare strategies that enhance terminal efficiency, throughput, and customer satisfaction. Key works of the CT management are the preparation and control of operations of all categories of containers. CT management is frequently steered by tradition rather than theory, hence being cautious to adopt novel thoughts or technologies. The quality of CT management can impact the selection of shipping lines to utilize a specific CT. Thus, CT management needs to satisfy its customers by minimizing the ship's time in port, through increased productivity of QC moves per hour, regarded as an important measure of CT performance.

Containerized trade has made global progress in the last two decades. The container throughput has grown to above 866 million TEUs in 2022 (Statista 2023). The growth in container ship size has compelled the ports to increase their operational capacity. Ports are burdened more than ships, as infrastructure development is costlier. To cater to growing containerized trade, ports must improve their container handling ability by adopting modern and innovative techniques, developing facilities, and improving services at low expense. Seaports may have one or a few CTs for the movement of containers. Because of the restricted space in the yard, container movement and stowage processes need to be integrated and efficient. If the CT runs out of yard space, it may not be able to service a ship, despite the availability of a berth.

Having realized the importance of CTs, many authors have written about their performance, improvement, and efficiency. As a CT altogether is quite complex, the authors have normally chosen to write about their segments (singly or in combination), rather than. Developing countries are more affected, as their ports need to improve their overall performance and efficiency. For example, even if the containers embark and disembark at the quay, stowage in the yard, and transportation to the hinterland by intermodal transport are achieved quickly. Yet some other factors may still cause an overall delay in the entire process of container management at the terminal, leading to extended dwell time. Such delays could be caused due to customs clearance, gate pass issuance, truck congestion, poor train service, container identification, paperwork, labour union strikes, lack of managerial skills, etc. To find out standard terminology, nomenclature, or taxonomy concerning CT operations and management processes, the literature was studied. The literature revealed that several authors used diverse terminology or nomenclature to describe the same or similar concept, as per Table 2.23.

Table 2.23: Standard Terminology, Nomenclature, and Taxonomy of CM at CT

S #	Title	Terminology used	Author
1	Multi-Agent Systems for CT Management	CT Management	(Henesey, 2006)
2	An integrated container management model for optimizing slot allocation plan and empty container repositioning	Container management (laden and empty containers)	(Chang et al., 2015)
3	Container Logistics and its Management.		(Hulten, 1997)
4	Smart empty container Repositioning re-planning system under inaccurate demand forecast		(Leiyi et al., 2019)
5	Automotive returnable Container Management with RFID: A simulation approach		(Giubilato et al., 2019)
6	Global intermodal tank container management for the chemical industry		(Erera et al., 2005)
7	Liner shipping cargo allocation with repositioning of empty containers		(Brouer et al., 2011)
8	Cargo routing and empty container repositioning in multiple shipping service routes		(Song & Dong, 2012)
9	Ocean container transport in global supply chains: Overview and research opportunities		(Lee & Song, 2017)
10	Empty Container Management and Coordination in Intermodal Transport	Empty container management	(Xie et al., 2017)
11	A systems analysis of empty container logistics – A case study of Melbourne Australia		(Gusah et al., 2019)
12	A Time-based Policy for Empty Container Management by Consignees		(Legros et al., 2019)
13	Empty container management in a port with long-run average criterion		(Li et al., 2004)
14	Empty container management at ports considering pollution, repair options, and street-turns		(Sainz Bernat et al., 2016)
15	Empty container management in cyclic shipping routes.		(Song & Dong, 2008)

16	Challenges in Managing Empty Container Movements at Multiple Planning Levels		(Braekers et al., 2011)
17	An operational model for empty container management		(Olivo et al., 2005)
18	Empty container management for intermodal transportation networks		(Choong et al., 2002)
19	Empty container management in a port with long-run average criterion		(Li et al., 2004)
20	Optimization of empty container allocation for inland freight stations considering stochastic demand		(K. Chen et al., 2022)
21	Managing empty containers		(Lun et al., 2023b)
22	Optimal decision-making for empty container management at seaport yard		(Vinh et al., 2023)
23	Simulation of empty container logistic management at depot	Empty container logistic management	(Sze et al., 2017)
24	Direct shipping service routes with an empty container management strategy	Empty container management strategy	(Jeong et al., 2018)
25	The Influence of Container Crane Productivity and The Ship Call Frequency on The Cargo Handling Performance	Cargo handling performance	(Aunillah et al., 2016)
26	A tabu search algorithm for the integrated scheduling problem of container handling systems in a maritime terminal	Container handling system	(Chen et al., 2007)
27	A beam search algorithm for the load sequencing of outbound containers in port CTs		(Kim et al., 2004)
28	A Novel Predictive Control Based Framework for Optimizing Intermodal CT Operations	Container handling capacity	(Nabais et al., 2012)
29	Modelling and analysis of container handling in ports	Container handling in ports	Taleb-Ibrahim (1989)
30	Handling Strategies for Import Containers at Marine Terminals	Containers handled	(de Castillo & Daganzo, 1993)
31	The economics behind cooperation and competition in Sea port container handling	Seaport container handling	Voorde 2005
32	Identification and Ranking of Factors Impacting on Efficiency of cargo handling operation in CTs	Container handling operations	Sayareh, 2015
33	A simulation analysis for a transtainer-based container handling facility	Container handling facility	Young-gyo chung, 1988
34	An Animated Simulation Model for a Transtainer Based Container Handling Facility		Chung 1985
35	Transshipment of containers at a CT: An overview	Container handling in seaports	Iris F.A. Vis, 2002
36	Co-operation in container handling: What are the effects on economies of scale?		Thierry Vanelslander 2006
37	A Study of CT Planning	CT Planning	(Park & Dragović, 2009)
38	A simulation model proposal to improve the productivity of CT operations through investment alternatives	CT Operations	(Sislioglu et al., 2019)
39	Coordinated optimization of equipment operations in a CT		(Jonker et al., 2019)
40	Digital Management of CT Operations		(Zhao et al., 2020a)

41	CT operation and operations research – a classification and literature review	CT Operation	(Steenken et al., 2004)
42	A simulation analysis for a transtainer based Container handling facility		(Chung et al., 1988)
43	Participation of Private Investors in CT Operation: Influence of Global Terminal Operators		(Heejung, 2015)
44	Optimization of CT Layouts in the Seaport - Case of Port of Montreal	CT Layouts in the Seaport	(Abu Aisha et al., 2020)
45	A MAS Approach for Port CT Management	CT management	(Rebollo et al., 2001)
46	A dynamic system simulation approach to CT management		(Cheng, 2010)
47	Analysis of Variables of Vessel Calls in a CT	Handling efficiency of CT	(Loke et al., 2014)

Source: Literature support and the Author's deliberation.

2.3.7.3 Terminology

Marine containers have become a popular means of global transportation for the past few decades. The container ship size and port capacities have grown much more quickly in recent years. The trade volume reached 822 million TEUs in 2022 and the trade value has surpassed 50 percent of total world trade. Due to this reason, containers have become an important commodity across the world. The CT's operational performance will depend upon its connectivity, capacity, throughput, technological advancement, infrastructure, equipment, human resources, services, charges, dwell time, berth occupancy rate, and ship turnaround time ship, among others. CTs have complex operations with numerous processes centred around the container. Within CTs, the containers are handled, stowed, transferred, transported, loaded, unloaded, custom checked, traced, tracked etc. In all these activities the containers are managed at one process or the other, however, there is no single terminology for the movement of the containers. At times it can be container handling, container movement, empty container management, container terminal management, container terminal operation(s), and others. Many terms in the existing literature on ports have evolved in the field, (United Nations Conference on Trade and Development (UNCTAD), World Bank Group, etc.), and the ensuing terminology has grown to describe specific concepts barely understood by experts and academicians unrelated to the subject.

2.3.7.4 Precise definition of terms.

Efforts are made to describe ideas and thoughts date back to the era of Aristotle, about 2,400 years ago, when he anticipated that a definition must state the necessary type or being of something. However, this belief might not explain well to maritime practice, where exact descriptions are required to communicate to associates and employees to perform processes, operations, and other activities related to cargo. In the maritime domain, exact and correct descriptions and classification of the terms (taxonomy) permit appropriate responses. The similar but different terms used for a specific action, requirement, or process can often be misleading *and could* correspond to diverse concepts. A description must explain its necessary characteristics while preventing complexity; it must not comprise conditions that are synonymous with it. It must not be excessively broad or extremely narrow (not lack or contain something to which the term must not be applied). It must also be clear, logical, and optimistic, endeavouring to prevent ideas obtained by omissions. After a description is decided on, it is feasible to adopt a terminology (taxonomy) that employs names and terms to categorize subsections inside the realm that share related attributes.

The pertinent **terminology** sets the basis for solid interdependent and wide-ranging distinction of the research therefore the objective of this segment is to describe the important terms founded on their significance and the prominence as the basis of research at the end of an overview of the research scope. Hence, this study defines the scientific writing of container management as a key term for container movement at the CT.

A simple search on Google Trends for ‘container management’ displayed an average figure of about 9 million in the last five years. For the same five-year data trend from 2020 to 2024, it showed a slow ascend. On a simple Google Scholar search it showed 1000 records for container management in general. However, it covered container management in various subjects, that is, maritime ports, shipping, and transport, but also IEEE, computers, mathematics, etc. Out of which there were 995 scientific publications and 5 reference books. The main important point is that more than 50 percent of records have shown a gradual ascend ahead of 2020 to 2024. The data reveals the attention of the public and eager interest from the scientific realm in participating in this area. Hence the purpose of this segment is to present the most pertinent scientific contribution of the study yet also consider literature that offers different ways to handle containers efficiently.

The terms related to the idea of ‘container management’ found in the literature are listed in the Table below. It was observed that several terms that were worded differently had been generally used by authors to describe similar functions. Thereafter the list was again reviewed in the literature and discussed with some port experts and scholars. After deliberation, the terms were narrowed down as mentioned in the same table. During the process, several other important overarching aspects were revealed without considering which concept of container management in the container terminal/ port realm would seem incomplete. Some of them are strategic management, port managers, decision-making, and leadership.

Top management and leadership are synonymous in some ways (Hewitt et al., 2021; Ugboro & Obeng, 2000) as the top management must also assume the leadership role due to the nature of their job and responsibilities. Strategic management and decision making is also linked and are important for container terminals due to their complex processes and operations, where frequent decision-making is required, whether wrong or right. Many wrong decisions or non-decisions can lead to bigger problems, which can affect the company's general performance. For instance, the stranded containers at Karachi port due to non-customs clearance and no action/decision taken by the top customs management or Karachi port authority, shows gross incompetence and lack of strategic management planning and decision making. Such behaviour displays a dearth of strategic direction, strategic capabilities, management skills, problem-solving ability, and operating processes. Strategies define the efficiency by which an organization reaches its objectives satisfying customer needs, and the responsibility amply depends on how well managers do their work (Fuertes et al., 2020). As Karachi port is generally performing below capacity and known world averages, there is a need to enhance the skill level of port employees and managers. Fuertes et al. (2020) found that a company requires staff with management skills, otherwise, it makes control more difficult for senior management.

In his study on Indonesian ports, Wahyuni et al. (2020) found that seaports are incapable of functioning alone and need a helping infrastructure to guarantee the sustainability of seaport operations. Also, several personnel and managers exhibit an absence of credibility and truthfulness, particularly while dealing with overseas participants. Hussein and Song (2022) analysed that in the future, employees will require considerable skill in maritime logistics to associate with digitalization and automation developments. Enhancing the strategic capability of port employees by ensuring their skill level and quality of education and training is a key responsibility of the top management. This will enable the port employees, including managers, to benefit from a better understanding of technological developments and acceptance of the change in port processes (Othman, El Gazzar, et al., 2022).

Table 2.24: Terms synonymous with container management

S No	Terms related to container management	Structure narrowed down
1	Cargo handling performance	
2	Container management (laden/empty)	Container management (laden/empty)
3	Container handling system	
4	Container handling capacity	
5	Container handling in ports	
6	Containers handled	
7	Container handling	

8	Container handling operations	
9	Container handling facility	
10	Container handling in seaports	
11	CT operation(s)	
12	CT management	
13	CT planning	
14	CT layout in seaports	
15	Empty container management	Empty container management
16	Empty container repositioning	Empty container repositioning
17	Empty container logistic management	
18	Empty container management strategy	
19	Handling efficiency at/of CT	
20	Seaport container handling	
21	Terminal management	
22	Yard management	
23	Decision making	
24	port manager	
25	Strategic management	Strategic management
26	Strategic leadership practices	

Despite diverse methods, no standard all-encompassing terminology and corresponding definition of CT management covering its functional, structural, and managerial processes exist. In one instance, CT functions are identified by spatial dimensions, i.e., ship/shore interface to logistics. In other instances, its functions are described by the level of its performance efficiency and monetary and societal effects. Also, CT ownership and structural model tend to be a mixture of three distinctions: the degree of public-private participation, the style of control, and the scope of CT capabilities, possessions, and services.

The need for a single taxonomy to classify CT management could be debated, which could also obstruct its research prospects. Yet, CTs may not be considered as distinct objects, but rather need to be understood by experts in the context of unified logistics and supply chain. The taxonomy for CT management is needed to permit port managers to compare their performance in a wholesome manner, with the specified benchmarks, and with competitors other than the maritime port sector, like inland intermodal terminals, dry ports, and provincial supply depots. Perhaps, the main difficulty in adopting a single standard taxonomy for CT management refers to the intricacy and multiplicity of CT management, which has several levels. These are structural (public-private), operational, spatial (location, connectivity, capacity), Legal and regulatory (policy, safety, security) (Bichou & Gray, 2005)

Varying terminologies used by more than one author have been summarized in Table 2.11 below. The available data has been organized in descending order for clarity. The terminology, Empty Container Management, has been more consistently used particularly in recent research papers. Empty containers comprise around 20% of the world's container population of about 25 million. Possible reasons for the importance of empty containers being accorded by researchers are due to their growing numbers, relocation difficulties, related costs, and spatial issues. The issue of empty containers multiplied during COVID-19, and many US east coast ports were clogged with severe congestion.

Table 2.25: Terminology, Nomenclature, and Taxonomy of Container Management at a CT, used by more than one author

S#	Terminology used	Number of Authors
	Empty container management	24
	Container management	15
	Empty container repositioning	9
	Container handling	7
	CT/port managers	6
	CT Operation (s)	6
	Strategic management	6
	Leadership practices	6
	Decision making	3
	CT planning	1
	Empty container logistic management	1
	Empty container management strategy	1
	Seaport container handling	1
	CT layout in seaports	1
	Handling efficiency at CT	1

Source: Literature support and Author's deliberation. Compiled from Tables 2.10 and 2.11

The terminologies used by various authors in their work have been further grouped based on their similarities. These groups have then been analysed based on the keywords used, as shown in Table 2.12. The result of this brief analysis reveals that Container Management is the preferred terminology that can be used when referring to the process of container management operation at the CT. On this premise the terminology Container Management will be used during this research work, to refer to container management operation at the CT. Further study is recommended in the future to explore container management in detail and determine its dimensions for further research.

Table 2.26: Terminology, Nomenclature, and Taxonomy of Container Management at a CT

S#	Terminology used	No. of Authors		Groups	Terminologies grouped	Common terminology Keywords in groups
1.	Empty container management	24	48	Group 1	Empty container management	Container management

2.	Empty container repositioning	9			Empty container repositioning	
3.	Container management	15			Container management	
4.	CT Operation(s)	5	13	Group 2	CT Operation(s)	CT Operation
5.	CT management	4			CT management	
6.	CT/port operations	3			CT layout and planning	
7.	CT process	1			CT process	
8.	Container handling in terminal /port operations	3	12	Group 3	Container handling in Terminal/port	Container handling
9.	Container handling	2			Container handling	
10.	Container handling in seaport	2			Container handling system	
11.	Container handling facility	2			Container handling facility	
12.	Container handling capacity/in ports	2			Container handling capacity	
13.	Container handling procedure	1			Container handling	
14.	Seaport container handling/handled	2	4	Group 4	Seaport container handling/handled	Handling container at seaport/terminal
15.	Handling efficiency of CT	2			Handling efficiency CT	

Source: Based on literature and the author's deliberation.

Container management at the port has been discussed by several researchers, such as (Hulten, 1997); (Erera et al., 2005); (Brouer et al., 2011); (Song & Dong 2012); (Chang et al., 2015); (Lee & Song, 2017); (Leiyi et al., 2019); (Giubilato et al., 2019). Few authors found the CT processes to be multifaceted procedures that are quite complex and complicated to model and examine. Hence, authors have avoided research on CT systems wholly. Rather, most authors opt to research one or two segments of the CT in parts.

In his study, Lu Chen (2007) found that owing to the robust interrelationship of container management equipment, a unified model was developed to resolve the scheduling of diverse equipment simultaneously for better management, considering loading and unloading operations simultaneously; minimize the loading and unloading period of ships; and consider the equipment work efficiency. He also suggested a unified model to plan several sorts of container handling equipment in a maritime CT. The aim was to increase the coordination of equipment to improve the productivity of the CT. (Lu Chen, 2007)

In their study on maritime container handling, McDowell et al. (1985) found that the cost of stevedoring containerized cargo in the US was about $300 million in 1980. As this cost, the container cargo handling is less than 50% compared to conventional cargoes, which means that the intermodal transfer is expected to grow quickly. This growth will subsequently generate the need for extra facilities requiring significant investments. Thus, considerable savings may be derived from improvements in the efficiency of CT operations by reducing terminal management costs (McDowell et al., 1985)

In his study, Loke (2014) found that the operating efficacy of CT might be influenced by ship visit frequency and the embarkation and disembarkation of containers in the CT. A survey was done at Malaysian Ports regarding vessel processes wait factors, ship turnaround time, overall moves, entire discharge, complete load, and total length of the ship. Results revealed that entire moves, whole discharge, and complete load had a great correlation with berth turnaround time. The research determined that the berth turnaround period is greatly affected by the entire moves, overall discharge, and complete load. Olivo et al 2005 presented an integer programming model for empty container management in ports and depots with multiple transport modes.

Choong et al. 2002 reported that a longer planning horizon could encourage the use of inexpensive slow transportation modes to reposition empties. Li et al. 2004 examined the structure of empty container management allocation in a single port. Song and Dong 2008 developed threshold policies to reposition empty containers for cyclic routes. These studies show that simple inventory-based repositioning policies can perform well in some situations.

2.3.7.5 Container Management Challenges

In his study about the challenges in port automation, Erin Curvey (2020) reasoned that container management becomes a challenge when space is limited, and terminal expansion is frequently hampered. When storage needs scale, ports are unable to scale their yards to match. This causes critical container management problems. Due to limited capacity, full containers are often stacked deep, preventing yard operators from efficiently storing and managing them. Compounding the problem are the empty containers that must also be stored until they are ready for reuse.

The related moving and storage costs are often higher than the value of the containers. The Boston Consulting Group estimated that the costs related to repositioning empty containers in the world hover around $20 billion per year. There is a need for container improvement strategies that reduce the movement frequency of individual containers.

In his study, Vaggelas (2019) argued that only 3% of ports are automated worldwide to a certain level, with 1% being fully automated while 2% are semi-automated. The Asia Pacific area leads in automated CTs, followed by Europe and North America (Gancheva, 2021). The majority of automated CTs in the Asia Pacific region are developed away from towns, which are new areas for ports. After setting up the first automated containers terminal, 'ECT delta', in Rotterdam in late 1998, the automation trend has not grown much among CTs.

Despite the advantages of automated CTs to improve efficiency, reduce operating costs, improve safety, and reduce GHG emissions, the deferred acceptance of automation raises queries about automation's ability to fulfil anticipated objectives. As per Singh et al. (2021) many terminals are taking a more modest approach toward automation, due to the hindrances they may encounter for its successful implementation. The key challenges for an automated port are; the expenses to introduce automation; the availability of skills and resources to implement and manage automation; labour union problems, and; the duration to install automation (Hirata et al., 2022).

2.3.7.6 Container Management covering laden and empty containers

In his study about intermodal tank container management for the chemical industry, Erera et al. (2005) developed a dynamic deterministic multicommodity network flow model for an intermodal transport network. He considered integrated container booking and routing decisions for laden and empty container repositioning.

In their study on global maritime container transport, and supply chains Lee and Song (2017) found that the most convincing model of Empty container repositioning (ECR) would acquire features like trade inequality (involving laden and empty containers). In network flow models for overall container management, limited studies (Brouer et al., 2011; Erera et al., 2005; Song & Dong, 2012) have contemplated laden and empty containers at the operational stage. Lesser authors have even considered the uncertain character of the problem. A lengthy planning perspective is mandatory to integrate the impact of EC movements as it frequently requires around four weeks to relocate an empty container to a different continent, although such decisions are made almost every day.

In their study, Song & Dong (2012) found the problem of joint cargo routing and empty container repositioning at the operational level for a shipping network with multiple service routes, multiple deployed vessels, and multiple regular voyages. The objective is to minimize the total relevant costs in the planning horizon including container lifting on/off costs at the original, transshipment, and destination ports, customer demand backlog costs, and demurrage costs at the transshipment ports.

2.3.7.7 Managerial skills at Container Port

Niavis and Tsekeris (2012) performed an efficiency analysis on 30 container ports in southeastern Europe. The authors used data envelopment analysis DEA, CCR, BCC, and super-efficiency models and concluded that there is low efficiency in the region caused by scale effects and lack of managerial skills.

In his study, Iyer et al. (2021) found that in 2014–2018, among 18 Indian CTs, 6 terminals (33%) were found efficient, and 12 terminals (67%) were inefficient. Out of 12 inefficient terminals, 3 terminals (25%) needed to improve operational aspects and managerial performance. Inefficient management and coordination at the port pose a risk of financial issues. Greater efficiency would enhance the profitability of CTs. The study identified the sources of inefficiency as managerial cum technological, or scale-related for each terminal.

Their research (Kaleibar & Krmac, 2024) argued that ranking ports is important not only to assess their efficiency but also to create a competitive environment and enable port managers and policymakers to recognize and consider their strengths and weaknesses, leading to an improvement in the port's performance.

Munim (2020) found that during the past few years of operations at Chittagong Port, the managerial knowledge gained from technical efficiency and service level inconsistency in the 1995–2007 era was not replicated in the events of Chittagong Port Authority (CPA). They barely acquired a piece of modern equipment or implemented any significant extension project after the launch of New Morring CT in 2007.

The financial and operational performance of port authorities emerges as a result of managerial skills, and the financial performance of a port is of great significance to guarding investments and strategizing novel developments in the future (Bolevics, 2017).

In his study (Bucak et al., 2020; Somensi et al., 2017) analysed 37 articles in the literature and suggested that it should be evaluated whether port management activities contribute to port performance. Similarly, (Dutra et al., 2015; Vieira et al., 2014) advocated that there is a research gap in the relationship between port governance and performance. On the other hand, our research suggested a more descriptive approach for collecting data and measuring port performance. Dutra et al. (2015) handled 23 articles and remarked that most of the studies are out of interacting with port managers (Notteboom & Haralambides, 2020). Unlike this, we think that stakeholders of ports should evaluate the service quality they receive and thus, port performance would show up.

Duru et al. (2020) found that, recently UNCTAD has suggested a port performance scorecard as a port training program to combine a set of indicators to assess and benchmark the skills of senior port managers. The key idea of this program is to align the industry and academic viewpoints on port performance to share best practices among port managers, particularly from developing countries (UNCTAD, 2012). Those indicators were mainly related to terminal operational efficiencies, largely based on throughput (movements per crane, per hour; berth utilization rates; labour ratio per TEU are some of the main indicators)

Kim et al. (2022) CTs or terminal operators require operating efficiency and effective management to acquire international market competitiveness, as worldwide container ships and global shipping alliances continue to become larger.

The Study investigated the effects of integrated operations of the existing separate CTs using scenario analysis. The scenario analysis is attempted based on actual vessel arrival data on additional effects that Busan New Port can obtain from the use of an infrastructure pool by consolidating all five terminals (Kim et al., 2022). The results explain the benefits of terminal consolidation: the reduction of vessel waiting time, balanced utilization across terminals at the port, and an increase in overall profits for the actors (Kim et al., 2022).

Davidson (2015) also suggested that physical integration would be the best option for multiple terminals operated by different agents, but virtual integration could be a more desirable alternative to realistic challenges.

When a vessel waits more than 12 hours, the status of the vessel is classified as congestion, and the ship pays the public water fee to Busan Port Authority (Kweon et al., 2022). Most of these vessels are small and medium-sized ships that serve the Intra-Asia Trade Lane. The status of waiting and congestion is caused by the low priority of the schedule for mega vessels to enter the terminal that they want to stop at Busan Port, rather than by the lack of berthing capacity in the port (Kim et al., 2022). In other words, ships often wait for a call from a terminal to load/unload containers, even though one or more berths are available at other terminals within the port. Inter-terminal transportation (ITT) means that the container in transit is unloaded at a terminal and loaded at another terminal (Ding et al., 2023). The study results (Almawsheki & Shah, 2015) provide valuable information for port managers, to mature resource usage, to slowly improve operational efficiency.

2.3.7.8 Processes at CTs

In his study, Sayareh (2015) found that a productive CT, in terms of container handling operations, not only promises efficiency and effectiveness but also customers' and stakeholders' satisfaction. Preston and Kozan (2001) modelled the seaport system to determine the optimal storage strategy for various container-handling schedules. The main objective was to minimize the turnaround time of container ships, and this was solved using a genetic algorithm (GA). An intense literature review and qualitative survey helped collect factors and criteria affecting the efficiency of container handling operations of CTs.

In his research, Vis (2002) found that ships were being unloaded and loaded at large terminals, which can be segregated into several sub-activities. After the arrival of a vessel at the port, the imported containers must be unloaded from the ship to shore by QCs. The QCs then transfer the containers to trucks moving among the vessel and the stowage yard. The stowage yard comprises several tracks for the temporary stowage of containers. The tracks are operated by YCs or SCs. An SC can move as well as stow the containers in the stowage yard. Dedicated vehicles can transport containers in the yard. When a truck reaches a stack, it leaves the cargo down, or the YC moves the container from the truck and keeps it in the stack. After a specified interval, the containers are recovered from the stack by gantries and transferred by trucks to intermodal carriage types like barges, container vessels, motor vehicles, or trains. This procedure can also be achieved by moving in a backward sequence, to embark export containers on a vessel (Vis, 2002).

Most CTs use crewed equipment, such as straddle carriers, gantry cranes, and trucks. Nevertheless, some CTs are automated, where automated guided vehicles (AGVs) may be used to transfer containers. The stacking procedure could also be performed repeatedly by automated YCs. The study revealed that the container management period (that is, the entire movement time of the crane) must be minimized by the favourable establishment of the stack lane sequence and complete containers to be moved at individual stack paths. The embarkation schedule must meet the job schedule of QCs, which is presumed to be the input (Vis, 2002).

The competitive environment in the maritime container trade segment is quite visible among seaports. Major CT operators like Hutchison Port Holdings (HPH), Port of Singapore Authority

(PSA), and Dubai Ports World (DPW) are expanding their global container handling operations. This permits the operators to compete in various container-handling submarkets around the world. The results of this study will help from an operational and policy perspective (Notteboom & Rodrigue, 2023b). The absence of a port improvement framework to improve efficiencies in the container handling abilities of Karachi port and other similar ports is felt as a shortcoming by decision-makers in the business.

The biggest container shipping lines are becoming larger. In 2021, three major alliances regulated the maritime transport market with around 80% of the entire container shipping volume: 2M (Maersk Line and MSC), Ocean Alliance (COSCO, CMA CGM, and Evergreen), and THE Alliance (ONE, Yang Ming, Hapag-Lloyd, and HMM) (Notteboom & Rodrigue, 2023b).

The study by Castilho (1995) discusses container import processes at CTs. It describes two approaches to determine the level of work needed once two fundamental approaches are agreed upon; one attempts to continue all stacks in identical dimensions, while another one separates containers as per arrival time. Castilho (1995) argued that container import processes usually engage relocating sets of containers from an arriving ship to an interim stowage space where the containers await loading on trucks. To decrease the capacity needed for interim stowage, containers are normally stuffed, with the help of moving equipment (for example, RMGs or RTGs) to relocate the containers in CY stowage areas. The taller stacks decrease the needed area in CY, yet surplus handling equipment is needed to recover containers at the bottom. To determine the needed CY stowage area and layout design, it is important to assess it by calculating the number of moves needed to recover a container. The additional handling endeavour needed for higher stacks could be negotiated alongside area needs and an appropriate operational plan to select the yard design. However, this kind of difficulty is not explicit to CY but can arise in any logistics system (Castilho, 1995).

Li et al. (2021) conducted a field study on the simulation of containers processed at a CT. The berth configuration and stowage projection are thought to be the foremost performance measures of a container port (Raeesi et al., 2023). Concerning investment decisions. The literature review revealed several studies on the improvement of CT operations. Majority of the authors have worked on the important procedures of container port operations. The absence of progressive models to choose profitable investments has been detected. A flexible approach is essential to cover the infrastructure outlay options as well as adjustments in other operation limits like presumed arrival rates of visiting container vessels (Mucahit Sislioglu, 2018)

In the study by Park (2014), it was found that CTs in the Korean Port are endeavouring to increase capability and performance at high investments. Moreover, CT operations are changing with time to meet increased customer demands as well as to adapt to new technologies. The researcher considered simulation models for CT operations by (Dahal et al., 2003), (Canonaco et al., 2008), (Petering & Murty, 2009), (Petering, 2009), (Petering et al., 2009). These documents revealed that the simulation models are utilized to examine queuing and blockage difficulties, container management procedures, yard truck and vessel scheduling, equipment and CY usage, port output, and working efficiency concerning CY, gate, and quay Park, 2014.

2.3.7.9 Global Terminal Operators

Yip (2011) found that the Ports are characterized by their geographical and operational settings. Each port has many terminals, which are operated by one or several operators (Yip et al., 2011). There are two categories of private investors in CTs; one is pure stevedores such as HPH, PSA, and DP World, and the other is global shipping companies that wish to integrate terminal operations into their business activities. The CT operators make technical decisions for their objectives. This, however, requires substantial investment, which would be justified by a high enough volume of traffic throughput (Pawlik et al., 2011).

Cheon et al., (2010) argue that partial privatization allows specialized entities to concentrate on terminal operations and cargo handling services. Improved operation of CTs creates technical efficiency.

Increased participation of private investors in managing ports and the entrance of new ports have increased pressure on port efficiency (Bergantino et al., 2013). CT operators are compelled to provide high-quality services at competitive prices (Araujo De Souza et al., 2003). They should invest in facilities, services, and management systems for sustainability. They should increase expenditure on cranes, information technology, and transshipment facilities and shorten vessel turnaround times (Notteboom, 2002).

Yeo (2015) argued that berth depth, CT area, container freight station (CFS) area, number of cranes, and CT space can measure the level of port infrastructures. These variables are highly correlated to one another because any variable can be used as a proxy of port infrastructures. The study applied the CT area and CFS area to measure port infrastructure. CT area and CFS area refer to the total area of the CT, and the container freight station respectively. (Boni, 2016)

Port Performance can be measured by costs, throughput, revenue, or whatever criteria the organization is assumed to pursue (Yip et al., 2011). Carlo et al. (2015) argued to challenge the current CT operations paradigms by identifying opportunities for improvement and deriving best practices from cargo handling, and stowing.

2.3.7.10 Documentation System in the CT

Ning Zhao (2020) argued that operations in CTs are an important section of container transportation. CTs have considerable clients, comprising shipping firms, consignment forwarders, customs clearance firms, truck operators, railway freight transport section, etc, and several related documents, comprising container loading plan (CLP), bill of lading (B/L), sea waybill, docking receipt (DR), equipment interchange receipt (EIR), manifest, BAPLIE (Bayplan), delivery order, cargo receipt, etc. Enterprise papers go over the entire procedure in the CT. Though having changed contents, all papers perform a valuable role in the activities of CT processes.

Dirk Steenken (2004) offered a different argument that CY stacks, vessels, trains, and trucks belong to the category ‘stock’. Stocks are statically described by their capability to stock containers, whereas, from an active perspective, a storage command is essential to define the regulations for how and in which place containers must be kept. A fundamental change relating to such distinct kinds of stockpiles does not exist. Movement and planning of vessels, rail, or automobiles do not join CT operations. Thus, they can be contemplated numerically as stowage objects, while a storage directive is there for automobiles, where the location of containers to be stacked must be described. For storage, vessels and trains require directions describing the location of each container Dirk Steenken, 2004.

In his study, Kap Hwan Kim (2004) found that the container handling system consists of QCs to embark and disembark from container vessels, transfer cranes for moving containers in the marshalling yard, and using yard trucks to transfer containers among the assembling yard and QCs. A terminal yard is split into several blocks. Each block comprises 20 to 30 bays, all having four tiers and six stacks.

CTs are defined in a few studies to be a method of freight movement with two crossing points. The initial crossing spot is quayside, where the loading and unloading tasks of the vessels are done. The subsequent crossing is on the landward side where containers get embarked on road and rail transport for relocation to another place (Stahlbock & Voß, 2008a). Each CT has a specific outline and related size amongst separate places for activities within the CT to determine these distances. In a common CT plan, the site of the train and yard is towards the end of CT opposing the wharf.

After the container arrives at the CT via rail or road transport, the container is verified for recognition and record (for example, last port, articles, and freight company). CT yard truck transfers the container to the allocated slot in the CY (bay, row, and tier in the block) via a gantry crane. Lastly, upon the vessel's arrival, the container is disembarked and placed in the CY; and then transferred to the quayside where QCs load it on a vessel at a pre-defined position as planned. The import process is performed in the inverse sequence (Steenken et al., 2004). Refining container management procedures can conserve energy and also avoid unfriendly gas emissions (Demir et al., 2011). The surge in container trade volume has led to a considerable need for quality services at CTs, logistics, and technical equipment (Burigana, 2022; Steenken et al., 2004). In his research, Carrascosa et al. (2001) presented a system architecture based on a multi-agent system paradigm to solve multifaceted problems. The architecture is useful for resolving CT management problems, particularly the automatic container allocation. The study is part of a task for the connected management at a CT.

CT management is quite a complicated system. The only way it can be judiciously resolved is by creating many segmental components that are dedicated to solving its specific features (Jennings & Wooldridge, 1998). The usual processes to be performed in the CT are quite extensive, yet the alternate methods share few common systems (Holguín-Veras & Jara-Díaz, 1999):

- **Seaward Interface**. This is an arrangement to embark/disembark containers to/from vessels. Usually, 2 to 3 quay cranes are utilized for container movement per vessel.
- **Transfer System**. Its handovers the containers from/to the marshalling area to/from the stowage area. Yard trucks are used in the terminal to move containers. Transtainers are used to pick up or drop a container in the stowage area.
- **Container Stowage System**. It aims to assign and regulate the containers in the storage area.
- **Landward Interface**. It emphasizes managing the connections with land transport. (Carrascosa et al., 2001).

CTs are an important part of a port as numerous containers pass through them. Overall, the CT is a multifaceted system that acts as a border of water and land. From the seaward side, ships arrive at the quay and are offloaded/loaded by quay cranes; to the landward side, the containers are transferred to inland area or vice versa by motor vehicle or train. Between the seaward and landward sides, the containers are processed through different stages and areas within the CT. It has been observed that while individual segments of the CTs have been discussed in the literature with clear terminologies, the CT has hardly been discussed with a standard one. This is probably because CT is quite complex. Therefore, standard terminology or taxonomy referring to the overall work being undertaken in a CT could not be found. Various authors have named this terminology as per their understanding and its suitability in the context of their study. With this background, an endeavour has been made to carry out a simple analysis and provide a rationale for using container management as a term for referring to the overall movement of containers during operations at CT in this study.

CT Management In his study Henesey (2006) found that the main objective of CT administrators is to create policies to increase the terminal's efficiency and customer satisfaction. To achieve this objective, CT management must plan and control operations in an organized way. Terminal managers are often driven by traditional approaches rather than innovative ideas or technologies. These managers can also influence the terminal choice by shipping lines through better customer care, like curtailing the ship's time in port, by extra efforts to increase productivity by greater crane moves per hour, which is viewed as a gauge of CT performance. The growing intricacy of terminal operations needs the management to determine the provision of assets with the sequential order and scheduling of processes. Due to obsolete processes, the organization of a CT is frequently disjointed, with diverse establishments handling exclusive responsibilities inside the terminal. Hence many CT managers often face procedural and decision-making issues (R. Chen et al., 2022) s (Gambardella et al., 2001).

Strategic port management by consolidating CTs. Container ports or terminal operators require operational efficiency and effective management to improve worldwide market competitiveness, as container vessels continue to become bigger, international shipping alliances reshuffle and become larger. CTs thus face the challenge of systematic and accurate container management with efficiency to achieve their objectives (Al-Rikabi, 2019). Container tracking supports cutting costs through instantaneous updates on container location, which assists in evading demurrage, detention, and port storage charges, which are applied when the permitted time has surpassed (D. J. L. Song, 2021).

Strategic plans, which are generally planned every 3 to 5 years, aim to assign port assets to numerous actions for achieving marketing and economic aims. It will contemplate viable conditions where the distribution of assets would alter the organization and level of need for better container management (Song et al., 2009).

A CT management system is of strategic importance as it enables better use of terminal resources like; labour, and equipment for logistics and promptly retrieve information which permits timely and cost-effective decision-making by port management (Chindondondo, 2021).

In their study, Olteanu et al. (2022) found that strategic management guarantees the identification of environmental opportunities and threats that an organization must encounter to gain a competitive edge in the market. Transport is recognized as a significant factor in the strategy of long-term progress, fiscal growth, and quality of life. In this sense, a transport system that offers maximum monetary and social influence must be developed to minimize the negative effects. Hence, we must highlight the important financial changes, trade growth, technological development, or environmental problems to have a major influence on the maritime industry and port activities. Identify the main strategic management decisions needed in the field of maritime transport for improved performance. The significance of strategic management determines that the seaport has (through updated strategic decisions and objectives) concerning CT management and keenness in foreign trade.

The worldwide port employment conditions have become quite complicated and unbalanced because of quick expansion and constant variation, making corporations exposed to a variety of challenges. Efficient management can foresee strategically and manage by sensing early warning indicators. Strategic management invests in; strategic abilities, defines strategic direction, improves and develops human resources, strengthens managerial skills with ethical habits, and implements sane governing supervision.

Strategic management of maritime trade has been important for regional growth and development since ancient times, (Chang & Khan, 2019). Adequate port reform can widen the variety of products traded and lower handling costs. The development of trade has increased demand for door-to-door delivery at competitive prices. Technology is utilized for quick customs clearance, input for accurate managerial decision making and to improve port-hinterland connectivity by reducing costs (Raza et al., 2020).

Shipping traffic has increased in recent years, involving substantial cargo flow which impacts the port infrastructure. Decision-makers must consider the port capacity when planning traffic management and port safety (Olba et al.,2019). Maritime ports and national land transport infrastructure are the key to global trade (Goolam Nabee & Walters, 2018). Increasing port efficiency will help the national economy and serve the hinterland (Dragomir, 2019).

A CT can be defined as a facility where freight containers are moved among dissimilar vehicles for onward carriage[6]. An area specified for the stowage of containers, accessible by rail, road, and maritime transport. In this area containers are handled, sustained, and stored (Rodrigue & Notteboom, 2024).

Defining Container Management: In their study, Alderton and Saieva (2013) found that a container port or terminal management system intends to regulate the moving process and stowage of containers (container management) inside a container port or its terminal. Container management can thus be described as the 'Systematic movement and stowage of containers within the CT's sea and land boundary, with the best utilization of available resources, space, and intermodal transport connectivity'. Better container management can accelerate the movement of containers in and out of port, thus reducing dwell time, handling cost, and ships' time in port, while increasing terminal capacity and berth occupancy rate (Zając et al., 2023). In other words, improved container management will help increase port logistic efficiency.

Functions and Challenges of CTs In his study Murty et al. (2005) found that a CT acts as a boundary among sea and shore transportation. Its primary role is to accept export containers from transporters for onward embarkation on ships and to disembark import containers from ships for clients. It also offers interim stowage of containers amid their passages on sea and land transportation. Steenken et al. (2004) discovered that CT is a complex system of container transactions, that acts as a sea and land interface. From the seaward side, ships arrive at the quay, for unloading/loading by quay cranes; to the landward side, containers are transferred to the heartland or vice versa by motor vehicle or train. Between the seaward and landward sides, containers are processed at different stages and areas within the CT. Brooks and Faust (2018) stated that the world average container vessel's time in port was 0.92 days in 2018, which was less than all other types of cargo vessels in the world. In their study Ghiara and Caminati (2017) found that due to the popularity of container trade the number of mega-ships of over 10,000 TEU capacity has exceeded 250 and many are on order.

As per Inoue (2018) with time few shipping alliances have become influential. They try to push container ports to ensure the agreed container handling quantity per berth, and work completion period of a ship or freight trucks. As per their study, Kim and Lee (2015) discovered that a 15000 TEU ship would require about 9000 transfers during its stay. This amounts to almost 350 transfers

[6] Container port - Wikipedia

every hour, which is a challenge even for developed ports. The presence of more mega-ships in the port will multiply the effect. Tetteh et al. (2016) in their study found that increasing the container management efficiency of ports will require judicious use of key valuable resources through robust procedural planning, decision-making, and communication. Marcio de Almeida (2019) in her study found that a few important areas to plan, in order of priority, are the allocation of berth, quay crane, stowage area, and embarking/disembarking pattern. The priority is the berthing allocation plan, then the quay crane timetable, and the storage area identification. The loading and unloading plan is linked with the quay crane availability.

Park (2023), found that the seaports and terminals management, combined with engineering practices, play a vital role in assisting worldwide trade and improving logistics operations. With the continued growth of sea trade, it is important to keep up with the modern developments and novelties in these fields. Dynamic appointment rescheduling of trucks under uncertainty of arrival time is a key area in which the trucks unable to make it in time for their appointments inform the port, and their appointment is rescheduled to save cost.

Kim, (2022) found that container ports or terminal operators require operational efficiency and effective management to improve international market attractiveness, as the container ship size continues to grow, the world shipping alliances reorganize and become bigger. The effects of integrated operations of the current independent CTs can benefit from the utilization of one another's infrastructure by unifying the distinct terminals. Terminal alliances can benefit by decreasing ship waiting time, judicious use of terminal resources, and higher profits.

Strategic management at container ports involves several dimensions, such as:

1. The need for operational efficiency and effective management to gain worldwide market competitiveness.
2. Consideration of the effects of integrated operations of existing separate CTs using scenario analysis.
3. Investigating the nonlinear dynamics and control strategy of CT output and volume.

Notteboom (2006) found that the problems faced by port managers are numerous and complicated. The logistics environment produces a high degree of uncertainty and leaves port managers with the question of how to respond effectively to market dynamics. The traditional concept of a seaport with facilities in a single location is no longer valid. The modern port concept leads to a comprehensive organization dealing with multiple services in several locations. To achieve such strategic objectives, the participation of skilled and innovative port managers is important.

Legato and Monaco (2004) found that improved planning and management of HR at maritime CTs plays a key role in achieving higher productivity and efficiency. A key objective for the terminal management and shipping firms is to attain a faster container loading/unloading operation, which helps to enhance the output and reduce the vessel turnaround time in port. The CT manager requires certain freedom at the planning level. The main danger is an under- or over-estimation of the workers, at any work period, being uneconomical. To cater to possible peak times in service demand, the terminal manager should have the authority to hire a temporary employee at short notice.

2.3.7.11 Basics notions of strategic management

Hunger (2020) described strategic management as the array of managerial decisions and actions that determine the long-run performance of a company. It comprises environmental scanning (external and internal) covering strategic direction, strategy formulation (strategic planning) describing strategic capability, strategy implementation (operations activity-related), and assessment and control (management-related).

2.3.7.12 Relationship among strategic management and strategic leadership

In his book Strategic Management: Competitiveness and Globalization, Hanson et al. (2016) explained that strategic leaders are individuals positioned in diverse parts of the company using strategic management procedures to help the corporation attain its vision and mission. Generally, the CEOs are accountable for ensuring that their companies appropriately use the strategic management procedure. The efficacy of the procedure is improved when it is grounded in ethical intentions and behaviours. The strategic leaders' work demands decision-making trade-offs, frequently between desirable options. It is critical for strategic leaders, particularly the CEO and participants of the top management team, to perform a detailed analysis of the situation confronting the corporation. Strategic leaders thus predict the potential outcome of their strategic decisions (Hanson et al., 2016).

2.3.7.13 Strategic Management Practices at Port

In his research, Hunger (2020) found that companies cannot succeed and continue to maintain accomplishment by performing safely by doing the conventional way of business. For example, the top management of Ford Motors and Boeing companies took a strategic risk by deciding to change the way they worked and succeeded. Aziri (2020) stated that strategic management has a positive impact on overall company performance.

In the context of container ports, given their complex operations and numerous activities, involvement of frequent decision-making processes, coordination, and collaboration with stakeholders, contemplation of the internal and external environment for competitiveness and external linkages to expand business (for example, shipping lines, shipping alliances, logistic firms, and other ports). The strategic management is very suitable for implementation in ports and container terminal operations.

The firms that are involved in strategic management usually outclass those that do not, particularly when the environment becomes unstable (Bhandari, 2020). Small companies may plan strategic management informally to avoid bureaucratic delays (Tosun, 2021). The president and top managers may meet casually to address strategic matters. In large companies, strategic planning may become complicated and time-intensive as the decision is taken through a formal process, as it can affect many people (Rodgers, 2022).

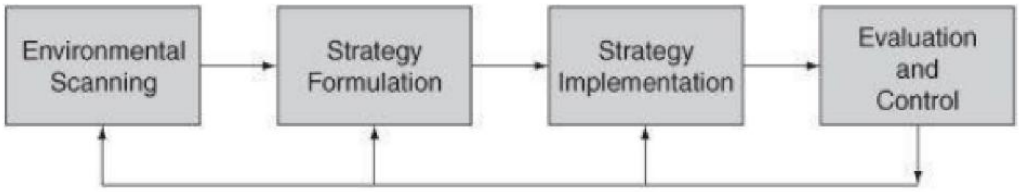


Figure 2.12: Key fundamentals of strategic management process - Source: Hunger (2020)

Strategic management comprises four key fundamentals: first, environmental scanning (strategic direction); second, strategy formulation (strategic capability); third, strategy application (operations activity); and fourth, evaluation and control (management-related).

Environmental scanning is the monitoring, evaluating, and distributing of information from the external and internal environments to important persons in the company. The external environment comprises opportunities and threats, which are outside the company and not in control of top management.

The internal environment of a firm comprises strengths and weaknesses that are within the organization and are not within the short-run control of top management. Strategy making is the development of continuing intentions for the effective management of environmental prospects and threats, considering the company's strengths and weaknesses. It describes the company's mission, indicating achievable goals, developing strategies, and adjusting policy instructions.

A company's goal is its reason or the justification for its presence. A well-conceived mission statement depicts the important, exclusive purpose of that company and identifies its operations in terms of products/services offered and regions served. It states what the company is now, and its vision. It gives a sense of expectations in employees and communicates an image to stakeholders. A mission statement reveals who the company is and what it does. Objectives state what is to be achieved by when and be quantified if possible. The achievement of corporate objectives should fulfil the company's mission. A strategy of a corporation is a comprehensive plan asserting how the company will attain its mission and objectives.

Executive leadership is the directing of activities toward the achievement of corporate objectives. Executive leadership is significant because it sets the tone for the entire corporation. People in an organization want to have a sense of mission, yet only top management is in the position to specify and communicate to the employees a strategic vision of what the corporation can become. Chief executive officers with a clear strategic vision are often perceived to be dynamic and charismatic leaders. They have many characteristics of transformational leaders, who encourage employees to innovate and provide change. Before strategy preparation, a corporation must examine the external environment to identify likely opportunities and threats, and its internal environment for strengths and weaknesses.

Strategic leadership is the primary function of organisational management. Strong leadership can help organisations to become competitive and help individuals and resources to achieve organisational goals (Samimi et al., 2022). Promoting effective leadership management through employment, selection, promotion, training, and development policies is likely to bear fruit in innovation and effective performance of the organisation (N. T. Nguyen et al., 2023). Leaders face numerous challenges in which change management is a persistent problem (Kouzes & Posner, 2023b).

As per Bolden et al. (2023) the leadership possesses executive positions in all organizations and exerts impact on others. Lasrado and Kassem (2021) indicated that leaders are necessary at all levels of the organization. Kouzes and Posner (2023a) described leaders as those who inspire a shared vision, build consensus, provide direction, and promote changes in beliefs and actions needed to achieve the goals of the organization. Leadership is a process that influences direction and organizational vision. Leaders must define the vision, trends, high expectations, and values (Kouzes & Posner, 2023a). Leadership is not just a process; rather, it involves influences that occur within a group context, and that involve discovering and developing the character as well as participating in achieving the goal McCauley (2021). Leadership is defined as the leader's ability to influence, motivate, and empower others to contribute to the effectiveness and success of organizations (Lee & Welliver, 2018).

2.3.7.14 The Concept of Strategic Leadership:

Several definitions cover the concept of strategic leadership, yet differ due to the author's understanding, writing style, and intellect. A few definitions are shown below:

Pisapia, (2009) stated that 'the ability to make logical decisions about goals, and actions in environments of uncertainty or uncertainty. Hussein (2011) defined it as 'thinking and making the necessary decisions to develop and implement the plan'. Al-Khafaji, (2008) defined strategic leadership as 'the ability to anticipate and visualize, maintain flexibility, and empower others to make strategic change when necessary'. Lee, & Chen, (2007) defined it as a person's ability to anticipate, visualize, retain flexibility, think strategically, and work with others to initiate changes that will create a viable and prosperous future for the organization'. Beatty & Quinn, (2002) represent the ability of individuals or teams to think, act, and influence others in a way that enables an organization to obtain a competitive advantage.

Table 2.27: Strategic leadership practices.

Strategic leadership practices	Author's name
Defining strategic direction, investing in strategic capabilities, human capital development, balanced organizational culture with ethical practices Implementing balanced regulatory supervision, Operations activities, Management related.	Ireland and Hitt (2005), Fuertes (2020), (Alayoubi, 2020), (Singh et al., 2023), (Samimi et al., 2022), (Ireland & Hitt, 2005), (Ferreira & Reis, 2023)
Making strategic decisions, futuristic vision, developing competencies and capabilities, developing organizational structures and processes, promoting an effective organizational culture, instilling ethical value systems	Boal and Hooijberg (2001)
Making strategic decisions, selecting key executives, allocating resources, formulating organizational and strategic goals, and providing guidance to the organization	House and Aditya (1997)
Defining the roles or practices of a strategic leader, such as Innovative, facilitated or easy, supervised, coordinated, produced, oriented	Quinn (1988)
Problem-solving, politics, communication, governance and management, change management, culture	Thompson, Peteraf, Gamble, and Strickland (2014)
Developing core capabilities, developing human capital, making effective use of information technology, developing appropriate strategies, and developing organizational and cultural structures appropriate to the specificity of each organization	Hagen, Hassan, and Amin (1998)

Source: Adapted from (Al-Masry, 2015; Kitonga, 2017; Fuertes 2020).

In this study the concept of strategic management practices presented by Ireland and Hitt (2005) and Fuertes (2020) defined strategic direction, investing strategic capabilities, management, and activities related as important dimensions to serve the study. Following is an overview of these concepts.

2.3.7.15 Defining the Strategic Direction (environmental scanning)

The strategic direction requires setting the firm's strategic goals and making a strategic plan. Defining strategic direction involves evolving a long-term strategic vision for the organization which provides motivation for followers to perform and provides leaders the capability to be involved in inspiring and empowering their followers to make effective organizational strategies. The team works collectively to advance the progress of the organization (Kitonga, 2017). Numerous elements explain the concept of describing a strategic direction, such as strategic intention or intent, which is described as a longstanding path. The intention is a description of longstanding aims and objectives instead of independent plans. (Ouirke, 2023) views it as an ambition, passion, aim, or objective and is a concern for accomplishment, or the targets set by higher management. (Shao et al., 2019) stated that strategic intent positively and significantly affects organizational performance. Developing a long-term strategic vision for strategic intent that in turn reflects the personal views of the inspiring leader. If the strategic leader can clarify his personal view to his subordinates, he can get their support for his strategic vision (Alayoubi, 2020).

2.3.7.16 Investing Strategic Capabilities (strategy formulation)

Strategic leaders develop and preserve core skills. The essential capabilities are the resources and skills that afford firms merit over contenders. Strategic leaders must recognize the assets and expertise that are expensive, rare, difficult to replicate, or replace as it will permit the firm to obtain a likely improvement. Moreover, each firm has knowledgeable capital (individual, operational, and relational (customer) that collectively establish fundamental skills. When the skills are important and expensive, difficult to replicate or copy, they develop a competitive benefit. Yet due to the altered outside atmosphere, it has become essential for the firm's key skills to expand. Hence the leaders' work is to find the key skills to attain the firm objectives, and to create, sustain, and utilize the key skills (Kitonga, 2017: Mutia, K'Aol, & Katuse, 2016). Strategic capabilities relate to the core ability of the organizational resources and its employability, which is a source of competitive advantage (Alayoubi, 2020).

2.3.7.17 Operational Activities (strategy implementation)

The results of planned activities depict the achievement of the objective. Usually, firms implement strategic management practices in operations activities through their strategic leaders (i.e., CEO)(Kowo & Akinbola, 2019; Singh et al., 2023). The CEOs/senior management expect to know what is to be achieved, by when, and what must be gauged if possible. The accomplishment of the company's aims must result in the fulfilment of the company's mission (Samimi et al., 2022). Operational competencies enable repeated and reliable performance of an activity (Okiridu & Onwudike, 2024).

Activity-based costing is a new accounting method to allocate indirect and fixed costs to a product (for example, a container) or on the value-added activities for that product. This method is very useful in analysing a firm's activities to make outsourcing decisions. It allows firms to charge costs more accurately as it allocates overhead more precisely. It can be used in several types of industries, including container terminals and ports. (Ferreira & Reis, 2023).

2.3.7.18 Management-related (evaluation and control)

A port is a well-defined administrative unit that involves land ownership and jurisdiction. The port authority is a common administrative framework for a port (Dempsey-Brench & Shantz, 2022). Terminal management and operations are leased to private companies (Notteboom & Rodrigue, 2023a). Port authorities usually spearhead port development projects. Good seaport infrastructure and high accessibility or connectivity have become basic requirements for competitiveness (Kammoun & Abdennadher, 2022). Ports have become a vital link in global supply chains and international transport networks (Grzelakowski, 2022). Green ports are emphasized to support the environment. Modern-era ports are experiencing higher dependency on capital rather than labour, the development of containerization and logistics, and changes in port operators and administration with vertical and horizontal integration strategies (Notteboom et al., 2022). (Notteboom & Rodrigue, 2023a)

In their study on the effect of Strategic Management, Masinde and Simba (2017) argued that the current strategic ICT and strategic training should be modified to improve the operational performance of CTs. Port Managers must be trained with an aim for strategic leadership roles in the future and be stressed to improve operational performance (Baştuğ et al., 2022). The strategic training and education programs for employees and managers must be given due priority (Othman, El Gazzar, et al., 2022).

In his research, Henry (2021) stated that strategic management is the system of organizations, people, activities, information, and resources involved in moving products or services from supplier to customer. Strategic management encompasses the planning and management of all activities involved in logistic management activities (Fuertes et al., 2020). Using implicit and explicit definitions from a set of scholars, Nag et al. (2007) identify seven components of strategic management: performance, firms, strategic initiatives, environment, internal organization, managers, and resources.

The main task of a port manager in HR is to improve the match among individuals and jobs (Wilton, 2022). A good HR department should have a feedback system to evaluate workers' satisfaction with their work and the corporation (Sainju et al., 2021). HR managers should examine and obtain job description information, important for correct worker choice, assessment, training, and development; remuneration management; and summarize the industry-wide employee-skill categories (Dempsey-Brench & Shantz, 2022). A company's information technology could be a strength or a weakness of strategic management (Henry, 2021).

Strategy formulation is frequently mentioned as a strategic or long-term development plan and is related to developing a company's mission, objectives, strategies, and policies. It starts with situation analysis: the procedure of finding a strategic fit between external opportunities and internal strengths while working around external threats and internal weaknesses. SWOT is an acronym used to define the specific strengths, weaknesses, opportunities, and threats that are strategic factors for a corporation. Strategy implementation is the entirety of activities and selections obligatory for the implementation of a strategic plan. Though the execution is generally considered after the strategy has been formulated, it is a crucial part of strategic management. Strategy formulation and strategy implementation should therefore be considered as two sides of the same coin.

Staffing focuses on the choice and usage of employees. The execution of new strategies and policies frequently calls for a review of HR employment. This may mean fresh intake with better skills, capacity building of current employees, and laying off unproductive ones. Efforts should be made to retain outstanding employees. In case of downsizing by the company, the management must specify the criteria to be used for the information of the employees.

Evaluation and control are the procedures by which business activities and performance outcomes are monitored so that real performance can be equated with anticipated performance. The procedure offers the feedback essential for management to assess the outcomes and take remedial measures.

Truck turnaround time. In their research, Ng et al. (2007) found that it is the period from the truck's entering the port entrance gate to its leaving the port departure gate. It helps curtail waiting time and bottlenecks at entrance and departure gates, and is also a gauge of the port facilities to truck operatives. This gauge aims to reduce the truck delay period and help avert flow bottlenecks in the seaport and at its entrance. It is the approximate period of the truck's presence in the port, from arrival to departure from the gate. Wasesa et al. (2017) discovered that in Singapore port, the truck reversal time is about 15 minutes. During a visit to Karachi Port, it was learnt that the truck turnaround time varied in the CTs between 50 to 60 minutes.

Ship turnaround time. In their research, Mokhtar and Shah (2006) found that ship turnaround time, measured in days, is equivalent to the overall time consumed by a vessel in port. Factors of the vessel turnaround period are the waiting period, the docking and undocking period, and the facilities availing period. A waiting period is usually a minor percentage of the turnaround period. But the docking period if curtailed, can considerably decrease the vessel turnaround period. The docking period rests on the amount of freight a ship is required to embark or disembark, the kind of ship, and the sort of equipment used at the terminal. Efficient ports endeavour to achieve nil waiting time for incoming vessels. In other words, an incoming ship should not be delayed for another vessel to complete its berthing or embarkation/disembarkation process. This can enhance the output of the seaport and increase the number of ship visits to it.

Quay Crane productivity Bartošek and Marek (2013) in their study identified QCs' productivity (TEUs per hour) as an important gauge to assess the CT output. The efficiency of a QC is gauged by the number of transfers in an hour. One move equals the movement of the container between the ship and the transport automobile in the quay. QCs can presently achieve 30 to 50 transfers in an hour. Almost all terminals can achieve an output of 70% to 80% of the calculated number. For instance, about 9000 TEUs can be transferred from a 12000 TEU vessel in 3 days by utilizing 6 QCs achieving 40 transfers per hour.

Berth Occupancy Rate In their study Radimilović and Jovanović (2006) found that the quantity of berths needed will be contingent on berth occupancy. To find out the quantity of essentially needed berths, the frequency of vessels visiting the port, and the duration of the vessel service period are to be learned. The average berth occupancy rate for each berth is usually calculated over a year. Henesey et al. (2004) in their research found that berth occupancy for container wharves will rest on the port management of the arriving vessels. A high berth occupancy factor may appear good as it produces the maximum berth use, though it is customary to accept a proportion of the usual waiting period not greater than 5 to 20%. Tang et al. (2016) in his research concluded that berth occupancy hinges on the navigation channel sizes, and added wharves, dual-way traffic channels, and a comparatively shorter channel would have greater wharf tenancy with similar port facilities. Lengthy one-way movement channels, have limitations and must be deliberated at the development phase to evaluate wharf occupancy and terminal stowage capacity, to avoid likely blockages for seaport's future working. Radimilović and Jovanović (2006) in their research observed that various types of container vessels having different quantities of containers visit seaports, every container needing an independent facility.

Berth Productivity (TEUs/year) In their study, Lu and Wang (2016) concluded that the rise in global trade has enhanced the value of port performance, mainly the CTs. The most significant factor is the rapidity of container embarkation and disembarkation at the wharf. Berth output is the key factor in gauging port achievements. Large Korean and Chinese CTs were analysed in this study to assess the linkage between berth output, reliant on the capacity and number of QCs and yard trucks. Lu and Wang (2016) found that their study verified the degree to which berth output could be enhanced by altering the independent variable and which dimension had a major effect on output. The outcomes of the study would enable port managers to enhance berth throughput by consolidating infrastructure (wharf extension), growth of yard equipment, IT and automation systems.

Yard utilization. In their study about yard utilization, Li and Yip (2013) found that it is planned to enable the management of large container circulation in restricted port premises, which is a test for terminal operatives. A delivery plan is utilized to decrease the level of reshuffles in the yard, but it sacrifices land utilization because of exclusively reserved storage space. In their research, Zhang et al. (2003) found that few studies have revealed solutions for container handling in limited storage space, and yard crane deployment is being experimented with. Throughput is associated with the degree of effort of multiple resources at a container seaport. Throughput can be explained as the quantity of freight (output) a terminal handle in each period and resource. For instance, wharf output (TEUs/year), Ship's output at seaport (TEUs/h), and Crane output (moves/h).

Table 2.28: Compilation of Port Container Management (PCM) in literature

Port Container Management (PCM)					
Sr. #	Author (s)	Strategic Capabilities (PCMSC)	Strategic Direction (PCMSD)	Management Related (PCMMA)	Operation Activities Related (PCMOE)
1.	Alderton and Saieva (2013)				●
2.	Raeesi et al., 2023				●
3.	Erin Curvey, (2020)		●	●	●
4.	Ding, Zhang, et al., 2023	●	●		
5.	Olteanu et al. (2022)	●			
6.	Yap & Ho, 2023	●			●
7.	Notteboom & Rodrigue, 2023a	●	●		
8.	Zhao et al., 2024				●
9.	Liang et al., 2024				●
10.	Orieno et al., 2024	●	●		
11.	Raza et al., 2020			●	
12.	Zając et al., 2023				●
13.	Heubeck, 2023	●	●		●
14.	Vrakas, Chan, and Thai (2021)	●	●		
15.	Wayne K Talley (2017)	●	●		●

Table 2.29: Port Container Management (PCM) Bibliometric Analysis

PCM Dimension	Total Studies	Empirical Studies	Conceptual / Other	Key Gaps Identified
PCMSC	8	3	5	Most studies are conceptual; limited empirical evaluation at developing ports; need integration with operations and container throughput metrics.
PCMSD	8	2	6	Strategic planning is often not empirically linked to operational efficiency; the Karachi-specific context is missing.
PCMMA	7	3	4	Management practices studied mostly in a European or global context; lack of quantitative performance data for Karachi Port.
PCMOE	3	1	2	Operational activities are analyzed independently; rarely integrated with strategy or HR/service dimensions; context-specific gaps for Karachi Port.

Comments:

1. Most research on PCM is conceptual and developed-port centric, highlighting a gap in developing country ports like Karachi.
2. There is a need for empirical integration of all four dimensions (strategic capabilities, strategic direction, management, operations) for container logistics performance.
3. Only a few studies combine strategy with operational activities, showing a research gap in linking container management capabilities to logistics efficiency.

Narrative Summary for Port Container Management (PCM)

The PCM literature table consolidates prior research on Port Container Management across strategy, capabilities, managerial practices, and operational activities, providing a structured theoretical base for comparison and critique. Its relevance lies in PCM's role as a core independent variable that directly shapes container flow, turnaround time, and throughput, especially important for Karachi Port, where congestion and coordination weaknesses persist. The literature highlights that effective PCM depends on integrating strategy with operations, that strong planning capabilities enhance container productivity, and that most existing research is biased toward advanced, automated ports. Key gaps remain, including the absence of empirical PCM studies in developing contexts, limited integration with other port constructs, weak quantitative measurement, and a lack of holistic models. These gaps justify the need for the present study's comprehensive, context-specific investigation.

2.3.8 Port Logistic Efficiency (PLE)

In their study on port logistics integration, Alavi et al. (2018) found that the competitiveness of a seaport vastly hinges on its efficiency, particularly in logistic practices and the supply chain linkages. As per Maure (2018), efficiency is gauged by the time of the transaction, the comparison of total expense and profit. For instance, a port having long lines is believed to be inefficient, though it may demand fewer charges. Bichou (2006) found that the spirit of logistics and SCM is a consolidative method to interface diverse procedures and functions within a company's protracted to a network of associations for cutting costs and improving customer satisfaction. As per Monfort (2011), efficiency is the use of proportions which depict the coefficient among a result (output), circulation, and a resource (input), such as infrastructure and equipment. In their study, Bichou and Gray (2004) revealed that seaports are generally believed to possess the ability of logistic hubs, yet their globally recognized accomplishment scales are still underdeveloped. The spirit of timely transportation of cargo to clients and the effective and inexpensive movement of freight and services is a unified method to link diverse procedures and purposes in a seaport, covering a system of management to cut costs and attain client satisfaction.

Table 2.30: Conceptualization of Port Logistic Efficiency (PLE) in literature

Author	Definition
(Iyer & Nanyam, 2021)	CT efficiency is frequently related to productivity and logistics. Other factors are how efficiently ports use resources (input) to yield throughput (output) degrees, and whether technologies implemented by the CT operators are important to establish CT efficiency.

(Fancello et al., 2021)	The yearly container throughput could be considered as a main indicator to gauge a container port's efficiency.
(Nyema, 2014)	Terminal operators are vital nodes in the logistics chain and should guarantee shipping lines reliable service levels. These include on-time berth of vessels, ship turnaround time, and certain connections of containers.
Wayne K Talley (2017)	A container port achieves efficiency in production when it maximizes its container throughput in the utilization of given levels of resources.

Brooks and Pallis (2008) discovered that the functioning of the port could be divided into two parts: efficiency and effectiveness, with the idea of assimilating customer satisfaction in port performance evaluation. The study also revealed that governance decisions at higher levels, were generally based on incomplete valuation of the port's working, and usually influenced by customer feedback, which is not the essential element to enhance port operations. Brown (2018) found that alterations in the arrangement of the port structure have changed the nature of port procedures. UNCTAD (2011) stated that efficiency often means the speed and reliability of CT services. As per Monfort (2011), efficiency is the use of proportions which depict the coefficient among a result (output), circulation and a resource (input) such as infrastructure and equipment.

Wang and Cullinane (2015) stated that some authors have analysed the relationship between seaport size and its efficiency. Wayne K Talley (2017) in his research pointed out that most studies revealed that; the larger the port, the greater its efficiency. Rajasekar and Deo (2018) in their research found that few studies indicate that port size does not affect efficiency. On the contrary, Nguyen et al. (2016) stated that few large ports reach the highest limit to which they can grow, and thus cannot further enhance their efficiency; whereas minor seaports find chances to further develop and achieve improved levels. Wang and Cullinane (2015) found that it becomes hard to find a cogent relation between efficiency and port size. Notteboom (2016) found that container ports are categorized by tough competition under the efficiency with which their resources are utilized. Wang and Cullinane (2015) learned that research on the efficiency of separate container seaports is significant to ascertain the effectiveness of a port. Notteboom (2016) equated the technical efficiency of key European and Asian CTs. Research revealed rivalry between smaller terminals inside a port which generates greater efficiency. On the other hand, Zhang and Roe (2019) discovered a differing conclusion linked to dimensions, that varied with the results (Cullinane & Talley, 2006) which is that terminal efficiency in hub ports is greater than in feeder ports. Song and Cullinane (2017) in their study found that port dimensions are not the primary reason of port efficiency. As per research, port efficiency has improved with growing tendency of privatization in CTs. Salient dimensions of port logistics efficiency are:

Container Throughput (TP) In their research Fancello et al. (2021); Le-Griffin and Murphy (2006) found that yearly container throughput could be considered as a main indicator to gauge a container port's efficiency. Throughput indicates the entire TEU berth or port handles in each duration, without specifying the capitals used. When throughput is stated in financial terms, the fiscal pointers are indicated. In their study Cullinane and Khanna (2000) stated that an important revolution in containerized transportation has been the swift growth in volume, dimensions, and depth of container ships, permitting them to carry a larger number of containers. This needed a compatible growth of port infrastructure and equipment, with which they could improve their embarkation, disembarkation, and storage capacity. Ducruet et al. (2011) found that many of the events of seaport throughput portray an image of the container volume or the number of ships the port would have handled in a particular period. For instance, the alteration in local and global requirements for cargo has an important effect on port efficiency.

Logistic Capability (LC) Gosasang et al. (2011) found that ports facilitate container trade and contribute to the national economy. Growth in global container traffic has affected the logistic capability of container ports worldwide. Countries need to monitor the trend of their container traffic and estimate the expected container output growth in the future. This will enable the ports to organize added resources to cater to increased container throughput in the coming years.

Russell et al. (2020) noticed four dimensions of port logistics capability, namely seaside border, platform, landside border, and system-wide, respectively comprising sub-elements that can be differentiated into fixed or flexible.

As per Mishrif et al. (2024) the port logistics capabilities portray a key part in facilitating worldwide trade, improving supply chain efficiency, and enhancing regional commercial growth. Contemporary ports are not just the points of freight relocation but are progressively amalgamated logistics centers offering value-added services (Blancas et al., 2022; Kolcubaşı & Yıldırım, 2024). Effective port logistics capabilities, such as infrastructure, operating systems, intermodal linkage, and digitalization, are key factors of port effectiveness (Koritarov & Dimitrakiev, 2024).

In the study by Q. Li et al. (2022) the results revealed that the dry port logistic supply chain integration (DPLSCI) has a positive effect on logistics cost performance (LCP) and service quality performance (SQP), which further improves dry port competitiveness (DPC). Outside of freight management, major ports have extended into offering value-added logistics services, branding, and delivery (Kolcubaşı & Yıldırım, 2024).

Table 2.31: Compilation of Port Logistics Efficiency (PLE) in literature

Port logistic efficiency (PLE)			
S #	Author (s)	Logistic Capability (PLELC)	Throughput (PLETP)
1.	Merk2012		●
2.	Cullinane2010		●
3.	Bichou2013		●
4.	Yang2019		●
5.	Munisamy2011		●
6.	Pinto2016		●
7.	Kammoun2018		●
8.	Sharma2009		●
9.	Gamassa2017		●
10.	Wanke2011		●
11.	Rubem2015		●
12.	Hlali2018		●
13.	Liu2008		●
14.	Cullinane2006		●
15.	Iris and Lam (2019		●
16.	Kalgora2019		●
17.	Tongzon2001		●
18.	Beuren2016		●
19.	Prokudin, 2022	●	
20.	Mogbojuri, 2020	●	
21.	Matsudaira, 2022		●
22.	Zaoudi et al., (2023)		●
23.	Iris and Lam (2019)	●	
24.	Steenken et al. (2004)		●
25.	Caldas et al., 2024		●
26.	Orieno et al., 2024		●
27.	Zając et al., 2023		●
28.	Vrakas, Chan and Thai (2021)		●
29.	Hsu et al. (2023)	●	●
30.	Awah et al. (2021)	●	●
31.	Cullinane and Khanna 2000		●
32.	Ducruet 2011		●
33.	UNCTAD (2011)	●	●
34.	Le-Griffin and Murphy (2006)		●
35. \	Wayne K Talley (2017)		●
36.	Bichou and Gray (2004)	●	
37.	Maure (2018)	●	
38.	Alavi (2018)	●	
39.	Bichou (2006)	●	
40.	Monfort (2011)	●	●

41.	(Iyer & Nanyam, 2021)	●	●
42.	(Fancello et al., 2021)		●
43.	(Nyema, 2014)		●

Environmental worries are progressively determining port logistics capabilities. Ports are implementing green practices such as coastal electricity, eco-friendly cargo handling equipment, and modal shifts to rail or barge to reduce carbon emissions (Nigro et al., 2024). Upcoming port logistics capabilities are expected to be specified by smart port technologies, independent freight management systems, and intense amalgamation with worldwide trade networks (Heikkilä et al., 2022).

Table 2.32: Port Logistics Efficiency (PLE) Bibliometric Analysis

PLE Dimension	Total Studies	Empirical Studies	Conceptual / Other	Key Gaps Identified
PLELC	12	5	7	Most studies are conceptual or limited to developed ports; they lack Karachi Port-specific empirical validation, and integration with HR, services, and container management is often missing.
PLETP	32	14	18	Throughput is widely studied but often in isolation; it lacks multidimensional integration with infrastructure, equipment, HR, and port services; limited developing country context.

Narrative Summary for Port Logistics Efficiency (PLE)

The PLE variable, capturing port performance through Throughput (PLETP) and Logistic Capability (PLELC), acts as the central efficiency indicator and is supported by literature that mainly emphasizes infrastructure and equipment as determinants of throughput, while logistics capability emerges as a broader, strategic measure of supply chain integration. Existing research is heavily concentrated on developed ports, resulting in a major contextual gap for developing regions such as Karachi. Studies are also fragmented, typically analysing operational, technological, or managerial factors in isolation without adopting an integrated framework. The bibliographic table, thus, guides the current study by identifying relevant determinants to test, reinforcing the need for a holistic performance model, and exposing gaps related to context, integration, comprehensiveness, and empirical validation. These gaps justify a new, context-specific empirical investigation into what shapes Port Logistics Efficiency at Karachi Port.

2.4 Theoretical Perspective

This study is built on two pertinent theories. An economic theory of the port (ETP), by Talley (2006a), is based on the idea that it can assess the performance of individual resources to measure the cumulative performance of the port. Resource Dependence Theory (RDT) explains in what way companies decrease environmental interdependence and ambiguity. RDT agrees on the impact of outside factors on organizational behaviour, yet despite constraints, managers could be instrumental in decreasing environmental ambiguity and dependence (Pfeffer & Gerald, 1978). In other words, RDT is founded on the concept that a firm cannot arrange for all the resources by itself (Drees & Heugens, 2013), so it may approach other firms to secure its objectives. These theories have been examined to develop a theoretical basis. The study has been seen through the lens of these theories.

2.4.1 Economic Theory of the Port (ETP)

The precise selection of variables, port charges, and operative choices, were inferred for a port with fiscal aims of exploiting output. This concept in ETP can similarly be utilized to infer efficiency indicators for seaports with other financial aims. The value of separate efficiency indicators that improve the seaport's financial aims are the indicators' values. As an indicator, a growing tendency comes close for the seaport to attain its financial aim. In the case of other indicators, it might be a falling tendency. A benefit to seaport administration in taking separate efficiency pointers to assess seaport efficiency is that it could assess the efficiency of different facilities (like terminal gates, berths, and approaches to seaport), as such finding out the working efficiency on the ground, where the efficiency is doing good or bad. Yet a drawback is in what way the overall effect of variance in these indicators acts on the seaport's cumulative efficiency (Talley, 2006a). The yearly request for the seaport's container outputs are functions of their wide-ranging (money and time) values; for instance, seaport fee and duration cost sustained by maritime vessels, domestic haulers and transporters, trucks, and cargoes, separately, when in the seaport. The best variables, seaport charges, and working choices may be utilized by the seaport as separate performance pointers for assessing its performance. Lin et al. (2022) found that the theoretical port period, resource, and price functions may be used in empirical studies of the port to examine the causes of, and their effects on the periods in seaport of vessels, automobiles, and cargo; seaport resource utilization; and seaport prices.

Talley (2006a) found that once a seaport's financial aim is improved, then it should entail that this seaport is also cost-effective, which is an essential state for port improvement. In case the seaport was cost ineffective, then improvement would not happen. However, if the seaport was cost ineffective and then converted to cost-effective, its income will grow for a certain output; therefore, it might enhance its output while observing its least profit limitation by becoming cost-effective. A seaport is considered cost-effective when its outputs are afforded at the lowest price (Miller & Hyodo, 2022). The selected variables, seaport charges, and working choices might be utilized by the seaport as separate performance indicators to assess its efficiency (Yen et al., 2023). As per Talley (2006a), the seaport assets usage; and charges can help ascertain port performance. The seaport period means and price functions can be utilized in empirical research of the seaport to examine factors, and their results on the periods of vessels, automobiles, and goods, in the seaport (Wayne Kenneth Talley, 2017).

In their study on port economics, Cullinane and Talley (2006) stated the basic port economic model. It was further elaborated by explaining that consider a port that handles containers, and its economic objective is to increase annual throughput subject to the least profit constraint. Yearly requirements for port services to handle containers are signified by yearly container throughput, gauged by the yearly container moves from the port. The yearly requirement for container throughput is a function of their generalized prices (money and time prices). The port's general price is the sum of the port's money charged (per TEU) for various services rendered and port time prices incurred by ocean carriers and shippers per unit of throughput (Cullinane & Talley, 2006).

2.4.2 Resource Dependence Theory (RDT)

The RDT is an assessment of the relationship among organizations and the resources essential for their operations. Jeffrey Pfeffer and Gerald Salancik introduced this theory in 1978 when they authored the book titled 'The External Control of Organizations: A Resource Dependence Perspective'. Several organizations endeavour to achieve sustainability but experience many setbacks. A major setback is resource dependence. This occurs because every company needs resources that are always in other company's control. For example, a company wants to manufacture smartphones, but the chip is produced by a certain company on which the smartphone manufacturer is dependent and is vulnerable to exploitation. RDT is related to the circumstances in which a company's maintainability is hinged on resources created from a company's surroundings (Pfeffer & Gerald, 1978). The concept is founded on the thought that organizations operating by themselves are unable to produce the entire assets needed to uphold their interests. Yet, as the attaining of outside assets is important for the long-term vision of a firm (Drees & Heugens, 2013), the significance of outside assets of firms was highlighted in this concept. Before trying the concept, the author has given valuable interpretations for the ideal construction of firms, exterior connections, policies, and numerous additional features of administrative policy, representing the standing of this concept in amplifying the activities of companies, mainly to advance a company's independence and legality. While upholding that sustainability is interpersonal, conditional, and joint, previous work on long-term vision proposes that companies must connect to guarantee tolerance and work in operation in dealings and relationships. However, working may be attained by effectively merging company abilities to govern the assets required by different people along with outside abilities to overwhelm a deficiency of reserve. The concept also relates to the requirement to enhance the harbour's output and performance, clarifying how the exterior surroundings trace behaviour of the company (Pfeffer & Salancik, 2003). The Resource Dependency Theory hinges on the concept that companies operating alone are unable to generate all the assets needed to continue smooth operations (Drees & Heugens, 2013). Therefore, the accusation of outside resources is significant for the long-term objectives of the firm (Pfeffer & Gerald, 1978).

The resource dependence model profits from the undeniable open-system proposal that firms are unable to internally produce all the resources essential to sustain themselves, and so firms are contingent on each other for their existence and therefore cooperate among themselves for their interest (Katz & Kahn, 1978). They should develop associations and do dealings in situations that can provide the needed possessions and facilities (Aldrich and Pfeffer 1976).

A corporation's obligation for resources offers a chance for others to enhance control of it (Frooman, 1999). One area where organizations interact or become dependent on each other is the procurement and distribution of items essential for the company's endurance (Galaskiewicz, 1985). Many scholars (Frooman, 1999; Galaskiewicz, 1985; Salancik, 1979) have examined the notion of 'dependence' among interrelating companies. A key area of this philosophy is the mutual reliance of participants, while others are control and strategic choices (Pfeffer & Salancik, 2003). Yet, mutual reliance in RDT covers control inequality and shared needs (Casciaro & Piskorski, 2005). RDT forecasts that companies will be influential more than others to; control resources required by other firms and, thus decrease their reliance on others for supplies (Provan et al., 1980). Dependence is defined as when one player relies on the act of the other to accomplish specific results (Pfeffer, 1982). Eminent interdependencies are horizontal, symbiotic, and vertical interdependence (Pennings, 1981). Horizontally interdependent firms are generally organizationally alike, symbiotic interdependence companies balance each other to execute services, while vertically interdependent companies are feasible business associates (Galaskiewicz, 1985).

As the privilege to regulate resources that create dependencies is shifted to the amalgamated unit, unification, and procurement a key worries of inter-company activity (Casciaro & Piskorski, 2005). Horizontal and vertical unification, shared projects, employee turnover, change, top management, control of vital supplies to the company, involvement in politics, and ability to resolve key problems of the company are strategies to reorganize the company or interfere with its participants (Pfeffer & Salancik, 2003). So, joint dependence stirs unification and acquisition, while control inequality restricts it (Casciaro & Piskorski, 2005). In the case of port technology, infrastructure, equipment, human resources, services, and port charges, the port management can invite other firms with the required expertise and resources to participate or invest, against benefit (Notteboom et al., 2022). However, the parent firm must restrict the level of participation by the collaborating company to ensure its control of the resources and interdependency (H. Jiang et al., 2023). In his study, Q. Li et al. (2022) found that the participation of other companies as per the notion of the RDT will contribute to improving the Port Logistic Efficiency.

As per Hillman et al. (2009), based on the content of Pfeffer and Salancik (2003), many authors have critically examined, 'what strategic actions can be taken to reduce the environmental dependence and uncertainty of the dependent organizations', by strategic actions through five options (mergers and vertical integration, joint ventures, board of directors, political actions, and executive succession). Several authors feel that the RDT framework has strategic actions.

According to Davis and Adam Cobb (2010), the RDT literature highlighted the dominance of Pfeffer and Salancik (2003) and Stanford University in the RDT domain. The influence of External Control of Organizations has also been exerted on many academic disciplines like political science, marketing health, etc., mainly in management and sociology. This research has comparable views to Hillman et al. (2009) on two accounts; that is RDT has a correct basis for empirical investigation and restricting the RDT framework of strategic actions to manage organizational dependence. Yet, distinct from Hillman et al. (2009), they examined the early claims, and elementary ideas of RDT, such as power and dependence. In their meta-analysis research about RDT, Drees and Heugens (2013) limited the RDT agenda to strategic actions. However, distinct from the earlier two studies, they dealt with strategic actions to consolidate the independence and validity of organizations. They argued that RDT is an organizational performance theory. The noticeable variance of Drees and Heugens (2013) from the above two studies is that this concept is used in a broad sense including interdependence throughout the study, whereas the previous studies conducted a literature review assessment in a descriptive form. Wry et al. (2013) criticized the limitation of RDT's context to strategic conflicts. Based on Pfefer and Salancik (2003), Wry et al. (2013) inquired how the theory is primarily used or not used by researchers in the field of management and where is

RDT placed among contemporary organizational theories. About 1772 articles in management-psychology-sociology from 1978 to 2011 were evaluated to respond to these questions. It was revealed that the book, The External Control of Organizations, was being reasonably cited compared to competing administrative theories, with an understanding of having specific strategic options for managing organizational dependence.

Hillman et al. (2009) supported Pfeffer and Salancik's (1978) initial claim that the organizations dependent on the environment can perform several strategies to fight these eventualities. taking a wholesome view, Hillman et al. (2009) differed with Pfeffer's claim (in Pfeffer & Salancik, 2003) that RDT was not thoroughly examined or studied appropriately. The RDT seems to be fully determined for general relationships among firms, their environments, and the procedures companies undertake to decrease the dependencies. Though the fields of political activities and administrative succession are rarely investigated,

The resources may include variety of meanings involving physical resources (e.g., basic materials, equipment, monetary award, etc.), human resources (e.g., training, proficiency, skills, etc.), and organizational resources (e.g., firm's image, procedures, schedules etc.) (Greer, 2021). Certain resources are quantifiable and touchable including production unit and equipment, whereas others are intangible, for example, training, knowledge and skill. Although some researchers indicate that skills are part of resources, others exhibit varying views among resources and skills (Hakanen et al., 2024; Ployhart, 2021; Prasad Agrawal, 2024). Managerial skills enable improved use of resources and must therefore be perceived as independent of resources (Prasad Agrawal, 2024).

Regarding the possible role of RDT to improve port operations, it is stated that RDT is founded on the concept that a firm cannot arrange all the resources required for its optimum performance, by itself (Drees & Heugens, 2013). Hence the firm may approach other firms to obtain the required additional resources and improve its productivity, against benefits (such as profit sharing). For example, if a CT operator takes a terminal for rent for operations, then a certain investment will have to be made to operationalize it. The CT operator may not spend 100% of its own funds to develop the CT for functionality. It may rather start by making the CT 40% to 50% functional, with a plan to progressively develop it from the earnings. However, investor firms may also be identified and approached for investment against incentive (for example, it wants to invest in port equipment QC/YC, yard trucks, technological equipment, provision of experts or temporary workforce), then the parent firm may consider it for negotiation before the final agreement. In this way, both firms can start benefiting concurrently. However, leverage beyond a certain level to the investors, should be avoided, so that they are unable to influence the decision-making and control of the parent firm due to dependency.

The RDT supports the outsourcing of some segments of port operations to investor firms, to an extent that the parent company retains control in decision-making by maintaining limited dependency on the stakeholder firm to avoid uncertainty. Participation by an investor firm saves the financial resources of the parent company. Moreover, both the investor and the parent company start earning from this investment, as per mutual agreement. RDT explains how organizations can reduce environmental interdependence and uncertainty. RDT agrees with the impact of outside influences on an organization's performance, yet despite constraints, managerial competence and skill in the parent firm could be instrumental in decreasing environmental ambiguity, obligation, and over dependence (Pfeffer & Gerald, 1978). The RDT has been examined to develop a theoretical basis. The study has been seen through the lens of the above theories.

2.5 Research Hypotheses

Hypotheses of the study, developed with literature support, are appended below:

H1 - Port technology has a positive impact on port logistics efficiency.

H2 - Port infrastructure has a positive impact on port logistics efficiency.

H3 - Port equipment has a positive impact on port logistics efficiency.

H4 - Port human resources have a positive impact on port logistics efficiency.

H5 - Port services have a positive impact on port logistics efficiency.

H6 - Port charges have a positive impact on port logistics efficiency.

H7 - Port technology has a positive impact on port logistics efficiency when mediated with port container management.

H7a - Port technology has a positive impact on port container management.

H8 - Port infrastructure has a positive impact on port logistics efficiency when mediated with port container management.

H8a - Port infrastructure has a positive impact on port container management.

H9 - Port equipment has a positive impact on port logistics efficiency when mediated with port container management.

H9a - Port equipment has a positive impact on port container management.

H10 - Port human resources have a positive impact on port logistics efficiency when mediated with port container management.

H10a - Port Human Resources has a positive impact on port container management.

H11 - Port services have a positive impact on port logistics efficiency when mediated with port container management.
H11a - Port services have a positive impact on port container management.
H12 - Port charges have a positive impact on port logistics efficiency while mediated through port container management.
H12a - Port charges have a positive impact on port container management.
H13 - Port container management has a positive impact on port logistics efficiency

2.6 Research Hypotheses Development

The quantitative methods are the best methodology chosen with a positivist approach, to objectively test and prove a set of hypotheses (Swanson & Holton, 2005). The purpose of the present study is to answer the research questions through the ensuing hypotheses.

In their study, Del Giudice et al. (2022); Jun et al. (2018) stated that technology is the applied application of knowledge. Beškovnik (2008) found that ideas to improve complex processes of CTs are being studied by improving port technology, infrastructure, equipment, HR, services, and charges to enhance the terminal output and capacity (Notteboom & Rodrigue, 2022; Vrakas, Chan, & Thai, 2021; Yau et al., 2020). Aprilianty and Evander (2017) discovered that an integrated IT system has an association with seaport facilities and efficiency. Javed et al. (2018) specified that the Internet of Things is a vital link for smart port operations. Yang et al. (2018) found that RFID improves traceability, identification, and tracking of containers, thus reducing human error, cost, and processing time, increasing CT efficiency. Medina et al. (2019); de la Peña Zarzuelo et al. (2020) identified that the use of laser, IT, and RFID sensors can change the seaport into a smart port. R. Chen et al. (2022) found that large-scale improvement in container handling can be achieved with existing port resources by adopting modern technology. Contemporary ports implement IT to integrate equipment for better port management (Bessid et al., 2020; Kapkaeva et al., 2021; Mi & Liu, 2022; Shafique et al., 2020).

The increased global maritime trade has forced ports to implement progressive digital technologies to uphold effectiveness and improve logistics efficacy. The technological advancement and process improvement with IT support to improve port operational and logistic efficiency (Q. Li et al., 2022; Othman, El Gazzar, et al., 2022; Vrakas, Chan, Thai, et al., 2021; Yau et al., 2020). As per the Economic Theory of the Port (ETP), ports operate as important connections in the carriage sequence where effectiveness, charges reduction, and throughput expansion establish their fiscal performance (Haralambides, 2017). Contemporary technologies, like Port Community Systems, digital customs platforms, automated gates, and actual freight tracking, decrease functioning bottlenecks, curtail ship reversal period, and rationalize data activities, hence refining overall logistics performance (World Bank & IAPH, 2023; Heilig et al., 2017). About Resource Dependence Theory (RDT), ports depend heavily on peripheral contributors, shipping lines, customs agencies, and regional logistics providers, whose arrangements and intelligence are mutually dependent. Technology permits ports to handle these dependencies successfully by increasing coordination, decreasing ambiguity, and harmonizing supply chain actions (Pettit & Beresford, 2009). Empirical findings depict that technology-operated ports attain better productivity, lower operation costs, and better freight-handling efficiency in contrast to conventionally operated ports (Heilig & Voß, 2017; Woo et al., 2018). Hence, consistent with both RDT and ETP, modern port technologies are expected to yield substantial improvements in port logistics efficiency. Port technology development reduces external operational constraints and enhances transformation capacity, thereby improving logistics efficiency. Thus, it is hypothesized that:

H1 - Port technology has a positive impact on port logistics efficiency.

Port infrastructure is generally identified as a primary contributing factor to logistics efficiency inside ports, as it models a port's capacity to manage ships, stockpile freight, and assist efficient freight movement. As per the economic theory of port (ETP), infrastructure quality, like quays, main port channel, stowage yards, road–rail connectivity, and cargo-management gear, clearly affects port productivity and cuts process and working charges (Notteboom & Rodrigue, 2020). As per Resource Dependence Theory (RDT) view, ports should continually upgrade physical resources to decrease environmental ambiguity, fulfil shipping lines' outlooks, and maintain attractiveness in international supply chains (Pfeffer & Salancik, 1978). Empirical studies depict that strong infrastructure substantially improves ship turnaround period, container dwell time, and inland connectivity, eventually increasing logistics performance (Cullinane et al., 2021; Yap & Lam, 2018). Hence, strong theoretical and empirical evidence suggest the hypothesis that port infrastructure positively affects port logistics efficiency. Findings exhibit that ports having advanced terminals, deeper approach channels, capable yard administration, and consistent inland networks attain better logistical results (Notteboom & Rodrigue, 2020). Infrastructure constraints, by contrast, establish operational chokepoints that hinder service quality. Hence, upgrading and increasing infrastructure helps as a strategic procedure through which ports improve logistics operations, invite shipping firms, and accomplish viable progress. Robust port infrastructure improvement lowers dependency on external logistical bottlenecks and supports efficient cargo flow, increasing logistics efficiency. Thus, the following hypothesis is proposed:

H2 - Port infrastructure has a positive impact on port logistics efficiency.

Port equipment, like quay cranes, yard cranes, yard trucks, and reach stackers, plays a key part in establishing port logistics efficiency. Contemporary equipment improves ship turnaround periods, decreases container dwell time, and enhances berth productivity, immediately impacting global operational efficiency (Stopford, 2009; Notteboom & Rodrigue, 2020). As per the Economic Theory of the Port (ETP), port working is molded by the ideal mixture of principal inputs, comprising equipment, human resources, and technology. Large cranes move high volumes, yet enhance insignificant productivity and lower usual operational expenditures, thus increasing logistics efficiency (Talley, 2017). According to Resource Dependence Theory (RDT), ports enormously rely on essential outside assets, especially equipment providers and technology sellers, to continue viable operations. By obtaining modern equipment, ports curtail operating liability, consolidate command over main handling procedures, and increase service reliability (Pfeffer & Salancik, 1978). Empirical studies further portray that ports employing advanced cranes and automated operating systems attain notably greater output and operational efficiency (Liu et al., 2020; Parola & Sciomachen, 2022). Hence, in consonance with the theoretical and empirical intuitions, it is anticipated that advanced and effective port equipment positively influences port logistics performance. Equipment reliability indicates operational discipline and reduces functional uncertainties, contributing to improved logistics efficiency. Thus, it is hypothesized that:

H3 - Port equipment has a positive impact on port logistics efficiency.

Human resource capability is progressively identified as a strategic factor of port logistics efficiency, specifically in intricate, technology-intensive maritime situations. As per the Economic Theory of the Port (ETP), port performance depends not only on tangible contributions like infrastructure and equipment, but also on the productive efficiency of human resources, which impacts container management, ship turnaround time, and CT service quality (Talley, 2017; Haralambides, 2019). Competent port employees facilitate precise paper handling, successful equipment management, and appropriate harmonization between port-related participants, thus reducing blockages in logistics chains. According to the Resource Dependence Theory (RDT) viewpoint, ports should train and hold extremely capable human resources to decrease uncertainty arising from outside environmental weights, like unstable freight demand, regulatory necessities, and technological transformation (Pfeffer & Salancik, 1978). Financing in training, digital protection competencies reinforce a port's inner potential, permitting it to effectively administer reliance and sustain operational strength. Empirical studies depict human resources growth, specifically in ICT skills, security practices, and operational decision-making, intensely improving port output and service reliability (Woo et al., 2013; Yuen et al., 2017). Hence, competent human resources and their development contribute to strengthening ports' adaptive capability and coordination performance, enhancing logistics efficiency. Hence, it is hypothesized that:

H4 - Port human resource has a positive impact on port logistics efficiency.

The quality and accessibility of port services, such as container management, cargo paperwork, warehousing, and ancillary support services, have a significant impact on the effectiveness of port logistics. According to academic research, effective port services improve overall port logistics efficiency by reducing bottlenecks, minimizing dwell time, and increasing throughput (Notteboom & Rodrigue, 2008; Brooks et al., 2017). According to Resource Dependence Theory (RDT), to sustain competitive operations, ports depend on both internal and external resources, such as shipping lines, service providers, and regulatory bodies (Pfeffer & Salancik, 1978). Effective service delivery improves operational predictability, which is crucial for logistics performance, and helps ports become less dependent on erratic outside variables. In a similar vein, the economic theory of the port (ETP) asserts that the provision of high-quality services influences trade volumes and economic efficiency by determining port productivity and cost-effectiveness (Lun et al., 2016). Therefore, by guaranteeing more efficient cargo flows, prompt vessel operations, and efficient coordination with hinterland transport, improving port services directly contributes to the operational efficiency of logistics processes. Consistent port services reduce exposure to operational risk and support uninterrupted logistics operations, improving efficiency. Considering these theoretical and empirical discoveries, the following hypothesis is put forth:

H5 - Port services have a positive impact on port logistics efficiency.

The effectiveness of port logistics is significantly impacted by port charges, which include tariffs, handling fees, and service costs. According to scholarly research, well-designed and transparent port fees enhance overall port efficiency by lowering operational bottlenecks, promoting prompt vessel scheduling, and increasing cargo throughput (Brooks et al., 2017). According to Resource Dependence Theory (RDT), ports must balance their connections with shipping lines and logistical providers while relying on financial resources to maintain and upgrade their equipment, services, and facilities (Pfeffer & Salancik, 1978). Ports can effectively utilize these financial resources because competitive and predictable port fees lower uncertainty for port customers and promote better coordination. In a similar vein, the economic theory of the port (ETP) proposes that suitable pricing mechanisms impact port productivity, cost-effectiveness, and shipper appeal, which in turn impacts trade volume and operational performance (Lun et al., 2016). In addition to maximizing cost allocation, transparent and well-planned port fees encourage quicker cargo handling, reduce dwell times, and boost logistics effectiveness. Strong port charges competitiveness reduces relational uncertainty and enables smoother coordination, enhancing logistics efficiency. In view of these theoretical and empirical discoveries, the following hypothesis is presented:

H6 - Port charges have a positive impact on port logistics efficiency.

It is commonly acknowledged that port technology, such as digital tracking platforms, automated handling systems, and Port Community Systems (PCS), is a major factor in the effectiveness of port logistics. According to scholarly research, cutting-edge technology systems increase port stakeholder coordination, decrease vessel turnaround times, and increase cargo throughput (Notteboom & Rodrigue, 2008; Brooks et al., 2017). However, port container management, which includes yard planning, stacking tactics, container tracking, and terminal operations management, often acts as a mediator between port technology and logistics efficiency. By maximizing resource allocation and reducing bottlenecks, efficient container management guarantees that technical investments result in increases in operational efficiency (Lun et al., 2016). To lessen uncertainty and reliance on outside parties like shipping lines and customs officials, ports use internal resources, such as container management procedures, according to Resource Dependence Theory (RDT) (Pfeffer & Salancik, 1978). Coordinated managerial and technological investments improve port productivity, lower operating costs, and boost trade competitiveness, according to the economic theory of the port (ETP) (Brooks et al., 2017). Thus, one of the most important ways that port technology increases the effectiveness of logistics is through port container management. Port technology development facilitates collaborative mechanisms that reduce inter-organizational dependency and jointly improve logistics efficiency. This logic leads to the following hypothesis:

H7 - Port technology has a positive impact on port logistics efficiency when mediated with port container management.

Berths, quay walls, storage yards, and intermodal networks are examples of port infrastructure that are commonly recognized as a crucial factor in determining the effectiveness of port operations. According to academic research, well-built infrastructure promotes effective cargo handling, speeds up vessel turnaround, and lessens congestion (Notteboom & Rodrigue, 2008; Brooks et al., 2017). However, port container management, which includes yard planning, stacking techniques, container tracking, and terminal operations coordination, often acts as a mediator between the beneficial impact of infrastructure on logistical efficiency. By maximizing container flows and reducing bottlenecks, effective container management guarantees that infrastructure expenditures result in improvements in operational efficiency (Lun et al., 2016). Ports use internal resources, such as container management systems, to lessen uncertainty and reliance on other parties, such as shipping lines and regulatory bodies, according to Resource Dependence Theory (RDT) (Pfeffer & Salancik, 1978). The port's economic theory (ETP) also asserts that by enabling more efficient cargo flows, infrastructure upgrades boost trade competitiveness, lower costs, and raise productivity. As a result, one important way that port infrastructure enhances logistics effectiveness is through container management. A robust infrastructure improvement strengthens collaborative operational processes, which in turn enhances logistics efficiency. Hence, it is hypothesized that:

H8 - Port infrastructure has a positive impact on port logistics efficiency when mediated with port container management.

For effective cargo handling and overall port logistics performance, port equipment such as quay cranes, forklifts, automated stacking cranes, and conveyors is essential. According to empirical research, well-maintained, contemporary equipment boosts throughput capacity, decreases container dwell time, and speeds up vessel turnover (Notteboom & Rodrigue, 2008; Brooks et al., 2017). However, port container management, which includes yard planning, stacking tactics, terminal coordination, and container tracking, often acts as a mediator between the influence of port equipment and logistical efficiency. By maximizing cargo flows and minimizing operational bottlenecks, efficient container management guarantees that investments in port equipment are adequately utilized (Lun et al., 2016). According to Resource Dependency Theory (RDT), ports rely on administrative and technological resources to reduce reliance on outside parties like terminal operators, shipping lines, and customs officials (Pfeffer & Salancik, 1978). In a similar vein, the economic theory of the port (ETP) proposes that productivity is increased, operational expenses are decreased, and trade competitiveness is increased when efficient equipment is combined with competent management. Therefore, one important way that port equipment improves the effectiveness of port logistics is through port container management. Equipment reliability promotes cooperative alignment among port actors, enabling collaborative mechanisms that support logistics efficiency. This leads to the following hypothesis:

H9 - Port equipment has a positive impact on port logistics efficiency when mediated with port container management.

For effective port operations and logistical performance, port human resources, which include skilled labour, administrative staff, and technical personnel, are essential. According to scholarly research, port workers who are properly staffed and trained improve cargo handling, vessel turnaround, and operational coordination, all of which contribute to increased logistics efficiency (Brooks et al., 2017; Lun et al., 2016). However, port container management, which encompasses yard planning, stacking tactics, container tracking, and terminal operations coordination, often acts as a mediator between human resources and port logistical efficiency. Smoother cargo flows and fewer bottlenecks are made possible by effective container management, which guarantees that human resource capabilities are fully exploited (Notteboom & Rodrigue, 2008). As per Resource Dependency Theory (RDT), ports use their own human resources to lower their reliance on outside parties like shipping companies, customs officials, and terminal operators (Pfeffer & Salancik, 1978). The port's economic theory (ETP) also highlights how effective management techniques combined with trained human resources boost operational productivity, lower costs, and improve trade competitiveness. As a result, one important way that investments in human resources enhance the effectiveness of port logistics is through port container management. Human resource capabilities enhance interactor coordination and knowledge sharing, which increases logistics efficiency through collaborative mechanisms. Thus, it is hypothesized that:

H10 - Port human resources have a positive impact on port logistics efficiency when mediated with port container management.

Crucial factors influencing the effectiveness of port logistics are port services, such as cargo handling, vessel scheduling, customs facilitation, and ancillary assistance. Excellent and well-coordinated port services improve overall port performance by reducing operational bottlenecks, curtailing cargo dwell time, and increasing throughput, according to academic literature (Notteboom & Rodrigue, 2008; Brooks et al., 2017). However, port container management, which includes container tracking, yard design, stacking techniques, and terminal operations coordination, frequently acts as a mediator between port services and logistics efficiency. Good container management improves cargo flow and minimizes delays by ensuring that service quality translates into quantifiable operational efficiency (Lun et al., 2016). Resource Dependency Theory (RDT) states that ports rely on internal resources, including container management systems, to control their reliance on other actors, such as shipping lines, regulatory bodies, and customs authorities (Pfeffer & Salancik, 1978). Effective container management and efficient service delivery boost productivity, lower operating costs, and improve trade competitiveness, according to the port's economic theory (ETP). Container management is thus a crucial technique by which port services enhance the effectiveness of port logistics. Consistent services promote trust and operational stability, strengthening collaborative mechanisms that improve logistics efficiency. Hence, it is hypothesized that:

H11 - Port services have a positive impact on port logistics efficiency when mediated with port container management.

Port charges have a big impact on how efficiently ports operate. These charges include tariffs, handling fees, and service-related expenses. According to academic research, well-structured, competitive, and transparent port fees can improve cargo throughput, promote timely vessel scheduling, and lessen operational bottlenecks, all of which improve port performance overall (Brooks et al., 2017). However, port container management, which includes container tracking, yard planning, stacking techniques, and terminal operations coordination, often acts as a mediator between port charges and logistics efficiency. Efficient container management guarantees the best possible allocation of port fee funds, increasing operational effectiveness and cutting down on delays (Lun et al., 2016). Resource Dependence Theory (RDT) states that ports manage their dependencies on other players, including shipping lines, customs officials, and regulatory bodies, by using their own management and operational resources (Pfeffer & Salancik, 1978). The economic theory of the port (ETP) also highlights how proper pricing mechanisms increase productivity, lower operating costs, and boost trade competitiveness when combined with efficient container management. Consequently, port container management is a major way that port fees enhance the effectiveness of port operations. The competitiveness of port charges fosters collaborative mechanisms that reduce uncertainty and enhance logistics efficiency. Thus, it is hypothesized that:

H12 - Port charges have a positive impact on port logistics efficiency when mediated with port container management.

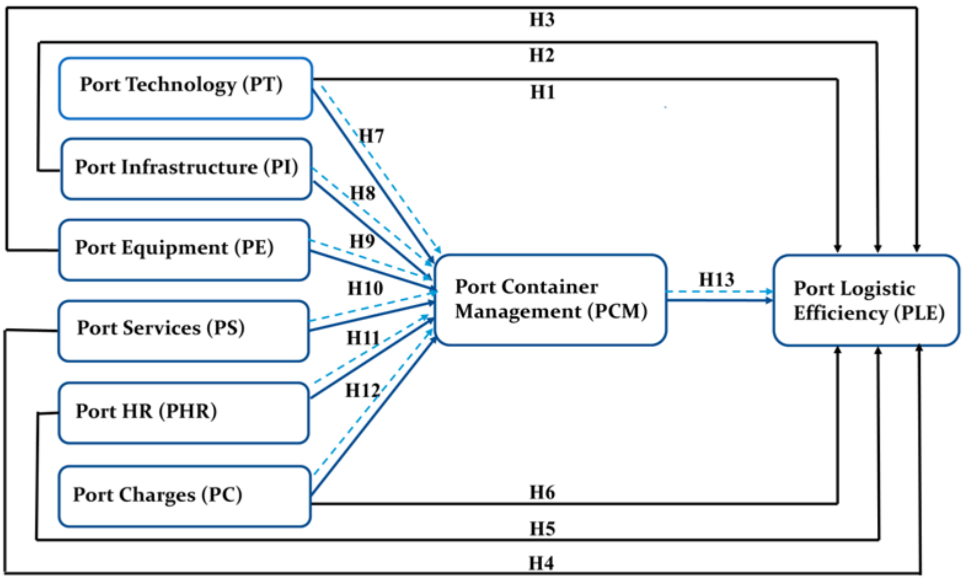
The Resource Dependence Theory (RDT) (Pfeffer & Salancik, 1978) suggests that organizations should realistically manage key assets to curtail uncertainty and improve performance.

In port circumstances, container management signifies a strategic resource system overseeing the flow, distribution, and management of containers all over the CT. Efficient container management improves scheduling, berth allocation, yard usage, and equipment disposition, thus upgrading logistics performance (Curvey, 2020; Ding et al., 2023). According to the Economic Theory of the Port (ETP), ports that improve container flow curtail operational bottlenecks, cut ship turnaround time, enhance throughput efficiency, and reinforce their competitive place (Notteboom & Rodrigue, 2023; Talley, 2017). Empirical research regularly exhibits that well-designed container management systems influence better productivity and efficient logistic flows. Hence, integrating strategic, managerial, and operational container management practices is anticipated to considerably increase port logistics efficiency. Container management mechanisms transform port capabilities into coordinated operational outcomes that directly improve logistics efficiency. With this premise, the following hypothesis is suggested.

H13 - Port container management has a positive impact on port logistics efficiency.

2.7 Research Model

Positivism is traditional research that can be addressed in an objective or scientific inquiry through relationships between variables to find the facts and answer the phenomenon (Zyphur & Pierides, 2020). Figure 2.10 presents a research model developed for the present study containing independent, mediating, and dependent variables.



Source: Author, with literature support.

Figure 2.13: Research model

= Indirect Effect = Direct Effect

2.8 Theoretical Development

The research model in Figure 2.10 shows the conceptual framework of this study. The purpose of this research model is to explore the impact of port resources on port logistics efficiency. That is a valid answer to the research question: 'Does port technology, port infrastructure, port equipment, port human resources, port services, and port charges have a positive impact on port logistic efficiency?'

Table 2.33: Variable and Theory Mapping

Construct/variable	Variable	RDT	ETP
Port technology	IV		
Port infrastructure	IV		
Port equipment	IV		
Port human resources	IV		
Port services	IV		
Port charges	IV		
Port container management	MV		
Port logistic efficiency	DV		

The research model has a total of eight constructs/variables. At this stage, we consider all variables to understand the model. The research model consists of six independent variables (IVs), one mediating variable (MV), and a dependent variable (DV). The six IVs are port technology, port infrastructure, port equipment, port human resources, port services, and port charges. The first four IVs are port resources with the help of which the port offers services (fifth IV) to clients, and levies port charges (sixth IV) for providing these services. Port container management is the MV, whereas port logistic efficiency is the DV.

As per the research model, all six IVs have a direct relationship with the DV, shown in black lines as H1 to H6 (hypotheses). All six IVs also have an indirect relationship with the DV through MV, shown by blue dotted lines, as H7 to H12 (hypotheses). The MV has a relationship with the DV shown by the blue dotted line as H13. The model will be tested through quantitative research, by primary survey data. SPSS and SmartPLS4 have been used for analysis as discussed later.

Explanation.

Theoretical foundation. The study is based on two pertinent theories, the economic theory of the port (ETP) by Talley (2006a) and RDT by Pfeffer (1978).

Hypothesis. Port technology has a positive impact on port logistics efficiency. (similar for all IVs)

Implications. The framework will guide the survey design and data analysis methods to test the relationships.

2.9 RDT and ETP with reference to Research Objectives (ROs)

Integrating Resource Dependence Theory (RDT) and Economic Theory of the Port (ETP) reinforces the study's theoretical framework by offering matching assessments on port management and logistics efficiency. The theoretical support by RDT and ETP to the research objectives is:

Firstly, in the case of RO1, ‘To determine which port resource capabilities impact logistics.’, and RO2, ‘To assess how port resources (technology, infrastructure, equipment, human resources, services, and charges), dimensions influence Karachi Port’s logistics performance.’ The RDT highlights ports' dependence on external and internal resources (that is, labour, infrastructure, equipment modernisation, IT systems) to function effectively (Pfeffer & Salancik, 2015). These dependencies’ structure strategic decisions regarding External Resources, such as Technical, infrastructural, and equipment dependencies; HR and Services, that is, collaboration with suppliers and labour unions for better working and facility management; External financing for infrastructure and equipment upgradation. The ETP emphasizes the advancement of port performance to minimize costs and maximize throughput efficiency (Saragiotis, 2019), concentrating on Port infrastructure and equipment investments that reduce turnaround time and handling costs; port technology for better information flow, operational coordination, and to cut idle time; HR for skills in logistics and container handling management; Port charges to cut costs, attract clients, and enhance throughput and port services for customer satisfaction and operational effectiveness.

In the case of RO3, ‘To examine how port resource capabilities shape container management effectiveness.’ According to RDT, the port relies on external entities like shipping companies, stevedores, and terminal operators for container movements. Interdependencies are managed through partners, outsourcing, or allied financing; RDT supports the idea of container management how well the CT unites and organizes critical resources. For RO4, ‘To evaluate the impact of port technology, infrastructure, equipment, human resources, services, and charges on port logistics efficiency’, the container management is seen by ETP as a subsystem to improve cargo moves and ship planning. Successful container movement, depending on several port resources, is converted to productivity. QCs, YCs, CY, IT systems, infrastructure, and workers are utilised. Mainly, ETP emphasizes cost-cutting and productivity (Tong, 2018).

For RO5, ‘To validate an integrated RDT and ETP port performance model within the Karachi Port operational environment.’ The RDT's efficient container management is achieved through effective coordination by skilled managers with crane operators, customs, carriage, and IT arrangements; managing dependencies well can result in better logistics and CT operations. However, in this case, the ETP is more effective as container management involves swift handling, stacking, and reducing dwell time to cut costs and improve throughput, and maintain service reliability. This helps in service efficacy and reduces transport costs.

Regarding RO6, ‘To determine the extent to which resource capabilities indirectly influence logistics efficiency through enhanced container management.’ Both objectives employ the two theories. On one hand, RDT emphasizes the implied impact of resource reliance. Support port competence to influence external and internal resource links in terminal operations. Technology can only improve productivity if integrated with CT operations. For ETP, the mediating role of container management displays the financial interconnection between inputs and outputs. Resources disturb intermediate operations, i.e., container movements, that successively impact logistic efficiency, supporting ETP’s input-output reasoning. Hence, Efficient container management becomes the main path through which resource investments convert into financial performance.

2.10 Literature Support to Research Objectives

The reviewed literature provides significant support for the research objectives (ROs). For RO.1 and RO2, the adoption of advanced technologies enhances information flow and operational coordination, leading to reduced idle times and increased supply chain responsiveness (Gupta et al., 2019). For instance, automation can lower operating costs by 15-35% (Financial Times, 2025). High-quality port infrastructure is necessary for efficient logistics performance. Investments in infrastructure enhance a port's ability to handle larger volumes of trade (Munim & Schramm, 2018). For RO3, modern and well-maintained equipment, such as cranes and handling machinery, is essential for efficient port operations. The integration of automated cranes and guided vehicles streamlines cargo movement and cuts labour costs (Financial Times, 2025). Skilled labour in logistics and cargo handling contributes significantly to efficient port operations (Khan et al., 2022); (Hussein & Song, 2022). Skilled labour is crucial for managing complex port operations and adapting to technological advancements (Othman, El Gazzar, et al., 2022). Good services meet user satisfaction and enhance port efficiency (Alsalfiti & Notteboom, 2025); (Nguyen et al., 2022). Pricing strategies influence cost-effectiveness and user choices, directly impacting overall throughput (Moghaddam et al., 2023); (Pajić et al., 2024). Port charges influence the cost-effectiveness of shipping routes and can affect a port's attractiveness to ships.

For RO4 and RO5, implementing technology can increase the capacity and efficiency of a port by optimizing loading and unloading operations, which is crucial for effective container management. Efficient container handling depends on investments in cranes, yards, and IT systems, aligning with the emphasis on cost minimization and productivity. Induction and management of skilled labour are crucial for maintaining logistic efficiency in container management. Quality services ensure smooth container handling processes, directly impacting container management effectiveness. Port charges can influence the cost structures of container handling, affecting decisions related to container management strategies. For RO6, effective container management, i.e., swift loading/unloading and stacking, cuts cost and boosts logistic performance like throughput and service reliability. Effective container management depends on a port's ability to secure cooperation and timely inputs from various stakeholders, leading to smoother logistics operations and improved overall efficiency. The combined effect of port resources on logistic efficiency is mediated by container management practices. Investments in technology, infrastructure, equipment, human resources, and services enhance container management capabilities, which in turn improve overall logistic efficiency.

2.11 Contribution of the study with reference to research gaps.

The existing literature on Karachi Port operations offers valuable insights into various aspects of port efficiency and container management. However, several research gaps persist, highlighting the necessity for a focused study on the impact of container management on the port's logistic efficiency. The research by Shahzad (2022) identifies key performance determinants of Karachi Port and suggests methods to mitigate delays. It mainly discusses liquid and general cargo while not relating to theories. Yet, it does not delve into the specific role of container management practices and their direct impact on logistic efficiency with a theoretical linkage. The study by Jaffry (2024) revealed the challenges in transporting containerized cargo from industrial zones to Karachi Port, highlighting issues such as the preference for trucking over rail and complexities in customs clearances. Yet, it does not comprehensively assess how container management within the port influences overall logistic efficiency. The studies focusing on vessel productivity at Pakistani CTs provide insights into operational gaps and potential enhancements. However, these analyses primarily focus on comparative aspects of liner services and do not extensively explore the broader implications of container management practices on the port's logistic efficiency. The recent developments, such as CK Hutchison Holdings' plan to invest $1 billion to upgrade port operations in Pakistan, aim to enhance operational efficiency through automation and improved logistics connectivity (Reuters, Feb 2025). While these initiatives are promising, empirical research assessing the impact of such technological advancements on Karachi Port's logistic efficiency remains scarce. Karachi port confronts enormous challenges in transforming by adopting modern systems for Port automation. In the three CTs in Karachi port, the progress observed during the last twenty-five years has only brought Ship-to-Ship (STS) and Rubber-Tyred Gantry (RTG) cranes to CTs. While some of the recent acquisitions are semi-automatic cranes (USAID, 2021). Addressing these research gaps is essential for developing targeted strategies to optimize container handling processes, reduce turnaround times, and enhance Karachi Port's performance in regional and global maritime contexts.

Summary and linkage with the next chapter

This chapter contains a literature review of the variables of the study. It comprises the theoretical perspective, the supporting research theories, hypothesis development, the research model, and the theoretical development. The discussion in this chapter has set the ground for proceeding further with the study. The next chapter will hence discuss the methodology of this research work.

CHAPTER 3

3 RESEARCH METHODOLOGY

The current segment explains the proposed research design and methodology for the existing study and justifies the adopted methodological choice and type. It also discusses the research instrument, population and sampling sample size, sampling technique, time horizon, unit of analysis, data collection methods, analysis techniques, and ethical considerations. This segment also explains the use of Partial Least Squares Structural Equation Modeling (PLS-SEM) and statistical analysis to estimate the reliability and validity of the research model.

3.1 Research Philosophy

The phrase 'research philosophy' is related to the progression and nature of Knowledge (Fellows & Liu, 2021). As per Al-Ababneh (2020), each research design is supported by a particular research philosophy. Hence, recognizing an appropriate research paradigm is significant in the development of research (Ugwu et al., 2021). Research philosophy can be classified into three major approaches: positivism, interpretivism, and pragmatism. Normally, a positivist paradigm is associated with the quantitative research approach, because the key supposition behind this paradigm is that there is one reality that can be revealed using empirical testing (Creswell, 2014; Erciyes, 2020).

This study is guided by a positivist research philosophy, which is rooted in the assumption that reality is objective, observable, and can be measured through empirical evidence. Positivism is particularly suitable for this study because it aims to examine causal relationships between quantifiable variables and supports the study's objective of assessing how port resources affect container management and port logistics efficiency.

As portrayed in Table 3.1, the Positivist research paradigm appears to be the most appropriate research paradigm to ascertain the impact of port Container Management on port logistic efficiency. The paradigm presumes that the knowledge is founded on the confirmed hypothesis, which assists in discovering the reality that can be generalized (Layder, 2021). The data-gathering technique implemented is mainly quantitative (Mohajan, 2020). Besides, this study includes theory integration and testing to ascertain the impact of Container Management on port logistics efficiency to validate and generalize the results.

Table 3.1: Research philosophy of this study

Research Philosophy	Positivism
Ontology (How the researcher views the nature of reality)	It is external, portrays objectivity and objectivity, and is independent of social actors.
Epistemology (What the researcher thinks constitutes the knowledge)	Observable phenomena provide reliable data
Axiology (What the researcher thinks about the role the values play in)	The researcher is independent of the data
Data Collection (Techniques most often used)	Highly structured, large samples, measurement, quantitative, can use qualitative.

Adopted from: Bell and Bryman (2007) and Mark, Philip, and Adrian (2011)

Positivism is a suitable approach for this research as it focuses on gathering measurable data to evaluate elements such as technology, infrastructure quality, equipment utilization, workforce productivity, service standards, and charges (Ali, 2024). Positivism enhances the credibility and reproducibility of the study's outcomes by minimizing researcher bias. It also permits the formulation and statistical testing of hypotheses regarding the relationship between port resources and logistics effectiveness.

The positivist approach supports the use of structured instruments like questionnaires to collect data, statistical methods for analysis, and hypothesis testing based on empirical observations (Dehalwar & Sharma, 2023). This aligns with the study's objective to develop and test a theoretical framework using quantitative data obtained from port and logistics professionals. Positivism also assumes researcher neutrality, which was maintained by using standardized questions and minimizing interaction with respondents during data collection to reduce bias.

The study employs structured surveys with closed-ended questions, demanding reliability and clarity in responses. Analytical tools like Partial Least Squares Structural Equation Modelling (PLS-SEM) help explore complex interrelations between multiple constructs and variables (S. Wang et al., 2024). The large sample size and thorough analysis contribute to findings that can be extended to wider applicability beyond Karachi port. Earlier research in maritime port logistics, related to technology use and congestion management, e.g., (Mlimbila & Mbamba, 2018) has effectively employed positivist methods to produce empirical findings. Adopting a positivist stance equips this study with a reliable, evidence-based framework for analysing logistics efficiency, making the results reliable and relevant to broader port management contexts.

3.2 Research Approach

As per Saunders et al. (2019), the level to which your study is concerned with theory testing or theory-building raises a prominent question concerning the design of your research study. It is frequently defined as two opposing methods: deductive and inductive. Selecting an appropriate research approach is an important step. This research study has adopted a logical method, commencing with a theory originating from earlier literature and related research studies. The research work commenced with a review of preceding work and literature on port logistic efficiency, concentrating on its concept, measurement, and association with additional variables, including port resources, services, charges, container management, and port logistic efficiency. After an extensive literature review, a research model was developed, and hypotheses were framed. This research aims to study the current efficiency level of Karachi Port and the effect of container management on its logistic efficiency and thus is explanatory (Shoukat & Xiaoqiang, 2023). The quantitative method has been employed to collect data to answer the research questions and address the objectives. Quantitative research is designed to study a relatively large number of people and to test the relationships of variables in an existing theory (Mohajan, 2020).

3.3 Research Strategy

The research strategy of the study is presented in Figure 3.1. The research process started with a literature review, as the problem and research questions were developed by identifying research gaps from the literature. Before finalizing the survey, this research formulated a model based on literature that specifies possible relations among these factors and helps in developing a hypothesis to test this correlational, explanatory study through a set of hypotheses. The nature of this study is cross-sectional, which employs quantitative research methods using snowball convenience sampling, to collect data for statistical analysis and to acquire results. The survey approach includes all variables utilized to define the scope of the study. The nature of survey research distinguishes it from other methods as it generates quantitative data from the population and the results may be generalized to population in standard areas. This substantially contributes to the existing literature.

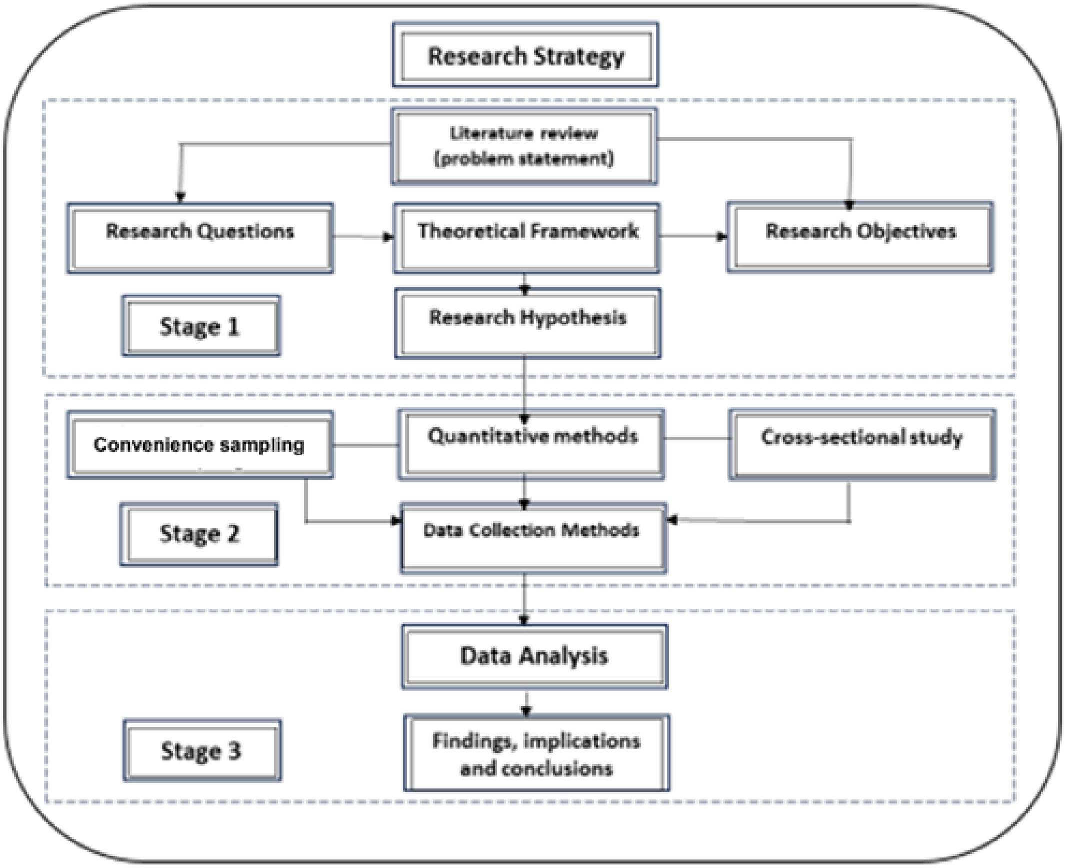


Figure 3.1: Research Strategy

3.4 Research Design

The general structure of the research is called research design (Kumar & Praveenakumar, 2025). It is founded on the kind of study planned and the outcomes anticipated. An old-style research design generally presents how a research study is based on research questions or problems, as well as the operationalization of variables to measure them by choosing an appropriate sample to study. Data gathering is the basis for testing hypotheses and examining the outcomes. The research design for the present study is a non-experimental, explanatory correlational research design. As per Zhao et al. (2021) The nature and direction of association among pertinent variables are ascertained and clarified by correlational research (Edwards & Bagozzi, 2000). Rather than just defining the variables with descriptive research, correlational proceeds a pace ahead to examine the relationships among variables. A correlational study involves assessing data to see if any relationships exist. Appropriate selection of the research design or methodology guides the research to conduct quality research and produce significant results (Saunders and Lewis, 2019). Thus, given the aim and objectives of the study, to offer uniform information regarding the constructs and their associations with the other variables being deliberated (Malhotra & Galletta, 1999), the quantitative methodology based on the positivist research paradigm is used.

The researchers implement a survey research design for quantitative analysis (Queirós et al., 2017). Hence, in this study, the survey research method is used due to its aptness with the study objectives to gather respondents' data and examine the relationships among the port-related constructs of technology, infrastructure, equipment, human resources, services, charges, container management, and logistics efficiency at Karachi port. The structured questionnaires were circulated to academics and related maritime professionals to assess the appropriateness for adoption within the context of container ports (Othman, El-gazzar, et al., 2022). The structured questions, adapted from the literature, were shared with maritime port experts for input. The adapted survey items were modified based on reviews and suggestions of industry experts and specific researchers. The items were adapted from earlier studies and vetted by experts to align with the study's overall instrument pattern for standardization and better understanding of the respondents. The professional's opinion helped rationalize the survey instrument for better comprehensibility and clarity for the respondents.

3.5 Population and Sampling

3.5.1 Population of the study

Population denotes the cosmos of units from which the sample must be chosen (Bell and Bryman, 2007). Choosing elements from a topic-related population is a sampling strategy used to reach a reliable conclusion about the population and the research topic (Blumberg et al., 2011). In general, the sampling strategy depends on the methods chosen and the availability of resources (Kemper, Stringfield, and Teddlie, 2003). In this quantitative method study, the employees working in the maritime CTs and related organizations (public and private) comprise a targeted population of the study who were involved in the operations, logistics, decision-making, container management, and administration of this aspect of the maritime sector. They contribute to the maritime sector's growth and market share, making it a prominent sector in the service industry that contributes to national earnings and the development of the hinterland. Units of analysis can be individuals, cities, countries, regions, and organizations. This study is intended to evaluate the relationships among port technology, its infrastructure, equipment, human resources, services, and charges as input with port container management as a mediator and port logistic efficiency as the dependent variable to determine the efficiency of Karachi port.

The target population involved professionals from CT operations and port management teams, shipping firms, individuals involved in logistics and customs activities at Karachi Port, and other related organizations. Karachi Port has been the focus of this research as it controls about 60% of Pakistan's national trade, while running three major CTs (KICT, KGTL (former PICT), and

SAPT), but struggles with continuous container management and logistics performance issues. The port functions as an excellent illustration of developing port facilities that encounter challenges in infrastructure, as well as technological and management sectors. The research area concentrates on Karachi Port, but the examined variables and port challenges apply to numerous South Asian ports, along with developing economic ports worldwide. The research findings can help guide operators of ports with comparable limitations who wish to improve their operational efficiency using constrained resources.

3.6 Population and Sampling Techniques:

The target population for this research involved managerial, operational, and technical employees involved in logistics, management, services, and CT operations at Karachi Port. The respondents were chosen because of their close association with port logistics practices and managerial matters, which are associated with suggestions to choose experts in port-connected considerations (Rodrigue & Notteboom, 2020). While probability sampling is usually favored to confirm characteristics, the COVID-19 virus generated serious availability issues, restricting the scholar and respondent collaboration and lowering cooperation to contribute to direct interactions or surveys. Moreover, there was an atmosphere of hesitation to fill in the form in the CTs, probably due to company policies to safeguard information, time limitations with the individuals, and no benefits. Among KPT officials, the input on the questionnaire was very slow. Reminders helped to a certain extent, yet referrals assisted in persuading some respondents. Entry to the CTs was by appointment and restricted in time and individuals, due to their own commitments as well. The Hong Kong-based HPH management was extra cautious as COVID-19 had spread from China. In such situations, scholars suggest that non-probability approaches, particularly convenience sampling, become a practical and justified alternative when the population is hard to access (Etikan et al., 2016). Consequently, this study adopted convenience sampling, enabling data collection from available and willing participants while maintaining continuity of research during pandemic-related restrictions, consistent with methodological adaptations recommended in crisis-affected research settings (Abdullah et al., 2021; Notteboom et al., 2021)

3.7 Pilot Study: Addressing Reliability and Validity

A comprehensive pilot study was conducted before the main research to ensure the reliability and validity of the research instruments. Firstly, for instrument development, the survey items were carefully adapted after an extensive literature review and expert consultations to accurately capture the constructs of interest. Secondly, six subject matter specialists reviewed the instruments to assess content validity, ensuring that the items appropriately represent the constructs they intend to measure. Thirdly, the instruments were administered to a small sample of 85 respondents from the target population for pilot testing. Fourthly, for reliability assessment, the internal consistency of the instruments was evaluated using Cronbach's Alpha coefficient, with a threshold of 0.70 considered adequate. For example, a pilot test assessed the reliability of the instrument items, reported a Cronbach's Alpha between 0.724 and 0.915, indicating reliable internal consistency. Lastly, for validity evaluation, the item-total correlations were calculated using Pearson's correlation coefficient to assess the degree to which each item correlates with the total score, ensuring each item contributes meaningfully to the construct. Also, content validity was evaluated through expert judgment, and construct validity was assessed by examining relationships between the instrument and external criteria.

The pilot study results demonstrated that the instruments possessed satisfactory reliability and validity, confirming their suitability for the main study as mentioned in para 3.7. This rigorous pre-testing phase enhances the credibility of the research findings and supports their potential applicability to broader contexts. As per information obtained during Karachi port visits, nearly 2,400 employees are working in the chosen maritime logistic organizations. The employee population base is linked to Karachi Port and related maritime logistic organizations, particularly CTs, Karachi Port Trust head office, and shipping and clearing firms. The maritime transport and logistics sectors are a vital part of the service industry and a contributor to the national GDP and regional development.

The population targeted in the research consists of top, middle, and lower management, including operations, logistics, technical, and administrative managers working at CTs, Karachi Port Trust Head office, and shipping and clearing firms. As per Shen et al. (2020), top managers are understood as people who are employed in public firms as members of the top administration team in designations, for example, Chief Executive Officer (CEO), General Manager (GM), Supervisor, Vice President, and Director. These individuals are straightforwardly concerned with important policy formulation except for the board of directors. The geographic area must be decided after determining the target population (Sekaran, 2006). Hence, the geographical area for these participants mainly encompasses the Karachi container port and related areas due to their important role in the functioning and productivity of the CTs. A limited related population is also available in major cities like Islamabad, Rawalpindi, and Lahore, which were chosen for data collection due to several reasons. Initially, prominent maritime logistics companies had their sub-offices in major urban centers. Secondly, in the urban areas literacy rate is higher, and there is more awareness related to maritime transportation, its services, and charges. Thirdly, there are maritime-related public and private officials (serving and retired) available in Islamabad and Rawalpindi area, making it easier for the researcher to have maximum interaction. The target population is shown in Table 3.2.

Table 3.2: Target Population

Organization	Top Management	Middle Management	Lower Management	Others	Total
KICT	15	43	188	321	567
KGTL (Ex PICT)	11	34	149	309	503
SAPT	14	39	165	318	536
KPT	9	45	60	523	637
Shipping and clearing firms	2	56	56	-	114
Total	51	217	618	1471	2357

Source: Data obtained from CTs, KPT head office, shipping firms, and websites

3.7.1 Sample Size

A consistent sample size is a requirement for generalizing the results. Studying the entire population is a difficult process and needs added resources, time, and expenditure. To overcome this issue, samples are chosen to evaluate, and the outcomes are generalized to the whole population. A good representative sample of any population reflects the characteristics of the population, even though it is smaller. The sample size is essential to the research design (Lynn, 2002). Diverse methods have been discussed in the literature to obtain a suitable sample size. Sekaran (2003) proposed that sample sizes above 30 and equal to 500 are reasonable. Cohen (1992) suggested sample size selection for PLS-SEM as per the maximum number of arrows pointing at a construct in the study model (RVSPK et al., 2020). Horwath (2021) recommended a sample size of 150 to be appropriate for a model having above three indicators per factor. Sekaran (2006) has recommended a sample size of 278 for a target population of 1,000, 322 for a population of 2,000, 341 for a population of 3000, and 331 for a population of 2400. In the study by Saunders et al. (2007) and Saunders (2017), the sample size for the target population at a 95% confidence level has been proposed. For a target population of 1,000, the size is 278, for 2,000 it is 322, for 5,000 it is 357, and it is 327 for 2,400 (by interpolation). During the data collection phase, 332 valid responses were obtained through a survey. Hence, a sample size of 332 supports (Sekaran & Bougie, 2016) and (Saunders & Bezzina, 2015) deductions, and meets the research requirement. An extract of the sample size tables by Saunders and Sekaran is in Appendix D.

3.7.2 Sampling Technique

Sampling is one of the most powerful tools in research. It is an essential part of methodology as it is used to select the respondents from whom the data is collected for its benefits, including greater accuracy of results, low cost, and data collection (Cooper, Schindler, and Sun, 2006). The study used convenience sampling as an approach because respondents from the maritime sector proved difficult to access due to the limited availability of terminal managers, KPT managers, port operators, and customs officials. The operational sensitivity of Karachi Port, together with limited stakeholder accessibility, prevented the use of probability-based sampling methods. The researcher was able to collect important data by using convenience sampling because it selected knowledgeable and available respondents during the data collection phase. The technique made it possible to obtain data from multiple stakeholders, but researchers should consider its downsides. The method of convenience sampling produces possible biases in collected data, which limits the complete generalization of study results across the entire population. The utilization of participants from different managerial levels (lower, middle, and top management) from diverse departments of various organizations managed to enhance the data's diversity and applicability and thus diminished the sampling bias effect. Future researchers must implement probability-based sampling because it helps minimize limitations in the generalization of findings despite restricted access to sample populations. Typically, probability sampling (random, cluster, stratified, and systematic) and non-probability sampling (judgmental, quota, and convenience sampling) are used in research (Saunders, 2003). Convenience sampling is carried out by locating possible respondents who meet the expected criteria and choosing them on a first-come-first-served basis till the sample size is attained (Robinson, 2014).

3.8 Rationale for Convenience Sampling

The convenience sampling was employed in this study due to time constraints, limited resources, and the need to access specific stakeholders during COVID-19 constraints. To elaborate a bit, due to limited budget and timeframe, convenience sampling was used as it offers an economical and efficient data collection method, utilizing readily accessible respondents. It also helped in circumventing the practical constraint due to COVID-19. Convenience sampling facilitates easy access to stakeholders such as port authorities and logistics managers to guarantee practical data collection. As an initial exploration into the impact of container management, convenience sampling facilitates the collection of pilot data for future, thorough studies. Convenience sampling has certain limitations, specifically regarding the generalizability of findings. Participants selected based on availability may lead to selection bias, as the sample may not accurately represent the broader intended population of port stakeholders. Non-random selection of participants limits the ability to generalize findings to the broader population of stakeholders within the port industry. To address these limitations, the study implements the following strategies, such as documenting the sampling method and its limitations, and informing readers of the study's context and scope. Interpreting results in the context of Karachi Port acknowledges that findings may not be broadly applicable to all port settings. Yet due to standardised processes at CTs worldwide, certain common findings may apply to other CTs as well, particularly in developing countries.

As the data regarding Karachi maritime port CTs and KPT head office employees was not readily available, due to confidentiality and non-availability during the COVID-19 phase, the use of the probability technique was difficult to use. Hence, a non-random and non-probability convenience sampling technique was utilized in this study. The data collection was undertaken from September 2022 to June 2023, whereas COVID-19 officially ended in May 2023 (Q. D. Nguyen et al., 2023). Several employees either worked in shifts or avoided meetings due to company policy, owing to the risk of pandemic infection, posing data collection difficulties. Due to the non-availability of respondents, hesitation to interact, access difficulties, and reluctance to participate in a survey, it was appropriate to use this technique. The above constraints led to a time lag in getting responses from respondents, which helped to mitigate, if not avoid, bias. Some researchers have stated that convenience sampling is prone to research biases and low generalizability (Saunders et al., 2005). However, it was difficult and almost impossible to use other probability methods due to a readily available list of maritime industry employees, particularly CTs in Pakistan, and their unavailability or provision due to confidentiality. In summary, while convenience sampling is employed due to practical considerations, the potential biases and limitations are acknowledged and addressed to provide a clear understanding of the study's scope and the applicability of its findings.

Till data collection, the three CTs at Karachi port were being operated by international terminal operators. The Pakistan International Container Terminal (PICT) was operated by Philippines-based International Container Terminal Services (ICTSI). The Hong Kong-based Hutchison Port Holdings (HPH) operated two other CTs, the South Asia Pakistan Terminal (SAPT) and Karachi International Container Terminal (KICT). Each CT followed stringent rules regarding COVID-19 precautions. Apart from entry restrictions for visitors, there were meeting constraints for employees within the CTs. The Hong Kong-based HPH was more cautious as COVID-19 had spread from China.

The focus of this study was the managerial employees working in various departments of the CTs at Karachi port, KPT head office, shipping firms, and related organizations, which contribute to the port's operational and logistics performance. The array and size of the sample are presumed to be the strong points of this study. Data collection was carried out in phases as the maritime port and CTs are scattered, and various port organizations are segregated for their services. Hence, a two-stage sampling technique was applied in this study. The first stage dealt with selecting Maritime logistics organizations that support improved container management, thus contributing to greater port productivity and efficiency. The second stage dealt with choosing employees working in specific departments contributing to port operations and logistic activities. Managerial employees were chosen due to their strategic outlook, role, and involvement in decision-making during port operations and logistic activities. Moreover, better insight into the seaport managers, greater opportunities to interact, and reliability of the shared information made managers the preferred choice as respondents.

Stage 1: Choice of Container Port-related Maritime Logistics Organizations

The first step was to select Maritime logistics organizations from where data could be collected. For the selection of Maritime logistics organizations from the targeted population, a convenience sampling technique was used in which current study participants referred to other prospective participants among their acquaintances for data collection (as explained in para 3.6). The focus of the current study is to examine container-related maritime operations and logistics efficiency for better container management. Thus, the maritime port and CT-related organizations that could contribute to improving container management and logistic efficiency were chosen for data collection. It is evident from earlier studies that organizations that achieve higher productivity with fewer resources are considered more efficient, as they generate higher output at lower cost.

In the COVID-19 period, there was an unusual constraint on traveling and meeting port officials. Initially, the shipping and clearing firms were contacted by telephone to learn their views about container handling processes in various CTs at Karachi port. Meetings were undertaken with the middle and higher management of the National Institute of Maritime Affairs (NIMA), Ministry of Maritime Affairs (MoMA), contacts in the Merchant Navy, and Pakistan National Shipping Corporation (PNSC) to obtain information and referrals intended for various container-related maritime logistic organizations. More important organizations visited were Pakistan International Container Terminal (PICT), Karachi International Container Terminal (KICT), South Asia Pakistan Terminal (SAPT), Karachi Port Trust (KPT) head office, shipping and clearing firms, and logistic providers to the port. The referrals were contacted, and a mixed response was experienced. The most valuable contacts were those provided by NIMA, who generally covered the operations and logistics related to senior and middle-level management of the above-mentioned maritime organizations. The referral in one maritime organization facilitated the researcher to contact with the managers or referrals in another organization working in the general management, operations, logistics, or technical domain. In short, the data has been collected from five major container-related maritime logistic organizations related to Karachi port, such as PICT, KICT, SAPT, KPT head office, and the shipping and clearing firms. The Google form link was distributed through the operations and logistics managers by contacting other referrals who dispersed or shared the Google form link with potential respondents. The list of maritime logistics organizations is in Table 3.3.

Table 3.3 List of Selected Maritime Logistic Organizations

S No	Organization	Nature of organization
1.	Pakistan International Container Terminal (PICT)	Container Terminal
2.	Karachi International Container Terminal (KICT)	Container Terminal
3.	South Asia Port Terminal (SAPT)	Container Terminal
4.	Karachi Port Trust (KPT)	Port Authority
5.	Shipping and Clearing Firms	Shipping and Clearing Firms

The geographic zone must be ascertained after defining the target population (Sekaran, 2006). Four cities, i.e., Islamabad, Rawalpindi, Lahore, and Karachi, were selected for data collection for three reasons. First, the seaport, CTs, Karachi Port Trust, and most of the shipping and clearing firms are located near Karachi port. Secondly, nearly all CTs, KPT, and shipping and clearing firms have their main operations and regional offices there. Thirdly, being a large metropolitan city, it has a high literacy rate, and the maximum number of container-related maritime logistic service providers and port employees are available in the local offices, making it easier for the scholar to obtain a maximum number of respondents. Due to these reasons, Karachi City had been primarily selected for data collection for the current study.

Three other cities, i.e., Islamabad, Rawalpindi, and Lahore, were also selected for data collection due to the following reasons. First, these major cities had a sizable presence of container-related maritime logistic retired employees, who were comparatively easier to approach. A few shipping and clearing firms and service providers also had their sub-offices in these cities. Secondly, the National Institute of Maritime Affairs (NIMA) is in Islamabad, whose officials frequently visit Karachi port and helped introduce the researcher to important managerial contacts in maritime organizations. Thirdly, the MOMA officials are available in Islamabad for possible discussion on maritime affairs. Fourthly, the above being bigger cities with higher literacy, and Karachi port officials visiting government offices in Islamabad and post-retirement settlements, etc., more respondents could be found. Due to these reasons, three more major cities were selected for data collection for this study.

The interviews and discussions were undertaken with several managers at Karachi port, CTs, KPT, shipping firms, and subject matter specialists to learn in detail about the working and problems being faced at Karachi port. However, the complete process for qualitative research was not done, as this research is mainly quantitative in nature. The discussion took place during several visits to Karachi. The salient officials with whom discussion took place included the Minister for Maritime Affairs, Chairman KPT, DG operations KPT, Traffic manager, technical and other KPT managers, DG NIMA, and other Directors at NIMA, Senior, middle, and lower managers at SAPT, KICT, and PICT, and managers at shipping and clearing firms. Besides, the discussion on Karachi port also took place with several other serving and retired CT, maritime port industry, and logistics-related officials. For example, former chairman KPT, CT managers, container ship captains, Manager Private container storage companies, Director Maritime Affairs at Pak secretariat, etc. The interviews and discussions also helped with topic identification and validation.

Summary of the problems enunciated from discussions with the above officials covered areas such as; infrastructure inadequacy, congestion in port, manual process at gates and fewer entry and exit points, untrained truck drivers not adhering to safety instructions in CT, lack of technology adoption and its training, some old equipment needs upgradation, human resource training and capacity building, poor customs clearance process, uncleared containers occupy unnecessary port space (KPT and customs to decide disposal), Karachi Dock Labour Board and its union is an irritant. Port charges are high, services are satisfactory at the quay for loading and unloading containers from ships, but delays occur in the yard due to customs clearance, identification issues, and the handling process. The intermodal rail and road connectivity is not up to the mark, which amounts to slower working and longer dwell time.

Stage 2: Selection of Respondents within the Port Logistics Organizations

Once the container-related maritime logistic organizations were selected, the second phase was determining the respondents to obtain the data in these organizations. Previous studies on port logistics efficiency have adopted several sampling techniques and sample sizes to select the respondents (Le et al., 2020). The respondents should be aware and well-informed about the related activities among the constructs used in this study. Thus, it was important to ensure that the respondents were from maritime port-related organizations that were involved in CT operations and logistic processes. There is no consensus on the methodological sampling approach of studies in the maritime industry.

The perspective of the current study was the container-related maritime logistics industry. The interest of the study was those maritime logistic resources, factors, and organizations that contribute towards higher efficiency and productivity. The list of various maritime logistic employees was not readily available in the selected organizations due to their secrecy and confidentiality during and toward the end of COVID-19 (Cheng et al., 2023). To ascertain that the online Google form link reaches the prospective respondents, in a certain department, the researcher contacted the Operations Manager or a referral in the selected maritime logistics organization. The related Manager or referral facilitated the researcher to disseminate the Google form link or a hard copy of the survey to respondents who met the criteria.

In this study, it was essential to ensure that the respondents were maritime logistics employees who met the following conditions: first, they must be from a particular section primarily responsible for promoting operational efficiency of port logistics. Second, the age group of the respondents ought to be between 20 to 60 years, as the average qualifying age for undergraduate studies in Pakistan is 20 years, and the superannuation age is 60 years in many of the maritime logistic organizations in Pakistan, except where a more skilled resource is required. Third, respondents must preferably hold at least an undergraduate degree to comprehend and complete the survey. All three levels of respondents, including the top, middle, and lower management, were selected in the study to address the limitations of earlier studies and to avoid common method bias. Initially, the operation and logistics managers or referrals in the selected maritime organizations were contacted. These individuals helped disperse the online Google forms and the printed survey forms to prospective respondents who met the criteria. This dispersal process was repeated a few times after a gap of two to three weeks. Some respondents were also approached through LinkedIn, which helped to increase the outreach to the respondents and resulted in obtaining valuable input. The key departments responsible for contributing to the operational efficiency of port logistics are operations, logistics, technical, and administrative, as they cover the technology, infrastructure, equipment, HR, services, and charges, which help maintain the level of container management for better port logistics efficiency.

3.8.1 Unit of Analysis

The unit of analysis in this research is members of the maritime logistics chain. Specifically, since this research aims to quantitatively validate the proposed conceptual model, the unit of analysis in this phase comprises managerial employees of the CTs at Karachi port, shipping and clearing firms/logistics service providers, and the KPT head office. The study then examines the effect of port resources on its operations and the impact of container management on port logistics efficiency. Therefore, the chosen unit of analysis as respondents may be seaport managers among the top, middle, and lower management levels.

3.9 Pretesting

3.9.1 Pretesting stage of the Questionnaire

The pre-testing of the questionnaire is a crucial assessment phase that permits the scholar to obtain feedback about the questionnaire content, wording, and design to eliminate any likely errors before distribution of the survey (Sekaran, 2016). Pre-testing is often carried out in two stages (Saunders & Bezzina, 2015). To get advice on the form of the questionnaire and identify any potential vagueness or inaccuracies, the scholar first reviews these survey questions and designs them with a few experienced associates or experts (Saunders & Bezzina, 2015). During pretesting, the scholar may also send a few copies of the survey questionnaire to a small subset of the target population to be completed after correcting any ambiguities or mistakes that emerge from Phase one (Buschle et al., 2022). This suggests possible miscommunication or misreading of likely problems (Stillman 2007). As per Saunders and Bezzina (2015), this step also assists the researcher in assessing the question's reliability and validity. Three stages were taken in the pretesting procedure for this survey examination. First, six experts, including port managers working in seaport CT operations and logistics, gave feedback on the questionnaire's configuration and wording. They proposed certain changes that the scholar considered before circulating the final survey form. The questionnaire was also shared with two university faculties to advise on improving its structure and wording. The survey questionnaire was also provided to three PhD research scholars at Bahria University to conduct the pre-testing procedure for the second stage. This phase attempted to gather feedback from PhD scholars with different specialties. They furnished useful comments, indicating certain problems in the questionnaire design and structure. After the results of the testing phase, the researcher considered the likely issues that were highlighted, and the questionnaire was updated. In the third step, the final version from the first two processes was shared with six subject experts of diverse experience.

The pilot study procedure involves distributing survey questionnaires among a sample of the target population before the main survey process to detect potential flaws in the constructed questionnaire and the survey design (Burns et al., 2008). The survey questionnaire was updated accordingly, and the final draft was ratified by the supervisor.

3.9.2 Experts for Content Validity/Review

In this study, 6 experts were engaged in content validity and review of survey items. Studies suggest a minimum of 3 experts, whereas most studies have advised 3 to 10 experts as follows:

- Lynn (1986) advised a minimum of three experts, essential to ensure stable and credible content validity of survey items.
- Polit and Beck (2006) suggested 3 to 10 experts. More experts can improve the robustness of the Content Validity Index (CVI).
- YAGHMAEI (2003) supports using 5 to 10 experts, especially for complex constructs, to enhance the reliability of consensus.
- Hsu and Sandford (2007) note that Delphi-based questionnaire validation typically uses 10–18 experts, but fewer (3–7) can be acceptable in focused fields.
- When research involves a specialized domain (e.g., port logistics), expert availability may be limited: Okoli and Pawlowski (2004) emphasize that "expert availability and domain specificity" often constrain the number, and 3 to 5 qualified experts can still produce sufficiently rigorous validation.

3.9.3 Technique for Relevant Item Selection and Criteria for Item Inclusion

The selection of important measurement items for this study was done based on a literature review and by considering the theory to attain conceptual clarity and empirical validity. First, a detailed review of the academic literature was undertaken to find items that had been commonly employed and validated in port logistics, supply chain management, and operations research (Hair, Black, et al., 2019). At the start, items were collected from peer-reviewed journals, established survey instruments, and theoretical frameworks, containing Resource Dependence Theory and the Economic Theory of Ports, confirming coverage of the necessary dimensions of port logistics efficiency. After the literature review, content validity assessment was done via expert assessment, a method advised by scholars for refining survey instruments (Boateng et al., 2018). Subject-matter experts from port management, maritime logistics, and academia were requested to assess each item for relevance, clarity, and alignment with the study's constructs. Only items that attained a high degree of agreement, usually 0.80 or above, on content validity ratios (Lawshe, 1975), were kept for addition. Surplus, unclear, or overlapping items were removed to maintain prudence and decrease respondent liability. Besides, the face validity of the tool was assessed to confirm that all involved items suitably denoted the constructs as perceived by subject experts. The last set of items, therefore, shows a thorough, multi-stage screening method blending empirical evidence, theoretical grounding, and expert judgment.

3.10 Pilot Study

Before full-scale data collection, a pilot study was conducted with a subset of 58 respondents drawn from various roles within the port and logistics sector. The objective was to assess the clarity, reliability, and validity of the questionnaire items. Feedback was obtained regarding the language, structure, and relevance of the questions. For reliability, Cronbach's Alpha values were calculated for each construct to assess internal consistency. All constructs showed acceptable reliability with Cronbach's Alpha values above the recommended threshold of 0.70. To establish content validity, the questionnaire was reviewed by subject-matter experts in port management and academic scholars in maritime logistics. Their suggestions were incorporated to improve the accuracy and relevance of items. In addition, a pilot factor analysis was conducted to examine item loading and identify potential issues related to construct validity.

A pilot study process can help to test questionnaire survey phrasing, flow, sequence, and potential respondents, determine the approximate time of survey completion, and the analysis method for the main survey (Burns et al., 2008; Forza, 2002). To achieve appropriate results in the pilot study phase, Blumberg et al. (2014) recommended a respondent rate of 25 to 100 as an acceptable response rate for the sample size that the researcher should use. Eighty-five online questionnaires were distributed to seaport-related individuals at the managerial level as part of a pilot study in Karachi, Lahore, Islamabad, and Rawalpindi for the survey investigation. Fifty-eight valid responses were received with complete answers, which produced a response rate of 68%. The time for completing the pilot survey was between 30 to 40 minutes. Table 3.4 exhibits the pilot study demographic results. It can be observed that many respondents in the pilot study were male (95%), and most of them (36%) were aged 50 to 59 years. The bachelor's degree holders were (53%), whereas (47%) held a master's degree. There were 53% of respondents with middle management level positions who had maximum participation. Most of the respondents were based in Karachi, and 26% of the respondents had over 21 years of experience.

Table 3.4: Demographical results for the pilot study.

Demographics	Responses	Percentage
Female	3	5%
Male	55	95%
Age		
20-29	7	12%
30-39	10	17%
40-49	15	26%
50-59	21	36%
60 or over	5	9%
Education Level		
Bachelor's degree	31	53%
Master's degree or equivalent	27	47%
Type of your present organization		
Port Authority	7	12%
Shipping and clearing firms, logistic firms	18	31%
PICT	10	17%
KICT	12	21%
SAPT	8	14%
Customer Services	1	2%
Researchers	2	3%
Geographic working area for the present organization		
Karachi	49	84%
Lahore (Retired Manager Karachi Port and Master container ship)	2	3%
Islamabad/Rawalpindi (Retired Manager PICT and KPT)	4	8%
Middle East (served at Karachi container terminals)	3	5%
Type of organization		
Private container storage firms at Karachi/Consultants	4	7%
Lower-Level manager	17	29%
Middle-Level manager	30	52%
Top-level manager	7	12%
Experience in Years		
1 to 5	15	26%
6 to 10	10	18%
10 to 20	18	32%
21 and above	15	26%

Reliability and validity are measurement tools for the quality of the survey and the data (Sekaran, 2016). Both tools are significant tests to assess the generalizability of findings and the study population in the quantitative model (Yarkoni, 2022). The reliability and validity of this survey are discussed below:

Reliability. In positivist research studies, the reliability of responses obtained from a survey is an essential issue in designing the questionnaire questions (Collis & Hussey, 2014; Straub et al., 2004). In other words, it concerns the credibility of the collected data and whether the type of data collected method led to yielding consistent findings (Saunders & Bezzina, 2015). This means that the findings of research can be considered reliable only if the same results could be obtained from repeatedly repeating the same research procedure, which is referred to as the repeatability and consistency of research findings over time (Bell et al., 2009). Moreover, as reliability focuses on the ability to repeat a study over time using the same data collection method, any involved errors or biases in measures or with the instrument structure can be observed over time (Sürücü & Maslakci, 2020). To enhance the reliability of this survey study, the researcher adopted positivist techniques, which are efficient methods to gather data for the variables of this research interest (Mohajan, 2020). This research survey questionnaire was designed to gain data from various levels of management in the Karachi port and container-related organizations. All respondents were sufficiently competent to meet this research requirement. Besides, to remove the research bias, all the survey respondents were assured of the confidentiality of the obtained data and nondisclosure of the respondent's identities. Also, these scale items were constructed carefully, and vague words or dual-meaning questions and unfamiliar terms were avoided. Before conducting the main survey, a pilot study was conducted to reduce and eliminate mistakes and doubts. Finally, as this survey research was designed and conducted online, there were no observed errors or biases.

In a positivist research format, reliability can be examined by three types of tests, (Straub et al., 2004). Test-restart examines whether the answers of the respondents are the same in one or more different periods. The second is the equivalence or split-half test to see if the respondents' answers have the same scores if they were given two halves or different forms of a set of items. The third one concerns internal consistency, which is used to see if the questionnaire questions have consistently measured the qualities, attitudes, and characteristics that they should have done.

In this study, the first two reliability tests have not been conducted as their job has been done by the pilot study. For the third reliability test, internal consistency, a statistical method of Cronbach's alpha, was employed and incorporated with the above-discussed procedural remedies for confirming that the common bias of the method used is under control. According to Nawi et al. (2020), the internal consistency method can be usefully used to measure the reliability of items in a questionnaire instrument. Cronbach's alpha test determines the consistency of the answers of all participants to all items in a scale measure (K. S. Taber, 2018). In other words, whether all items in a scale measure the same concept. Commonly, any determined value of the Cronbach alpha test between 0.7 to 0.8 is accepted as an indication of the reliability of the research data (Kennedy, 2022). The estimated value of the Cronbach alpha test below 0.6 indicates poor reliability, and above .8 is a sign of a good one (Sekaran, 2016). It can be viewed that all constructed measures used in this study related to Cronbach's alpha values have shown good reliability based on the arguments (Sekaran, 2016).

Table 3.5: Reliability test results in the pilot study

Dimensions/ Variables	Items before the pilot study	Items after the pilot study		Corrected Item Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Port Technology (PT)						
Information Technology (PTIT)	10	5	PTIT-1	.518	.785	.803
			PTIT-2	.719	.739	
			PTIT-4	.500	.790	
			PTIT-5	.586	.771	
			PTIT-8	.684	.732	
Port Infrastructure (PI) 19						
Accessibility (PIAC)	8	8	PIAC-1	.434	.840	.842
			PIAC-2	.687	.808	
			PIAC-3	.581	.824	
			PIAC-4	.675	.813	
			PIAC-5	.640	.818	
			PIAC-6	.636	.817	
			PIAC-7	.493	.838	
			PIAC-8	.553	.827	
Container Berth (PICB)	5	5	PICB-9	.730	.884	.899
			PICB-10	.757	.879	
			PICB-11	.750	.881	
			PICB-12	.759	.877	
			PICB-13	.799	.867	
Container yard (PICY)	6	4	PICY-14	.830	.841	.893
			PICY-15	.570	.928	
			PICY-16	.837	.835	
			PICY-17	.842	.832	
Port Equipment (PE)						
Quay crane (PEQC)	3	3	PEQC-1	.683	.898	.879
			PEQC-2	.836	.765	
			PEQC-3	.784	.812	
Yard crane (PEYC)	4	4	PEYC-4	.799	.892	.915
			PEYC-5	.750	.908	
			PEYC-6	.854	.873	
			PEYC-7	.823	.883	
Equipment Reliability (PERB)	5	3	PERB8	.727	.889	.889
			PERB10	.759	.873	
			PERB12	.881	.757	
Port Human Resource (PHR)						
Training and Education (PHRTE)	8	4	PHRTE3	.781	.859	.894
			PHRTE4	.805	.849	
			PHRTE5	.757	.867	
			PHRTE7	.726	.880	
Employee Reliability (PHRER)	6	6	PHRER9	.208	.852	.807
			PHRER10	.743	.733	
			PHRER11	.586	.773	
			PHRER12	.716	.743	
			PHRER13	.632	.761	
			PHRER14	.557	.779	
Port Services (PS)						
Dwell Time (PSDT)	4	3	PSDT1	.783	.715	.845
			PSDT2	.653	.840	
			PSDT3	.705	.792	
Custom Clearance (PSCC)	3	3	PSCC5	.769	.854	.888
			PSCC6	.757	.862	
			PSCC7	.822	.808	

Service Reliability (PSSR)	5	5	PSSR8	.820	.860	.896
			PSSR9	.619	.899	
			PSSR10	.806	.860	
			PSSR11	.868	.847	
			PSSR12	.654	.900	
Customer service (PSCS)	7	4	PSCS16	.753	.807	.862
			PSCS17	.639	.851	
			PSCS18	.738	.815	
			PSCS19	.719	.820	
Port Charges (PC)						
Service cost (PCSC)	8	8	PCSC1	.605	.713	.763
			PCSC2	.552	.724	
			PCSC3	.588	.717	
			PCSC4	.595	.715	
			PCSC5	.221	.776	
			PCSC6	.242	.786	
			PCSC7	.421	.745	
			PCSC8	.552	.721	
Port Container Management (PCM)						
Strategic Capabilities (PCMSC)	6	4	PCMSC1	.833	.792	.867
			PCMSC2	.847	.783	
			PCMSC3	.625	.865	
			PCMSC5	.637	.882	
Strategic Direction (PCMSD)	4	4	PCMSD7	.794	.755	.846
			PCMSD8	.688	.803	
			PCMSD9	.517	.883	
			PCMSD10	.771	.771	
Management related (PCMMA)	9	7	PCMMA11	.572	.806	.829
			PCMMA12	.703	.784	
			PCMMA13	.664	.790	
			PCMMA14	.751	.777	
			PCMMA15	.569	.807	
			PCMMA16	.782	.774	
			PCMMA19	.122	.882	
Operations Activity related (PCMOE)	6	6	PCMOE20	.783	.775	.833
			PCMOE21	.623	.804	
			PCMOE22	.773	.772	
			PCMOE23	.811	.765	
			PCMOE24	.635	.802	
			PCMOE25	.153	.896	
Port Logistic Efficiency (PLE)						
Logistic Capability (PLELC)	8	7	PLEPC2	.183	.824	.797
			PLELC3	.468	.781	
			PLELC4	.563	.764	
			PLELC5	.711	.733	
			PLELC6	.697	.737	
			PLELC7	.450	.787	
			PLELC8	.631	.752	
Throughput (PLETP)	5	5	PLETP9	.617	.860	.867
			PLETP10	.686	.842	
			PLETP11	.756	.828	
			PLETP12	.761	.825	
			PLETP13	.681	.841	

Descriptive statistics are shown in Table 3.6 below.

Table 3.6: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Dev	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	SE	Statistic	SE
PTIT	58	1.000	5.000	3.567	.506	.256	-.970	.314	2.060	.618
PIAC	58	1.000	5.000	3.825	.692	.479	-1.056	.314	1.392	.618
PICB	58	1.000	5.000	4.120	.678	.460	-1.126	.314	1.330	.618
PIYC	58	1.000	5.000	3.666	.609	.371	-1.334	.314	2.785	.618
PEQC	58	1.000	5.000	3.885	.742	.552	-.247	.314	.220	.618
PEYC	58	1.000	5.000	4.034	.656	.431	-.993	.314	1.825	.618
PERB	58	1.000	5.000	3.969	.672	.452	-.895	.314	.658	.618
PHRTE	58	1.000	5.000	3.497	.560	.314	-.281	.314	.597	.618
PHRER	58	1.000	5.000	3.465	.691	.478	-.768	.314	1.188	.618
PSDT	58	1.000	5.000	3.607	.618	.382	-.943	.314	3.761	.618
PSCC	58	1.000	5.000	4.034	.683	.467	-.854	.314	1.221	.618
PSSR	58	1.000	5.000	3.703	.753	.567	-.946	.314	2.146	.618
PSCS	58	1.000	5.000	3.875	.820	.674	-.715	.314	-.248	.618
PCSC	58	1.000	5.000	3.525	.598	.358	.021	.314	.024	.618
PCMSC	58	1.000	5.000	3.750	.572	.328	-.356	.314	-.070	.618
PCMSD	58	1.000	5.000	4.107	.638	.408	-1.057	.314	2.341	.618
PCMMA	58	1.000	5.000	3.616	.617	.381	-.138	.314	-.280	.618
PCMOE	58	1.000	5.000	3.712	.672	.452	-.964	.314	2.288	.618
PLELC	58	1.000	5.000	3.635	.570	.326	-.406	.314	-.389	.618
PLETP	58	1.000	5.000	4.048	.649	.421	-1.030	.314	1.520	.618
Valid N (listwise)	58									

Descriptive Statistics Interpretation

The descriptive statistics for the 58 respondents disclose largely elevated agreement through all measurement items, with mean values fluctuating between 3.46 and 4.12 on a five-point Likert scale, demonstrating positive insights for port logistics and management aspects. The standard deviations (0.50–0.82) and variances (0.25–0.67) indicate minor scattering, implying that though responses are usually consistent, certain variability occurs in participants' beliefs (Field, 2018). Numerous items—comprising PICB (Mean = 4.12), PEYC (Mean = 4.03), PSCC (Mean = 4.03), and PCMSD (Mean = 4.11) show the uppermost rankings, highlighting robust apparent performance in container berth equipment yard capacity, customs clearance, and management system design. Skewness indicators exhibit primarily negative rates, demonstrating left-skewed distributions where the majority of respondents chose higher-scale responses, a model common in service quality and operational performance research (Hair, 2014). Kurtosis quantities vary widely, with few items displaying leptokurtic (positive kurtosis) trends (e.g., PSDT, PCMSD), indicating clustered high responses, whilst others continue near to normality. Generally, the statistical profile proposes that stakeholders observe port technology, infrastructure, equipment, human resources, services, and container management practices as mostly effective, reinforced by reliable and positively skewed data patterns.

Validity. It refers to the soundness all accuracy of the measurement tool to reflect the reality of the under-investigation phenomena accurately and precisely (Saunders & Bezzina, 2015). There are six types of measures used in social sciences (content, construct, convergent, discriminant, criterion-related, and nomological validity). The content validity is also known as face validity (Rubio et al., 2003). It tests whether the characteristics or thoughts that the item questions intend to measure are truly represented by these survey item questions (Lam et al., 2018).

The researcher can use feedback from related experts to be sure about the content's readability (Hatcher & Colton, 2007). In this study, a thorough and delicate search was undertaken in the literature review, where several measuring items were collected. Then, specialists and expert panels having definite experience in port operations, logistics, and management were requested to assess the measurement items in the questionnaire and whether they were suitable for the research topic and reply to the research questions. Third, the measurement skills were weighed by researchers at Bahria University at the start of the study. Lastly, the measurement skills were estimated before and after performing the pilot study process through PhD research scholars at Bahria University, and with the help of several managers at Karachi Port.

3.11 Measurement of variables

Variables in the above research model are required to be operationalized through the operational definition and measurement items. The ensuing segment defines all the constructs and the items to measure them. Some items had been omitted from the instrument after EFA.

3.11.1 Port Technology (PT)

Table 3.7: Port Technology (PT)

Theoretical Definition	Operational Definition
Technological developments and process optimization could be used to improve several features of port operations and efficiency. It can also provide port management the managerial insights for productivity growth at	The efficiency and safety of cargo movement in seaports vastly rely on the related information flow. Hence, it must adopt modern technologies for accurate decision-making, optimization of

container terminals (Vrakas, Chan, Thai, et al., 2021).	port processes, information flow, and port operations (Garrido Salsas et al., 2022)

The items for Port Technology are taken from earlier landmark studies. For Information Technology (IT). One item related to terminal operating system has been taken from (Alhameedi et al., 2018), one item regarding information quality for decision making has been taken from (Jeevan, 2017), one item about the IT system and invoice/online payment is taken from (Thai & Logistics, 2008); (Alhameedi et al., 2018), one item for integrated information flow for operations and management is taken from (HA, 2016), and one item about electronic data sharing is taken from (Panayides, 2008).

Table 3.8: Items to measure Port Technology (PT)

Code	Item statement	5	4	3	2	1	
Information Technology (IT)							
PTIT-1	Our seaport CT has a modern and efficient terminal operating system (TOS) which can also track container location.						(Yang & Lu, 2012)
PTIT-2	Our seaport CT IT system can provide quality information for accurate decision-making.						(Jeevan, 2017)
PTIT-4	Our seaport CT IT system produces error-free invoices and enables online payment.						Thai, 2008 (Alhameedi et al., 2018)
PTIT-5	Our seaport CT IT system is integrated and covers all operations and management applications.						Ha, 2016
PTIT-8	Our seaport terminal has the efficient establishment of an EDI system to share container operations data with stakeholders in the supply chain.						Panayides 2008 Marlow and Paixao, 2003 Ha 2003

3.11.2 Port Infrastructure (PI)

Table 3.9: Theoretical and operational definition of port Infrastructure

Theoretical Definition	Operational Definition
Port infrastructure refers to the physical facilities and structures necessary for the operation of a port, including terminals, berths, docks, storage yards, and other facilities. It also includes transportation connections for cargo from the port, such as roads, railways, and waterways (Wayne K Talley, 2017).	Port infrastructure refers to the quality of physical structure critical for ship docking and cargo handling. Port infrastructure can be assessed by measuring sea-land accessibility and connectivity, container berths, container yard, and gate operations (Ligteringen & Velsink, 2012; Yap, 2020)

The items for port infrastructure are taken from the related landmark studies. All items for accessibility and connectivity are adapted from (Chang and Thai (2016); Thai 2008; Wang et al. (2014), for Container berths, items are adapted from (Chang and Thai (2016), Thai (2008), Wang et al. (2014), for container yard items are adapted from (Chang and Thai (2016), Thai (2008), Wang et al. (2014) and Kim, 2014) for congestion, items are adapted from (Alhameedi et al., 2018).

Table 3.10: Items to measure port infrastructure

Code	Item statement	5	4	3	2	1	
Accessibility and Connectivity (AC)							
PIAC-1	Our seaport CT has adequate seaside and channel accessibility						Thai (2008) Chang and Thai (2016), Wang et al. (2014)
PIAC-3	Our seaport CT has adequate physical infrastructure such as berths, yards, stacking areas, distribution centres, exit gates, and hinterland connection networks.						
PIAC-4	Our seaport has adequate channel reliability.						
PIAC-5	Our seaport CT has adequate landside accessibility and connectivity for hinterland transport (road and rail)						
PIAC-6	Our seaport CT has adequate accessibility and capability of entrance and departure gate operations.						
Container Berth (CB)							
PICB-9	Our seaport CT has an adequate number of operational berths for incoming container ships.						Kim, 2014 Chang and Thai (2016), Thai (2008), Wang et al. (2014)
PICB-11	Our seaport CT has adequate berth reliability.						
PIBL-12	Our seaport CT has adequate berth length to dock ships of the required size.						Kim, 2014
PIDB-13	Our seaport CT has adequate depth alongside berth to dock ships of the required size.						
Container Yard (CY)							
PICY-14	Our seaport CT has an adequate land area for container operations and logistics management.						(Alhameedi et al., 2018)
PICY-15	Our seaport CT has adequate container storage capacity in the yard area.						Chang and Thai (2016), Thai (2008), Wang et al. (2014)
PICY-16	Our seaport CT has adequate container handling and management capacity in the yard area.						
PICY-17	Our seaport CT experiences occasional congestion related to customs documentation, container scanning, and vehicle gate operations.						(Alhameedi et al., 2018); Feng 2010

3.11.3 Port Equipment (PE)

Table 3.11: Theoretical and operational definition of Port Equipment

Theoretical Definition	Operational Definition
Port equipment refers to the machinery, tools, and devices used in port operations and activities for the handling, loading, unloading, and storage of cargo (Bichou, 2014)	The efficacy of container port equipment can be assessed by measuring the level of quay cranes, yard cranes, and equipment reliability by relating their numbers, service rate, availability, and maintenance regime (Kizilay & Eliiyi, 2021).

The items for Port Equipment are taken from the landmark studies on container ports. All items for quay cranes and yard cranes are adapted from (Nyema, 2014). Whereas all the items for the port equipment reliability are adapted from (Chang and Thai (2016), Dıaz-Reza et al. (2018), Tortorella and Fettermann, 2018); Nyema, 2014).

Table 3.12: Items to Measure Port Equipment

Code	Item statement	5	4	3	2	1	
Quay Crane (QC)							
PEQC-1	Our seaport CT has an adequate number of operationally efficient Quay cranes.						(Nyema, 2014)
PEQC-2	Our seaport CT Quay crane design has an adequate container loading service rate.						
PEQC-3	Our seaport CT Quay crane design has an adequate container unloading service rate.						
Yard Crane (YC)							
PEYC-4	Our seaport, CT has an adequate number of operationally efficient yard gantry cranes.						(Nyema, 2014)
PEYC-5	Our seaport, CT has an adequate loading service rate for container vehicles.						(Nyema, 2014); Jeevan, 2017; (Talley, 2006a)
PEYC-6	Our seaport CT, has an adequate unloading service rate for container vehicles.						
Port Equipment Reliability (RB)							
PERB-8	Our seaport CT has an adequate number of terminal equipment.						Chang and Thai (2016), Diaz-Reza et al. (2018), Tortorella and Fetterman (2018)
PERB-10	Our seaport CT has reliable equipment.						
PERB-12	Our seaport CT regularly maintains the equipment with planning, without causing operational delays.						

3.11.4 Port Human Resource

Table 3.13: Theoretical and operational definition of Port Human Resources

Theoretical Definition	Operational Definition
The workforce is employed in various roles and functions within a port, including administrative, operational, and managerial positions (Marlow & Casaca, 2003).	Due to complex port activities, the handling of human resource demands strategic management and planning to foresee and address related issues. The HR capacity can be broadly assessed by measuring the level of training, education, and reliability (Storey et al., 2019; Thornton III & Rupp, 2006).

The items for Port Human Resource are taken from landmark studies on the subject. The items for Training and Education (TE) are adapted from (Elferjani 2015, HA, 2016 and Nzeru Willard 2014. The items for employee reliability (ER) are adapted from Chang and Thai (2016); Schellinck and Brooks (2015); and (Nzeru Willard 2014).

Table 3.14: Items to measure Port Human Resource

Code	Item statement	5	4	3	2	1	
Training and Education (TE)							
PHRTE-3	Our seaport CT offers professional training and education to employees for capacity building and attaining productivity targets.						HA, 2016
PHRTE-4	Our seaport CT offers training and education to employees to achieve safe and efficient operations.						Elferjani 2015
PHRTE-5	Our seaport CT offers training to employees which improves their confidence and work quality.						Nzeru_Willard 2014
PHRTE-7	Our seaport CT operations have adequately skilled operators due to regular training.						Elferjani2015
Employee Reliability (ER)							
PHRER-10	Our seaport CT operations have capable employees.						Chang and Thai (2016), Schellinck and Brooks (2015), Thai et al. (2016)
PHRER-11	Our seaport CT operations have reliable employees.						
PHRER-12	Our seaport CT operations have trustworthy employees.						
PHRER-13	Our seaport CT operations have trained employees who respond swiftly to customer inquiries and needs.						Revised from Chang and Thai (2016)
PHREP-14	Our seaport CT management offers training and incentives to employees to attain productivity targets.						Nzeru_Willard 2014

3.11.5 Port Services

Table 3.15: Theoretical and operational definition of Port Services

Theoretical Definition	Operational Definition
Seaport services can be defined as the range of activities and functions carried out within a seaport to facilitate the exchange of goods and services between maritime and land spaces (Bichou & Gray, 2005).	Seaport services involve several facilities provided to ships during port visits. Customer satisfaction is a key outcome of seaport services that is largely governed by customs clearance, service reliability, and dwell time. (Eliakunda, 2019; Jeevan et al., 2019)

The items for port services are taken from landmark studies on the subject. The items to measure Container Dwell Time are adapted from (Alhameedi et al., 2018) and Feng 2010. The items to measure Custom Clearance are adapted from Elferjani 2015 and Nyema 2014. All items to measure Service Reliability are adapted from (Tongzon & Nguyen, 2021), Kim, 2014, (Alhameedi et al., 2018), Song 2008. All items to measure Customer Satisfaction are adapted from (Alhameedi et al., 2018), Kim, 2014, and Tongzon, 2021.

Table 3.16: Items to measure Port Services

Code	Item statement	5	4	3	2	1	
Dwell Time (DT)							
PSDT-1	Our seaport terminal takes on average 7 to 9 days dwell time to clear containers from the port.						(Alhameedi et al., 2018)
PSDT-2	Our seaport terminal yard storage capacity increases when container dwell time is reduced.						Feng 2010
PSDT-3	Delay in the custom clearance process is a key contributor to increased dwell time.						(Alhameedi et al., 2018)
Custom Clearance (CC)							
PSCC-5	Our seaport CT has an effective custom clearance process with realistic charges.						(Ngari, 2018)
PSCC-6	Our seaport IT system performance influences the pace of the custom clearance process.						Nyema 2014
PSCC-7	Our seaport custom clearance efficiency affects CT productivity						Nyema 2014
Service Reliability (SR)							
PSSR-8	Our seaport CT has highly reliable services						(Tongzon & Nguyen, 2021)
PSSR-9	Our seaport CT has reliable multi-modal interface and supply chain services.						HA, 2016 Kim, 2014
PSSR-10	Our seaport CT delivers services on time (minimize delays) with high delivery reliability.						Kim, 2014 Doan, 2017 Alhameedi, 2018 (D. Song, 2021)

PSSR-11	Our seaport CT employees give quick responses to customer requests.						Alhameedi, 2018 Ogwude, 2004
PSSR-12	Our seaport CT employees give quick response to customer complaints and refund process						Kim, 2014 Gamze 2017 Alhameedi, 2018
Customer Satisfaction (CS)							
PSCS-16	Services provided by our seaport meet all the customer needs						(Tongzon & Nguyen, 2021)
PSCS-17	Our seaport CT has efficient ship clearance process for departing ships						(Alhameedi et al., 2018)
PSCS-18	The cargo owners feel that their cargo is safe and secure at our CT						Kim, 2014
PSCS-19	Overall, our customers are highly satisfied with the port services						(Tongzon & Nguyen, 2021)

3.11.6 Port charges

Table 3.17: Theoretical and operational definition of Port Charges

Theoretical Definition	Operational Definition
Port charges are levies imposed on ships and cargoes for utilizing port facilities and services during a port visit (Meersman et al., 2015).	Port charges can be categorized for port facilities, ships, and cargo and assessed by measuring the charges levels of infrastructure facilities, shipping services, cargo handling services, and yard storage (Kaliszewski et al., 2020; Wayne K Talley, 2017).

The items for Port Charges are taken from landmark studies on the subject. The items for service cost are adapted from (Alhameedi et al., 2018), Song, 2008; (Tongzon & Nguyen, 2021)

Table 3.18: Items to measure Port Charges.

Code	Item statement	5	4	3	2	1	
Port Service Charges (SC)							
PCSC-1	Our seaport CT offers competitive charges against the services provided.						(Alhameedi et al., 2018), Song 2008
PCSC-2	Our seaport infrastructure charges (berth charge and channel charge, etc.) are competitive.						(Tongzon & Nguyen, 2021)
PCSC-3	Our seaport shipping service charges (mooring, pilotage, towage) are competitive.						(Tongzon & Nguyen, 2021)
PCSC-4	Our seaport container cargo handling services and storage in the yard are cheaper than competitors.						(Tongzon & Nguyen, 2021), Song 2008

3.11.7 Port Container Management

Table 3.19: Theoretical and operational definition of container management

Theoretical Definition	Operational Definition
It is the strategic management, systematic planning, coordination, and control of container activities, aimed at ensuring efficient and effective handling, storage, and movement of containers within a port (L. H. Nguyen, 2024a; Song & Panayides, 2012).	Container management is the optimized use of port resources by skilled managers for the movement of containers. It can be attained by well-coordinated and integrated logistic activities within a port by investing in strategic capabilities, defining strategic direction, broad management, and innovative activities (Notteboom et al., 2022; Song & Panayides, 2012)

The items for port container management are taken from important studies. The items are adapted from (Investing Strategic Capabilities (Al Thani & Obeidat, 2020) and Song 2008, Defining Strategic Direction (Al Thani & Obeidat, 2020), Chin-Shan Lu, 2016. Management-related (MA), Thai (2008), Thai (2016), and Yeo et al. (2016) (Alhameedi et al., 2018), Operational Activities related (Alhameedi et al., 2018), Thai (2008)

Table 3.20: Items to measure port container management.

Code	Item statement	5	4	3	2	1	
Investing Strategic Capabilities (SC)							
PCMSC-1	Our senior management has developed and communicated a clear strategic vision of our seaport CT						(Al Thani & Obeidat, 2020)
PCMSC-2	Our senior management ensures that actual performance is in line with the seaport's strategic objectives.						
PCMSC-3	Our senior management pays attention to very experienced staff for work quality and to reduce dependencies.						
PCMSC-5	Our senior management views shipping lines as strategic partners in mutually designing the flow of containers and information.						(Song 2008)
Defining Strategic Direction (SD)							
PCMSD-7	Our senior management regularly analyses external and internal environments to identify strengths and weaknesses, which affect our seaport's future work.						(Al Thani & Obeidat, 2020)
PCMSD-8	Our seaport management has a strategy of green sustainable development, focusing on port infrastructure and environmental protection.						(Chin-Shan Lu, 2016)
PCMSD-10	Our senior management ensures a balance between supervision and independence necessary to perform work.						(Al Thani & Obeidat, 2020)

Management-related (MA)							
PCMMA-12	Our seaport demonstrates efficient terminal operations and management with ICT support.						Adopted from Thai (2008), Thai (2016) and Yeo et al. (2016)
PCMMA-13	Our seaport CT management ensures adequate training for capacity building of employees, including incident-handling capability.						
PCMMA-15	Our seaport CT management collects customer feedback about their services and reflects on their improvement.						
PCMMA-16	Our seaport management continuously improves customer-oriented terminal operations and processes based on the feedback received						
Operational Activities-related (OE)							
PCMOE-20	Our seaport terminal gate management offers efficient container cargo receipt and delivery operations.						(Alhameedi et al., 2018)
PCMOE-21	Our seaport terminal customs clearance process is quick and aligned with container operations productivity targets.						
PCMOE-22	Our seaport has adequate container track and trace capability for efficient terminal management at a low cost.						Thai (2008)

3.11.8 Port Logistic Efficiency:

Table 3.21: Theoretical and operational definition of Port Logistic Efficiency

Theoretical Definition	Operational Definition
The efficiency and productivity of logistic operations and processes within a port, including the movement, handling, and storage of container cargo (Bichou & Gray, 2004)	The logistic efficiency of a port can be determined by assessing its logistic capability and throughput. This can be measured by its accuracy level of data, intermodal connectivity, call size, and optimization of asset utilization, hence reducing time and costs (Notteboom & Neyens, 2017; Song & Panayides, 2012)

The items for Logistic Capability (LC) are taken from landmark studies on the subject. The items for Logistic Capability (LC) were adapted from Seo 2014, Tongzon 2021, and Kaliszewski 2021. All items for Container Throughput are adapted from Nyema 2014.

Table 3.22: Items to measure Port Logistic Efficiency

Code	Item statement	5	4	3	2	1	Author/ year
Logistic Capability (LC)							
PLELC-3	Our seaport ICT system offers accurate and real-time container shipment data, enabling efficient logistics operations.						Seo2014

PLELC-4	Our seaport CT has adequate operability for ship-road interface						Tongzon 2021
PLELC-5	Our seaport CT has adequate operability for ship-rail interface						Tongzon 2021
PLELC-6	Intermodal landside transport facilities are available at our CT (rail and road)						Kaliszewski 2021 Feng 2010
PLELC-7	Our seaport terminal can serve Very Large Container Ships (up to 13500 TEUs)						Kaliszewski 2021
PLELC-8	Our seaport terminal can serve Post-Panamax Container Vessels (below 8000 TEUs)						Kaliszewski 2021
Container Throughput (TP)							
PLETP-10	Our seaport's current annual throughput is nearly half of its designed capacity.						Nyema 2014
PLETP-11	Our seaport CT can attain higher throughput with wise use and better management of existing resources.						Nyema 2014
PLETP-12	CT efficiency can be measured by the level of increase in inputs and throughput.						Nyema 2014

Data analysis

3.12 Time Horizon

A strategy for the survey during the research to test the hypothesis was employed. The time horizon describes and governs the study's design to evaluate the association between the impact of port resources on port logistic efficiency through container management, the mediating variable. As it was a cross-sectional study, the time horizon for data collection was utilized. The survey used was cross-sectional as it could generate data for several variables concurrently. The time constraint also became a reason to conduct a cross-sectional study. Overall, it took about nine months for data collection.

3.13 Data Collection Method

The data was gathered from Karachi port-related organizations in Pakistan. The research was premised on the idea that employees spend about 33% time at the workplace (Blok et al., 2015; Meyer & Herscovitch, 2001). The ensuing paragraphs discuss the data collection method, research instrument, and ethical considerations related to this research work. In this study, the survey research method was used because of its suitability with the study's objectives to collect respondents' data and examine the relationships between port resources, port container management, and port logistics efficiency. Zikmund, Babin, Carr, and Griffin (2000) stated that surveys are relatively less timeconsuming and inexpensive, as they enable the researcher to investigate a research phenomenon by collecting data from a large sample (Coughlan et al., 2009). This method is the most appropriate as it allows us to measure the variables and collect the data by using the least resources concerning time and cost (Young, 2015). The web-based questionnaire survey (google. form) was conducted to collect data from the top, middle, and lower management of the organizations working in conjunction with CTs at Karachi Port (Nayak & Narayan, 2019).

3.13.1 Questionnaire Instrument

There are different techniques and instruments to collect data. For example, direct observation, interviews, focus groups, questionnaires, etc. Each method has its advantages and disadvantages in terms of cost, time, reach, and response rate (Sekaran and Bougie, 2003). This study used a questionnaire with structured items as a research instrument to gather data from respondents. This method of collecting data, i.e., via questionnaire, is considered a much more commonly applied method in data collection (Sekaran and Bougie, 2016). Enormous data can be collected through a questionnaire from a big sample economically, in a comparatively shorter period (Mitchell, Jolley, and O'Shea, 2012). Dillman (2000) suggests that questionnaire design should be seen to achieve two key objectives: reduce non-response and measurement error. Respondents can quickly respond to closed-ended questions from the options provided. Therefore, only closed-ended questions were incorporated in this study. Coding the information for ensuing analysis is easy (Sekaran, 2003). Considering the nature of the study closed-ended questionnaire was formulated for data collection from the respondents. Sekaran (2000) suggested a few guidelines for consideration while devising the questionnaire, which were stressed while making the questionnaire for this work.

Pertinent items were adapted from the published scholarly literature and compiled for each construct as a questionnaire. The draft questionnaire was carefully examined for duplication, ambiguous statements, spelling mistakes, difficulty level, etc, and unsuitable items were deleted. The refined draft questionnaire was shared with selected maritime experts and academics for their review and to identify duplication, relevance, required alterations, and unsuitable and ambiguous items. After updating the input, the scholar again examined the draft questionnaire. The revised version was once again circulated to a few researchers and experts for their review. Considering the guidelines, efforts were made to use correct phrasing and sequencing of questions. It was also endeavored to make the content, purpose, and words used in the questionnaire accurate and brief. After incorporating the inputs, 120 items were shortlisted and verified. The research questionnaire was then tested to ascertain the filling-up time and clarity of the items. Before undertaking the main survey, the questionnaire was subjected to a pilot study to reduce and eliminate mistakes and doubts about the items. Consequent to the pilot study, 78 items were retained for the main survey.

The current study adopted a Likert scale to measure the response from the respondents. The Likert scale permits obtaining the response in terms of direction and strength relating to the study (Lindner & Lindner, 2024). This scale also provides respondents with the liberty to respond to either strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree with the items (Mitchell et al., 2012). The choice of the Likert scale is justified by its ability to better explain and predict the behavior of the respondents (Bohte et al., 2009). Earlier studies in social sciences have used the Likert scale, and its usefulness has been established (Rokeman, 2024). As per Lindner and Lindner (2024), no single scale is suitable for all types of research. The rating scale of 5 to 7 provides the most accurate results. A Likert rating scale above seven results in reliability issues, as the probability of an increase in reliability is minimal (Robinson, 2024). Therefore, a Likert scale of 1 to 5 was chosen for this study. The questionnaire is attached as Appendix B.

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

Figure 3.2: Five-point Likert scale

3.14 Ethical considerations

The term 'Ethics' refers to lifestyle. It guides the social customs and the behavior of individuals in a culture (Akaranga & Makau, 2016). Also, in research, ethical standards have been defined through rules and procedures for conducting research honestly. The main ethical thoughts associated with research contributors comprise (i) Informed agreement, (ii) Regard for privacy, secrecy, and namelessness, (iii) Generosity may be protected (iv) Regard for privacy (Burles and Bally, 2018; Fleming and Zegwaatd,2018). The key ethical matters linked to the study, including (i) Distortion, (ii) Production, and (iii) plagiarism (copying) (Akaranga & Makau, 2016), were guaranteed.

3.15 Reliability and Validity

Utilizing a survey instrument has the benefit of allowing validity and reliability checks on the information gathered through the questionnaire. These ideas are briefly covered in the ensuing part, along with how they relate to the current study.

3.15.1 Content Validity

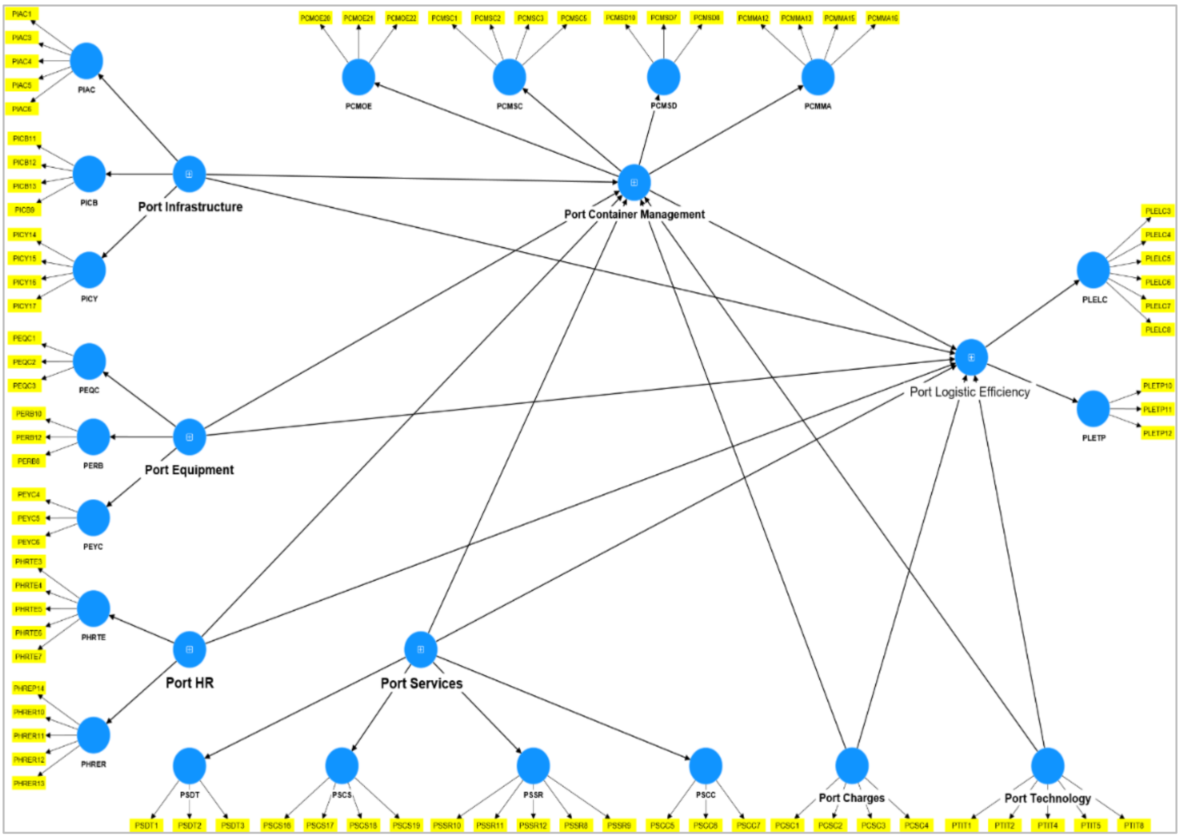
The term validity describes how well items measure the construct, and item scales must measure the real construct. The representativeness and thoroughness of the items used to measure a construct are measured by content validity. It is important to ensure the content's legitimacy before gathering any data. Content validity and reliability were already demonstrated for the current investigation. The scales had already been constructed and used by past researchers, and all the elements were drawn from earlier publications, though items have been obtained from various studies to add richness to the research.

3.15.2 Construct Validity

According to Hair et al. (2010), construct validity is the extent to which a test assesses what it claims or signifies to measure. Convergent and discriminant validity are two construct validity techniques used in this investigation. The similarity of variance between the items of a particular construct is examined through convergent validity. Factor loading, average extracted variance, and construct dependability are used to measure it. A construct's discriminant validity demonstrates how it differs from others. It is carried out by comparing the square correlations and average square root. After the final data collection, the current study conducted convergent and discriminant validity.

Figure 3.3: Structural model

3.16 Data Analysis Technique:



After gathering the data, analysis was conducted in two steps. The data was first subjected to a preliminary analysis using IBM SPSS Statistics 25 to provide a broad overview of the data. In the second stage, the structural equation modelling technique, which included a measurement model and structural model analysis, was implemented using Smart PLS version 4.0.9.2. Understanding the connection between the constructs is the goal of the current investigation. SEM is a second-generation method that can deal with measurement inaccuracies in the variables that are being observed (Hair Jr et al., 2021a). SEM can be used to quantify the causality of complicated interactions between constructs (that cannot be observed) and indicators (which are observable). The partial least squares approach to structural equation modelling (SEM) has been widely implemented in business research areas like information systems, consumer behavior, and marketing (Sarstedt et al., 2021). The use of PLS-SEM is increasing in management sciences and social sciences (Magno et al., 2024).

3.17 Considerations for choosing PLS-SEM.

This study employed Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS4 software to analyze the data. PLS-SEM was chosen over other analytical techniques, such as covariance-based SEM (CB-SEM) or multiple regression, due to several key reasons aligned with the nature and objectives of this research. First, PLS-SEM is quite suitable for exploratory research and theory development, which aligns with this study's aim to explore the impact of port resources on port logistics efficiency and the mediating role of container management. PLS-SEM examines multiple constructs and paths in a relatively underexplored context of maritime port logistics. Moreover, PLS-SEM is recommended for prediction-oriented and exploratory research (Sarstedt et al., 2021).

Second, the study involves a complex structural model with multiple latent constructs having reflective and mediation effects (Hair et al., 2021). PLS-SEM provides greater flexibility in modelling formative and reflective constructs without the identification issues that can arise in CB-SEM (Hair & Alamer, 2022). PLS-SEM handles complexities with multiple relationships more efficiently than traditional regression or CB-SEM, especially with smaller to medium sample sizes (Usakli & Rasoolimanesh, 2023). Third, PLS-SEM makes fewer assumptions about data normality, making it a robust option for real-world datasets, where data may not strictly follow a multivariate normal distribution. Moreover, PLS-SEM provides both path coefficients for hypothesis testing and variance explanation (R^2) for endogenous variables, making it ideal for prediction-oriented research to understand practical and managerial implications (Hair, Risher, et al., 2019). The focus on predictive accuracy, combined with the ability to assess measurement model reliability and validity, supports the empirical testing of the conceptual framework developed in this study.

Understanding the underlying assumptions of the methods to be chosen is necessary for selecting the best one. Research objectives, measurement model requirements, modeling of the structural model, data characteristics, and model evaluation are a few variables that influence the selection of PLS-SEM (S. Wang et al., 2024). In summary, PLS-SEM was selected because of its flexibility, robustness, and suitability for testing complex theoretical models in data-constrained environments, such as those found in port and logistics management research within developing countries, including Pakistan’s Karachi Port.

Justification for choosing a cross-sectional study over a longitudinal approach.

A cross-sectional research design was selected to evaluate container management and logistics efficiency at Karachi Port at a specific point in time (Shoukat & Xiaoqiang, 2023). The cross-sectional method is suitable for fast-changing operational entities like seaports, presenting timely, practical, and profitable perceptions (Mincė, 2024). Unlike longitudinal studies, which need more time and resources to track variations over time, the cross-sectional method supports immediate analysis vital for instant strategic decisions and policy approvals (Goniewicz et al., 2024). It aligns well with the study’s focus on assessing existing port practices using RDT and ETP.

CHAPTER 4

4 DATA ANALYSIS AND FINDINGS

4.1 Introduction

This section contains the analysis of the data gathered via a questionnaire and concludes that the information gathered is expressive of the populace. Within 500 circulated questionnaires, 332 were discovered to be workable, giving a response rate of 68.2%. The data had no missing values, and very few outliers were found in the data, which were engaged for further investigation, considering them to be a part of the sample. The data gathered was not very far away from normality, and common-method bias was not an issue. After cleansing the data, PLS-SEM was adopted for analysis. The first stage in PLS-SEM is assessing the measurement model and establishing the reliability and validity of the data gathered. The results from the structural model analysis show that all the hypotheses were supported except one mediation hypothesis, whose results were insignificant. The model shows a good fit as SRMR was 0.075, which is within the threshold value.

4.2 Survey Response Rate

The concluded questionnaire was used to gather data from the respondents, mainly in Karachi. Some responses were also received from respondents comprising retired officials who had served in these organizations earlier and were located elsewhere (in Islamabad, Rawalpindi, Lahore, and abroad). The data was collected from the employees of CTs at Karachi port, Karachi port Trust head office, and shipping and clearing firms, aged between 20 to above 60 years. At the end of the questionnaire, a 'Thank you' note was endorsed for the respondents as a gesture of appreciation for their time and effort. For those who communicated on LinkedIn, email, or telephone, a thank you note was specially sent, also requesting them to ask others in their profession who may be interested in filling out the survey.

Responses retrieved from the Google Form web survey were first downloaded into a Microsoft Excel spreadsheet. These were then coded and entered SPSS for further analysis. Five hundred questionnaires were distributed among the targeted respondents to achieve the desired sample size. Of the 500 distributed questionnaires, 341 replies were received, giving a response rate of 68.2%, whereas responses to 159 Questionnaires were not received, and 9 responses were rejected, as these were biased and dubious, and did not fulfil the desired criteria. Three thirty-two questionnaires were found useful, giving an overall response rate of 66.4%. The review of social research shows that a response rate of 50% is sufficient, whereas 60% is reasonable, and a 70% response rate is good (Nulty, 2008). Hence, the response rate for the present study is considered adequate. A summary of the response rate is given in Table 4.1

Table 4.1: Summary of survey response rate

Survey Method	Questionnaires survey	Frequency	Percentage
Google Form (online) and hard copies	Total Questionnaires Dispersed	500	100
	Responses Received	341	68.2
	Reply not received	159	31.8
	Overall responses received	341	100
	Faulty Reply and Rejected	9	2.6
	Useable Responses	332	97.4

4.3 Demographic profile of respondents

The data is analysed from 341 respondents. Details of each demographic are explained below:

Table 4.2: Summary of respondents' gender

Category	Respondents	Percentage %	Cumulative Percentage
Male	303	88.9	88.9
Female	38	11.1	100

Table 4.2 highlights the gender distribution of respondents, with a substantial majority being male (88.9%). This reflects the male-dominated nature of the port and container terminal sector in Pakistan, consistent with trends in maritime and logistics industries globally.

Table 4.3: Summary of respondents' Age

Category	Respondents	Percentage %	Cumulative Percentage
Between 20 and 24 years	41	12.0	12.0
Between 25 and 34 years	59	17.3	29.3
Between 35 and 44 years	128	37.5	66.8
Between 45 and 54 years	85	24.9	91.8
Between 55 and 60 years	19	5.6	97.3
Above 60 years	9	2.7	100

Table 4.3 focuses on the age of the respondents, with a substantial majority falling between 35 to 44 years (37.5%). The age bracket of the respondents was between 20 to above 60 years, which is the minimum and maximum employment age limit in the Pakistani port. 37.5% of the respondents fall in the age group between 35 and 44 years, 24.9% between 45 and 54 years, 17.3% are between 25 and 34 years, 12.0% are between 20 and 24 years, 5.6% are between 55 and 60 years, while only 2.6% are above 60 years. Nine respondents above the age of 60 years were excluded as they are retired external freelancers.

Table 4.4: Summary of respondents' experience

Category	Respondents	Percentage %	Cumulative Percentage
Under 3 years	82	24.7	24.7
4 to 7 years	87	26.2	50.9
8 to 12 years	92	27.7	78.6
13 to 20 years	59	17.8	96.4
Over 20 years	12	3.6	100.0

Table 4.4 shows that most respondents had between 4 to 12 years (53.9%) of professional experience, indicating a well-informed participant group with relevant operational exposure. Only a small fraction (3.6%) had over 20 years of experience, suggesting limited representation from senior-most personnel. A total of 27.7% of employees have experience between 8 to 12 years, whereas 26.2% have experience between 4 to 7 years, 24.7% have experience under 3 years, and 17.8% employees have experience between 13 to 20 years. Merely 3.6% have experienced above 20 years.

Table 4.5: Summary of respondents' education

Category	Respondents	Percentage	Cumulative Percentage
Bachelors	166	50.0	50.0
Masters	112	33.7	83.7
MS/MPhil	53	16.0	99.7
PhD	1	0.3	100.0

As shown in Table 4.5, half of the respondents held a bachelor's degree, while a significant portion (49.7%) possessed postgraduate qualifications. This suggests that the survey participants were generally well-educated, supporting the reliability of their input on port operations and management. A total of 50.0 % of respondents possessed a bachelor's degree, 33.7% of employees had a master's degree, 16.0% had an MS/MPhil degree, and 0.30% had a PhD qualification.

Table 4.6: Summary of respondents' Position level

Category	Respondents	Percentage	Cumulative Percentage
Top Management	19	5.7	5.7
Middle Management	215	64.8	70.5
Lower Management	98	29.5	100.0

As per Table 4.6, most of the respondents, i.e. 64.8%, belonged to the middle management category, while the least number of respondents, 5.7% belonged to the top management. In addition, 29.5% of respondents belonged to the lower management positions.

Table 4.7: Summary of respondents' organization

Category	Number of Respondents	Percentage %	Cumulative Percentage
Pakistan International CT (PICT)	89	26.8	26.8
Karachi International CT (KICT)	98	29.5	56.3
South Asia Pakistan Terminal (SAPT)	85	25.6	82.0
Shipping and Clearing Firms	29	8.7	90.7
Karachi Port Trust (KPT)	31	9.3	100

Table 4.7 reveals that most respondents were affiliated with Karachi's three main container terminals, KICT, PICT, and SAPT, collectively representing over 80% of the sample. This distribution ensures that insights are grounded in the core operational environment of Karachi port, enhancing the relevance of the study's findings. Most respondents, i.e., 29.5% belonged to KICT, 26.8% to PICT, 25.6% to SAPT, 9.3% to KPT, and 8.7% to Shipping and Clearing Firms.

Table 4.8: Summary of respondents' sector

Category	Respondents	Percentage	Cumulative Percentage
Private	301	90.7	90.7
Public	31	9.3	100.0

As shown in Table 4.8, the vast majority of respondents (90.7%) were from the private sector. This indicates that the study predominantly reflects the perspectives of private port operators and logistics firms, who are directly involved in the day-to-day functioning and competitiveness of Karachi's CTs.

Table 4.9: Respondents' Department

Category	Respondents	Percentage	Cumulative Percentage
Operations	106	31.9	31.9
Logistics	94	28.3	60.2
Technical	38	11.4	71.6
Information technology	11	3.3	74.9
Finance	9	2.7	77.6
Human Resource	8	2.4	80.0
General management/ Administration	28	8.4	88.4
Services	27	8.3	96.7
Equipment/ Infrastructure	11	3.3	100

Table 4.9 shows that the largest share of respondents belonged to Operations (31.9%) and Logistics (28.3%) departments, reflecting the study's focus on core port functions. The presence of participants from technical, IT, finance, HR, and administrative roles adds depth and diversity, enabling a more comprehensive view of container terminal management and port logistics efficiency. Most of the respondents belonged to the Operations department (31.9%), followed by Logistics (28.3%), Technical (11.4%), General Management/Administration (8.40%), and Services (8.3%). Areas having less than 5% of respondents include Information technology (3.3%). Equipment/ infrastructure 3.3%), Finance (2.7%), Human Resources (2.4%).

Table 4.10: Summary of respondents' city of participation

Category	Respondents	Percentage	Cumulative Percentage
Others	3	0.9	100.0
Lahore	3	0.9	99.1
Karachi	314	94.6	98.2
Islamabad/Rawalpindi	12	3.6	3.6

The largest number of respondents in the sample size, i.e., 94.6% were employees at the Karachi container port or the Karachi-based port-related organizations. Few currently serving and retired CT officials of Karachi port, and those working at the Ministry of Maritime Affairs in Islamabad, were also contacted for input, i.e., 3.6%. Respondents who worked as Masters on container ships and retired Karachi port officials living in Lahore represented 0.9%. Respondents who had served in Karachi port or CTs but had recently switched jobs have been mentioned in others and comprise 0.9%. Due to the long distance, coordination, and cost involved in visiting Karachi port, frequent visits were difficult. The inclusion of respondents from nearby cities helped to interact with officials working at the Ministry of Maritime Affairs and the retired officials of Karachi port, CTs, and shipping lines living here. It was easier to approach them, and they were more candid during informal discussions. The inclusion of these cities was useful as it contributed a reasonable number of senior and knowledgeable respondents to meaningfully support the data analysis.

4.4 Data analysis overview:

The data collected in this study have been measured with SMART PLS4 version 4.0.9.2, which is a software method that is being increasingly used in management, human resource management, IT, equipment, leadership, logistics, and maritime studies (Jawabreh et al., 2023; Ngah et al., 2023). The initial data analysis phase employed SPSS version 25. The SPSS software was used for preliminary procedures involving data screening and for purifying the data, coding/labelling, outlier handling, and normality assumption testing. This software was also used for summarizing the data through descriptive statistics. Structural equation modelling (SEM) was employed to test the research hypotheses in the second phase. Since this study has origins in social and behavioral sciences, where constructs are often directly unobservable; hence, the SEM technique seemed to be an appropriate analytical choice (Dash & Paul, 2021; Usakli & Rasoolimanesh, 2023). The data analysis procedure comprised two phases: preliminary data analysis and PLS data analysis for this study. The former phase dealt with data screening methods, and the latter phase was concerned with applying the two-stage SEM process, as confirmed by the literature. In the first. Stage, the measurement model was assessed using the tests of internal consistency reliability, convergent, and discriminant validity. Path relationships between the latent constructs were specified in the second stage, leading to the last stage of model validation, i.e., hypothesis testing.

4.4.1 Handling - Coding, Entering, and Editing

Once the data was collected and the final survey stage (fieldwork) was completed, the next step was to prepare the raw data for processing and analysis. The raw data had to undergo diverse preparation processes at the preliminary data analysis stage, including data editing, coding, and purification (screening). The objective of preliminary data analysis was the completeness of the data. Data preparation was provided through data handling and data screening. First, data coding was performed in which each participant's response was assigned a unique number. Second, data entry, where all the responses were required to be entered into the database through any accessible software. In the current study, SPSS and Excel served the purpose. Third, data editing was performed in which data collection forms, i.e., questionnaires, were checked for possible omissions, consistency in classification, and legibility (Weiskopf & Weng, 2013). Data from the web survey was automatically accessible in Microsoft Excel form and pre-coded. Since online responses to all sections and items of the questionnaire were mandatory through the 'required' option; hence, no such omission or incomplete response issues were observed in the web survey. The data from the Excel file was entered into SPSS software, where the 'compute variable' function was used to transform all responses. This step partly handled raw survey data for the initial data analysis procedures.

4.4.2 Screening

The next step in the preliminary analysis was data screening, i.e., to purify the handled data from potential issues. The screening step was performed mainly to ensure that the data used for analysis as free from missing and extreme values (outliers) while meeting the primary testing conditions, such as distributional assumptions. The ensuing sections detail the data screening methods performed in this study by focusing the discussion on the rationalized choices of identifying and treating missing values, outliers, and distributional assumptions, i.e., normality issues.

Missing values

Missing data is a missing value not stored for a construct/variable/item in a particular observation or participant's response (Alanazi, 2023). ln practice, missing data can be observed when participants provide answers to only a few of the survey items, or they fail to answer one or more items. The awareness of how severely nonresponse bias can impact the interpretation of survey findings was a fundamental driver behind the improvement of a varied range of techniques to increase response rates (Hamdoun et al., 2024). In case of the existence of non-response bias, survey results could yield misrepresented inferences that do not generalize to the whole population (Bailey, 2023). Therefore, all questions through Google forms were made mandatory to fill out by the respondents for the current study, in addition. Frequency analysis via SPSS was also performed for the initially processed data as a diagnostic step. However, results from frequency analysis provided no evidence of missing observations or values for any variable in the dataset. Since data from the web survey did not present any missing values, no missing value was found on the data.

Outliers

Outlier detection was the next aspect to consider in data screening. Temple et al. (2019) viewed outlier detection as a pre-processing step involving identifying data points in each sample "that do not conform to most observations," (Mallikharjuna Rao et al., 2023). An outlier is a value falling beyond the normal range of data (Boukerche et al., 2020; Osborne & Overbay, 2019). Like missing data, the prevalence of outliers can compromise the statistical power of research (Kwak and Kim, 2017); hence, they need to be identified and managed. Box plots in SPSS were produced using descriptive statistics for each item to detect the present study outliers. The analysis revealed that only a few outliers were present. The value of the 5 trimmed mean was calculated by SPSS after deleting the top/bottom 5 cases, and the mean value was recalculated. The SPSS results of the mean comparison showed an insignificant distinction between the original and trimmed mean values. Therefore, as there were few outliers, this fragment of the sample did exhibit the population's opinions, and thus was retained for further analysis to improve the generalizability of the results (Degtiar & Rose, 2023; Hair Jr et al., 2017). After deleting the responses from overaged respondents above 60 years, being unreliable, 332 responses were left, which complied with the normality criterion.

Normality Assumption

Examination of data normality is vital to certain regression analyses and SEM. The most Fundamental statistical assumption is that the data points follow a bell-shaped curve, as it assumes that the theoretical distribution of the sample means is normal (Dudley-Marling, 2020). The normality of the data was established by using two statistical methods: first, by skewness and kurtosis, and then by the Shapiro-Wilk test. The test results are shown in Table 4.11 and Table 4.12, respectively. The present study used a test of skewness and kurtosis which were achieved to detect data normality. As a thumb rule, a skewness value beyond +/-1 and a kurtosis value of +/-2 indicate the non-normality of the data. The outcome shows that values were below the minimum threshold, showing the data's normality. However, the results also showed that the data were not distant from the normality, as extremely non-normal data inflate the standard errors and prove problematic in assessing parametric significance (Knief & Forstmeier, 2021). As per Cheah et al. (2024), smart PLS-SEM can perform when distribution issues are a concern, such as a lack of normality.

Table 4.11: Summary of Descriptive Statistics

Variables	Min	Max	Mean	Std. Dev	Skewness	SE	Kurtosis	SE
Port Technology	1.00	5.00	3.8912	.51872	-.443	.134	.478	.267
Port infrastructure	1.00	5.00	4.1056	.46515	-1.047	.134	1.150	.267
Port Equipment	1.00	5.00	4.0781	.52598	-.493	.134	.319	.267
Port Human Resources	1.00	5.00	4.0166	.50849	-.897	.134	.923	.267
Port Services	1.00	5.00	3.9270	.46010	-.898	.134	.473	.267
Port Charges	1.00	5.00	3.6399	.46174	.314	.134	1.458	.267
Port Container Management	1.00	5.00	4.0231	.51118	-.762	.134	.437	.267
Port Logistic Efficiency	1.00	5.00	3.7104	.59089	.520	.134	-.987	.267

Source: As per (Demir, 2022; George, 2011) acceptable values of skewness fall between +/-2. Whereas kurtosis is appropriate for a range of +/-7 (Demir, 2022; Hair et al., 2013).

Table 4.12: Kolmogorov-Smirnov & Shapiro-Wilk Tests of Normality. Appendix E

Table 4.11 presents the descriptive statistics for the study's key constructs. All variables have mean scores above 3.6 on a five-point Likert scale, suggesting that respondents generally agreed or strongly agreed with positive statements about port resources, container management, and logistics efficiency. The standard deviations are relatively low (around 0.46 - 0.59), indicating a consistent pattern of responses across participants. The skewness values for all variables fall within the acceptable range of ±2 (Demir, 2022; George, 2011), indicating no severe asymmetry in the data distribution. Similarly, kurtosis values fall well within the acceptable ±7 range (Hair et al., 2013), confirming that the variables exhibit near-normal distributions.

These results validate the reliability of using Partial Least Squares Structural Equation Modelling (PLS-SEM) for hypothesis testing. Since the data demonstrate appropriate skewness and kurtosis, the relationships proposed in the hypotheses (H1 - H13) can be meaningfully tested. Moreover, the relatively high mean scores for Port Infrastructure (M = 4.11), Port Equipment (M = 4.08), and Port Container Management (M = 4.02) reinforce the theoretical assumptions of the Resource Dependence Theory (RDT), that stronger organizational resources contribute to greater operational efficiency.

4.5 Common Method Variance

Common Method Variance (CMV) arises when data for all (independent and dependent) variables in quantitative analysis is collected using the same method or source (Saxena et al., 2024). This can alter the actual relationship among variables, compromising a study's internal validity. CMV can be caused due to: Measurement context (e.g., survey setting), Response styles (e.g., social acceptance), or Item characteristics (e.g., question wording or order) (Wall et al., 2022). CMV can be managed/reduced, and the credibility of research findings can be improved by using the preventive or detection/correction methods (Phipps et al., 2024). Firstly, in **Preventive Methods**, we can use different data sources (e.g., interviews, surveys); assure anonymity to reduce biased responses; vary measurement formats and scales; separate the measurement of variables in time or method; randomize question order; and provide clear instructions to avoid misinterpretation. Secondly, in **Detection and Correction Methods**, we can use Harman's Single-Factor Test to check if one factor dominates the variance; CFA with Method Factor: Adds a common method factor to detect CMV; Unmeasured Latent Method Construct (ULMC): Models method bias directly; Marker Variable Technique: Uses an unrelated variable to estimate CMV; and Statistical Controls: Applies methods like partial correlation to adjust results.

As a potential source of measurement error, Harman's single-factor test is a traditional approach that has been criticized as a conceptually flawed and weak statistical remedy with little statistical usefulness in controlling the method bias (Podsakoff et al., 2003). Instead, Sabol et al. (2023) introduced a complete collinearity approach as a statistical control procedure for CMV in SEM-based studies. Full collinearity measures lateral and vertical collinearity and assesses CMV through variance inflation factors (VIFs). VIF is a statistical measure of collinearity between two or more constructs or among formative measurement indicators in a model (Purwanto & Sudargini, 2021); (Hair, Black, et al., 2019). VIF > 3.3 indicates pathological collinearity, which adheres to a conservative view, alarming CMV's potential presence in a model (Kock, 2015). A model is considered free of CMV if VIFs for all constructs are <3.3 (Kock, 2015). Hair et al. (2019, p.777) stated that "VIF above 3.3 is an indicator of a likely collinearity problem while VIF > 5 is 'a definite indicator of high collinearity'. Following Kock (2015), this study performed a whole collinearity test to identify CMB in the proposed model. The entire collinearity procedure yielded all VIF values less than the conservative threshold, i.e., < 3.3, as shown in Table 4.4. Based on the VIF outcomes, the sample data was not contaminated by noise, and there was no single-source bias issue; thus, the decision was made to proceed further with the analysis.

Table 4.13: Summary of collinearity testing

Port Charges	Port Container Management	Port Equipment	Port Human Resources	Port Infrastructure	Port Services	Port Technology
1.399	2.021	2.617	1.459	2.865	1.300	1.696

Endogeneity is a common problem in research because it occurs when an independent variable is also associated with the error term (Eckert et al., 2022; Liang & Xue, 2022). Biased estimates and wrong conclusions can emerge from endogeneity, resulting from sample selection measurement error, omitted factors, or simultaneous causality (Hill et al., 2021). Endogeneity occurs when one or more of the latent variables pointing at the endogenous latent variables are correlated with the structural error associated with the endogenous latent variables in the context of partial least squares structural equation modelling. The predicted path coefficients for the links pointing at an endogenous latent variable may be biased if endogeneity exists concerning the latent variables (Kaufmann and Kock, 2022). Endogeneity also includes using various sources for dependent and independent variables to minimize common method bias (Jordan & Troth, 2020). Therefore, data for independent and dependent variables were collected from different organizations and various tiers of respondents in the telecom sector, in addition to testing the common method bias.

4.6 Common Method Bias

Common method bias can appear when both the independent and dependent variables are captured by the same response method (Jordan & Troth, 2020; Kock et al., 2021). Common method bias refers to a variance that is attributable to the measurement method rather than to the construct of interest' (Baumgartner et al., 2021). As one of the basic causes of measurement error, common method bias is a problem in surveys, because it often leads to invalid conclusions about the relationships between variables through inflation or deflation of the findings (Podsakoff et al., 2003). Hence, common method bias is one of the most frequently cited concerns among information system scholars (Jordan & Troth, 2020; Kock et al., 2021). It is usually possible for researchers to employ practical remedies to minimize the potential impact of common method bias on the findings of their study. Several authors (Straub, Boudreau and Gefen, 2004; Malhotra, Schaller and Patil, 2017) agree that Harman's single-factor test is the most utilized statistical remedy for assessing and controlling common method bias across all fields. In this single-factor test, all the items and variables in a study are under the control of exploratory factor analysis (EFA) (Malhotra, Schaller and Patil, 2017). By examining the unrotated factor solution, the test determines the number of factors of importance in explaining the variance in the variables (Podsakoff et al., 2003). Common method bias is assumed to occur 'if (a) a single factor will emerge from factor analysis or (b) one general factor will account for the majority of the covariance among the measure' (Podsakoff et al., 2003). In addition to testing the common method bias, the data collection was done in steps by giving 10 to 15 days gap to avoid the bias in responses for respondents working in CTs at Karachi port and related logistic organizations. In smart PLS4 the common method bias (CMB) through variance inflation factor (VIF) values of the inner model. In the current study, all the VIF values are lower than 3.33, so the model can be considered free from common method bias (Kock 2015).

4.7 Exploratory Factor Analysis

The purpose of exploration factor analysis (EFA) is to define the structure of potential underlying latent variables and reduce a data set with many variables to a smaller and more manageable size (Moolchandani, 2024). It is a complex procedure, and researchers need to select the most efficient options, mainly for factor extraction and factor rotation (Costello and Osborne, 2005). Factor extraction is the process of deciding how many factors to keep (Brown, 2006). Several methods of factor extraction include principal component analysis, principal factors, maximum likelihood factoring, image factoring, alpha factoring and unweighted and generalized weighted least squares factoring (Tabachnick and Fidell, 2013). Among them, the principal component analysis method was selected for the EFA, as it is a commonly used method for extraction to classify the latent variables in research (Hair, Risher, et al., 2019).

The result of the factor extraction technique offers the eigenvalue related to the respective factors, which shows the significant importance of each factor. Kaiser (1974) recommended retaining the factors with eigenvalues above 1 (Ruscio & Roche, 2012). However, Jolliffe (1986) claims that Kaiser's criterion is quite severe and proposes the criterion of an eigenvalue up to 0.7. In this study, the decision of whether to employ Kaiser's (1974) or Jolliffe's (1986) criterion depended on the number of extracted factors associated with each criterion. It was expected that the number of factors extracted would meet the required number of factors proposed in the theoretical model. Once factors were extracted, the factor rotation technique was utilized to discriminate between factors. Among three methods of orthogonal rotation in SPSS, (i.e., Varimax, Quartimax and Equamax) and two methods of oblique rotation (direct Oblimin and ProMax)' (Field, 2013, p.681). The varimax rotation method developed by Kaiser (1974), was selected for the EFA process, being the most used technique to classify important factors (Field, 2013; Hair et al., 2019). Field (2013) proposes retention of items with factor-loading values of 0.4 and higher. Items loading on more than one factor are to be removed to evade cross-loading (Hair, Risher, et al., 2019).

It is imperative to undertake a reliability analysis on each identified factor to obtain Cronbach's alpha value (Izah et al., 2023). A value of 0.7 to 0.8 is considered adequate for Cronbach's alpha (Ahmad et al., 2024); (Kennedy, 2022; K. S. J. R. i. s. e. Taber, 2018). Yet, in the case of psychological constructs, a Cronbach's alpha value of below 0.7 could be suitable due to the variety of measured constructs (Kline, 2016). The values of Cronbach's alpha, if the item was removed, were also checked to deliberate whether the removal of an item could improve the global reliability value of its related construct (Izah et al., 2023). The Exploratory Factor Analysis (EFA) was performed to ascertain the reliability of the questionnaire and extract the variables, factors, and reduce the dimensions (Karimian & Chahartangi, 2024). Usually, the factor analysis is conducted for samples larger than 100. Therefore, the sample size of 341 used in this study is suitable for EFA. In his study, Watkins (2018) recommended that the loading of EFA must be above 0.40. The cut-off points of factor loading in EFA should be 0.50 (Rawlings et al., 2024). The result revealed that all factor loading values were above the 0.50 mark. Thus, the factor loading of every item in this study is above the needed level, as displayed in Table 4.16.

Table 4.14: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.802
Bartlett's Test of Sphericity	Approx. Chi-Square	26586.546
	df	7140
	Sig.	.000

Table 4.15: Total Variance Explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	21.830	18.192	18.192	4.630	3.859	3.859
2	6.074	5.061	23.253	4.496	3.746	7.605
3	4.900	4.083	27.336	4.217	3.514	11.119
4	3.960	3.300	30.636	4.104	3.420	14.539
5	3.624	3.020	33.656	3.978	3.315	17.854
6	3.306	2.755	36.411	3.704	3.087	20.940
7	3.100	2.583	38.995	3.410	2.842	23.782
8	2.798	2.332	41.327	3.333	2.777	26.560
9	2.548	2.123	43.450	3.324	2.770	29.330
10	2.509	2.091	45.541	3.231	2.693	32.022
11	2.360	1.967	47.508	3.189	2.658	34.680
12	2.214	1.845	49.353	3.165	2.637	37.318
13	2.026	1.688	51.041	3.091	2.576	39.893
14	1.974	1.645	52.686	2.969	2.474	42.367
15	1.823	1.519	54.206	2.843	2.369	44.737
16	1.784	1.487	55.693	2.805	2.337	47.074
17	1.694	1.412	57.104	2.733	2.277	49.351
18	1.665	1.388	58.492	2.669	2.224	51.576
19	1.566	1.305	59.797	2.571	2.143	53.718
20	1.519	1.266	61.063	2.474	2.062	55.780
21	1.413	1.178	62.240	2.363	1.969	57.750
22	1.373	1.144	63.384	2.181	1.817	59.567
23	1.340	1.117	64.501	1.892	1.577	61.144

24	1.300	1.084	65.585	1.883	1.569	62.713
25	1.227	1.023	66.608	1.800	1.500	64.213
26	1.203	1.002	67.610	1.798	1.499	65.712
27	1.175	.979	68.589	1.700	1.416	67.128
28	1.162	.969	69.557	1.665	1.387	68.515
29	1.115	.929	70.487	1.531	1.276	69.791
30	1.076	.897	71.383	1.375	1.146	70.937
31	1.043	.869	72.253	1.350	1.125	72.062
32	1.012	.844	73.096	1.242	1.035	73.096
33	.955	.796	73.892			

Table 4.15 presents the total variance explained through Exploratory Factor Analysis (EFA). Initially, 32 components were extracted with eigenvalues greater than 1.0, but after rotation, the meaningful variance was more concentrated across fewer components. The first component accounted for 18.19% of the variance, and cumulatively, the first five components together explained approximately 17.85% of the total variance after rotation. As rotation proceeds, it becomes evident that the cumulative variance explained by 32 components reaches 73.10%.

The results suggest that the underlying factor structure of the data is strong, with a large portion of the variance captured by relatively few components. This supports the theoretical constructs developed in the study, aligning with the Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP), which argue that port performance can be explained through structured, multidimensional resource components.

Moreover, the findings confirm that the observed variables cluster well into distinct latent factors such as Port Technology, Port Infrastructure, Port Equipment, Port Human Resources, Port Services, Port Charges, Port Container Management, and Port Logistics Efficiency. These results validate the dimensionality of the constructs used for hypothesis testing (H1–H13), ensuring that the study's model is empirically sound and theoretically justified.

Table 4.16: Exploratory Factor Analysis (EFA) Rotated Component Matrix, (at Appendix E).

The above EFA results in Table 4.16 show that the items with higher factor loadings and stronger relationships with the various dimensions of the constructs have been identified and retained for further analysis. The EFA was conducted using Principal Component Analysis with Varimax rotation, which confirmed that the data were suitable for factor extraction and that all retained items loaded strongly on their intended constructs. Factors with eigenvalues greater than 1.0 were retained, and items loading below 0.50 or showing cross-loadings were removed. After removing low-loading or cross-loading items, the rotated matrix revealed clear and coherent factor patterns across the constructs. Minimal cross-loading and stable convergence demonstrated strong construct validity, and the validated factors were subsequently used for reliability assessment and structural modelling.

4.8 Measurement Model

The measurement model is developed from the conceptual framework earlier conceived in the study. The measurement model results are obtained with the help of collected data, and its results are interpreted with lower-order constructs (LOCs). The conceptual framework comprises eight constructs, of which six are independent variables (IVs), a mediating variable (MV), and a dependent variable (DV).

Phase 2: Data Analysis. After EFA, 78 items were retained for further analysis. Smart PLS software version 4.0.9.2 was chosen to perform the measurement and structural model assessment. Sarstedt et al. (2019a) and Lai and Hsiao (2022) recommended a two-stage approach to carry out SEM, to assess the measurement model, which is followed by an analysis of the structural relationship (path analysis).

4.8.1 Assessment of Measurement Model

A measurement model was developed in this research to measure the degree of dependence observed variables tend to display on the latent variables. SmartPLS4 version 4.0.9.2 was used to run the PLS algorithm for this purpose. The measurement model was evaluated at the lower-order and higher-order levels for each construct using indicator reliability, internal consistency reliability, and construct validity to ascertain convergent and discriminant validity. The measurement model reveals in what way latent constructs were measured via their observed variables and assesses their measurement properties. Before proceeding to the structural model, the measurement model properties should be satisfied (Anderson & Gerbing, 1988; Cheung et al., 2024; Fornell & Larcker, 1981; Hair Jr et al., 2020).

This study has eight reflective constructs, including port technology, port infrastructure, port equipment, port HR, port services, port charges, port container management, and port logistic efficiency. These constructs were measured through 78 items. The valuation of the measurement model is normally done for reliability and validity (Sürücü & Maslakci, 2020). The model is exhibited in Figure 4.1, with circles exhibiting the constructs, whereas rectangles demonstrate the items utilized to measure the exhibited constructs.

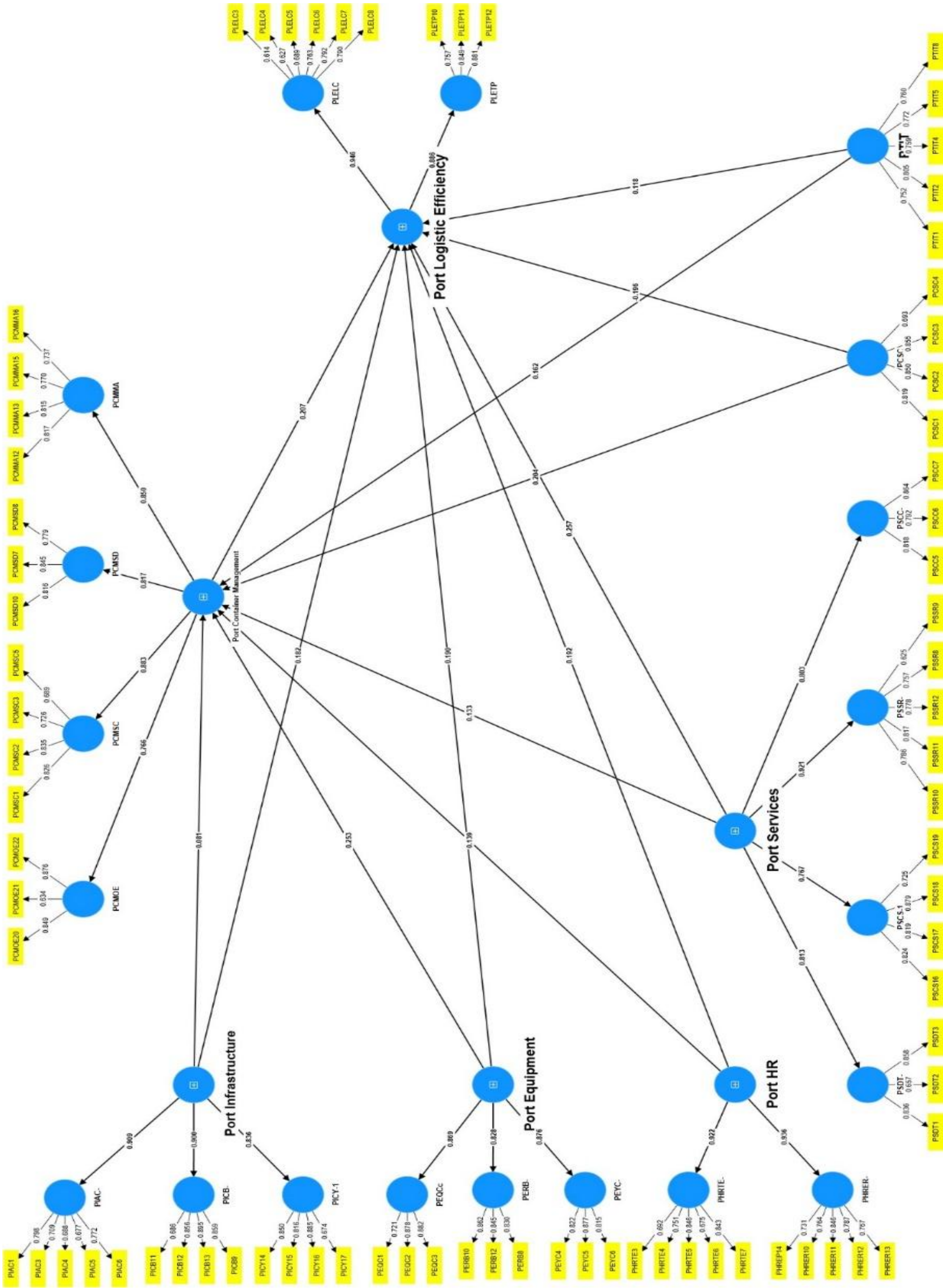


Figure 4.1: Image of the measurement model analysis - Lower Order Construct (LOC)

Indicator reliability. On a choice between single-item (SI) and multi-item (MI), (Diamantopoulos et al., 2012) recognize SI as a suitable measure option for exploratory research designs. In an empirical situation, however, MI is a fairly feasible option. As per the guiding principle by Diamantopoulos et al. (2012), and Sarstedt et al. (2016), this work has adopted the MI option to measure the individual construct of the research model. Every set of items measuring the underlying construct was first assessed for indicator reliability in Table 4.57. Outer loadings are used as a parameter to evaluate how items that clarify the underlying factor fulfil the purpose. For the present study research model and multilevel constructs.

4.8.2 Lower Order Construct (LOC).

Indicator reliability was tested between each construct and its items at the first-order level (lower-order construct). The lower-order construct (LOC) shown in Figure 4.1 is port technology, port charges, and the dimensions of the constructs, port infrastructure, port equipment, port human resources, port services, port container management, and port logistic efficiency. All the items of variables and their measurements are shown. The outer loadings for LOC range from 0.533 to 0.859 at a significance level of 0.000. The LOC results from the algorithm exhibited that outer loading values were above the minimum cut-off point of 0.50 (Maskey et al., 2018; Sanchez-Garcia et al., 2024) and the items fulfilled the CR, AVE value criterion, and indicator reliability at the LOC level, as shown in Table 4.16. The construct composite reliability and convergent validity concerning the first-order or lower-order construct are shown in Table 4.17 below:

Table 4.17: Construct Reliability and Validity (CFA)

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
PCMMA	0.792	0.792	0.866	0.617
PCMOE	0.707	0.767	0.834	0.630
PCMSC	0.770	0.770	0.854	0.595
PCMSD	0.744	0.745	0.854	0.662
PCSC	0.822	0.856	0.881	0.651
PEQC	0.769	0.771	0.869	0.689
PERB	0.801	0.806	0.883	0.715
PEYC	0.788	0.788	0.876	0.703
PHRER	0.838	0.841	0.886	0.608
PHRTE	0.820	0.834	0.875	0.585
PIAC	0.779	0.784	0.850	0.533

PICB	0.842	0.846	0.896	0.685
PICY	0.824	0.846	0.884	0.657
PLELC	0.807	0.816	0.862	0.513
PLETP	0.773	0.772	0.869	0.690
PSCC	0.767	0.780	0.864	0.680
PSCS	0.829	0.840	0.886	0.662
PSDT	0.702	0.753	0.830	0.623
PSSR	0.811	0.825	0.869	0.571
PTIT	0.829	0.838	0.879	0.593

Table 4.17 presents the results of the Confirmatory Factor Analysis (CFA) for construct reliability and validity. All constructs exhibit strong internal consistency, as indicated by Cronbach's alpha values exceeding the threshold of 0.70, which is widely accepted for reliability (Hair et al., 2013). The Composite Reliability (CR) values (both rho_a and rho_c) are also above the 0.70 benchmark, confirming that the items within each construct are consistently measuring the same underlying concept.

Further supporting construct validity, the Average Variance Extracted (AVE) values for all constructs are above 0.50. This implies adequate convergent validity, meaning that each set of indicators shares a high proportion of variance in common with their corresponding construct. The reliability and validity results strengthen the theoretical foundations of the study based on the Resource Dependence Theory (RDT) and Economic Theory of the Port (ETP). According to these theories, the consistent and reliable measurement of port resources (such as Port Technology, Port Infrastructure, Port Equipment, Port Human Resources, and Port Services) is critical to understanding their influence on Port Logistic Efficiency and Port Container Management.

Table 4.18: Summary of indicator reliability for lower order construct (LOC)

Lower-order Constructs (LOCs)	Dimensions	Items	Loading	Composite reliability (rho_c)	Average variance extracted (AVE)	Mean (M)	Standard deviation (SD)
Port Technology	Information technology (PTIT)	PTIT-1	0.656	0.879	0.593	3.98	.994
		PTIT-2	0.811			3.91	.836
		PTIT-4	0.731			3.85	.856
		PTIT-5	0.648			3.80	1.005
		PTIT-8	0.665			3.80	.951
Port Charges (PC)	Service Cost (PCSC)	PCSC-1	0.718	0.881	0.651	3.67	.937
		PCSC-2	0.670			3.57	.868
		PCSC-3	0.762			3.59	.873
		PCSC-4	0.673			3.62	.833

Table 4.18 presents the indicator reliability analysis for the lower-order constructs (LOCs) of Port Technology and Port Charges. The item loadings for Port Technology Information Technology (PTIT) dimension range from 0.648 to 0.811, all exceeding the commonly accepted threshold of 0.60, indicating acceptable reliability for individual items (Hair et al., 2013). The composite reliability (CR) for PTIT is 0.879, and the average variance extracted (AVE) is 0.593, confirming strong internal consistency and convergent validity. The mean scores (ranging from 3.80 to 3.98) with moderate standard deviations suggest that respondents generally perceive port IT systems positively but with some variation in opinions. Similarly, the Port Charges (PC) dimension, measured through the Service Cost (PCSC) items, shows item loadings between 0.670 and 0.762. The composite reliability for PCSC is 0.881, and the AVE is 0.651, both exceeding recommended cutoffs. These results indicate that the items reliably measure perceptions related to port service costs. The mean values (approximately 3.57 to 3.67) suggest moderate agreement among respondents that port charges impact logistic operations, which supports the relevance of this construct for further hypothesis testing.

Overall, the lower-order constructs meet the reliability and validity criteria, reinforcing the robustness of the measurement model. The strong indicator reliability underpins the theoretical assumption, based on Resource Dependence Theory (RDT) and Economic Theory of the Port (ETP), that technological advancement and cost factors are critical influences on port logistic efficiency.

4.8.3 Higher Order Constructs (HOC) - PLS-SEM Model

The current study comprises eight constructs, i.e., Port Technology, Port Infrastructure, Port Equipment, Port HR, Port Services, Port Charges, Port Container Management, and Port Logistic Efficiency, as shown in the measurement model in Figure 4.2. The higher-order components are needed to decrease the number of relationships and to address collinearity problems (Ciavolino et al., 2022). At the high-order construct, i.e., second-order level, indicator reliability is assessed for each latent variable and its indicators. As shown in Table 4.8, all indicators displayed satisfactory indicator reliability by sustaining the cut-off value of loadings >0.5; $p < 0.05$. The outer loadings for HOCs, at a significance level of 0.000, ranged from a minimum of 0.694 to a maximum of 0.944.

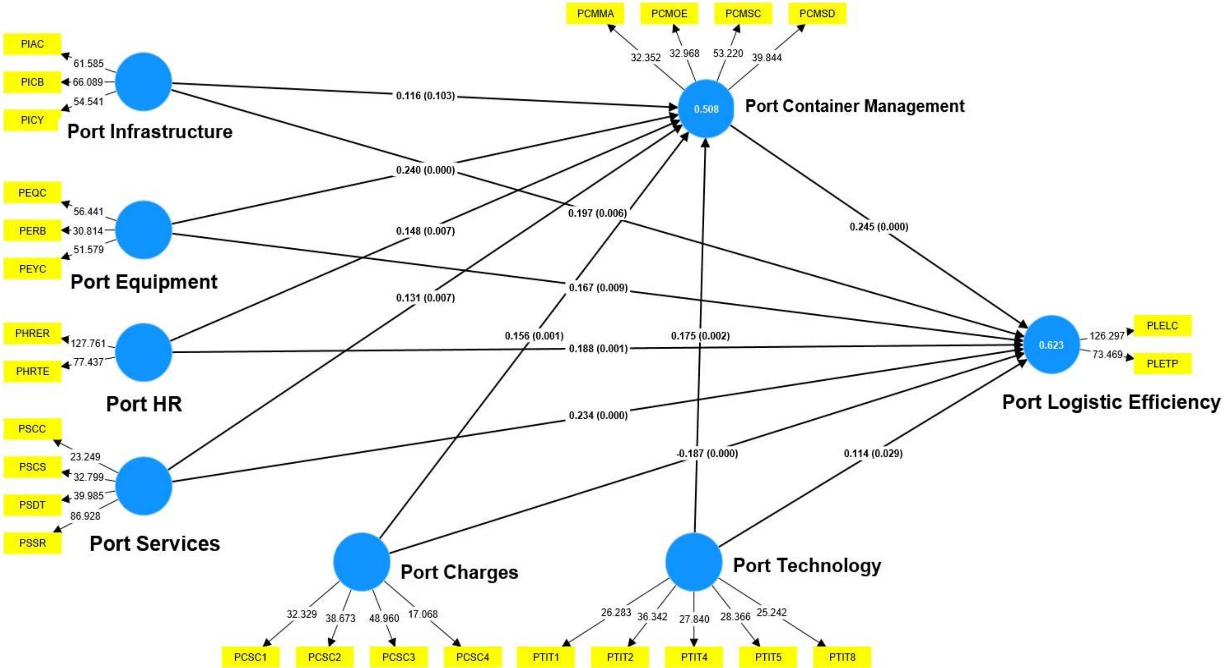


Figure 4.2: Measurement model of Higher Order Construct (HOC)

4.8.4 Internal Consistency

The composite reliability measure should be higher than 0.7 to assess the constructs' reliability (Munir, 2018). Composite reliability is considered the most reliable measure for internal consistency, and all the values of CR are above 0.7, meeting the internal consistency reliability criterion as shown in Table 4.8. Cronbach's alpha is a less precise measure since the items are unweighted. CR considers item weights and produces higher values, while Cronbach's alpha is a conservative measure (Peng & Lai, 2012). Appendix F displays the bar charts of reliability, validity, and other trials.

4.8.5 Convergent Validity

Typically, the convergent validity is compared by using composite reliability, Cronbach's alpha, ρA, and average variance extracted (AVE) suggested by (Jöreskog, 1971). However, composite reliability is often used for internal consistency reliability as it considers the actual figures while calculating the indicators (Agarwal, 2007). The result of the algorithm shows that CR and AVE for all the constructs meet the criteria (Purwanto, 2021).

Table 4.19: Summary of the Constructs, Composite Reliability, and Convergent Validity

Constructs		Composite reliability	Average variance extracted (AVE)
	Lower-order constructs		
Port Technology	Information technology	0.879	0.593
Port Charges	Service cost	0.881	0.651
	Higher-order constructs		
	Accessibility	0.850	0.533
Port Infrastructure	Container Berth	0.896	0.685
	Container yard	0.884	0.657
	Quay crane	0.869	0.689
Port Equipment	Yard crane	0.876	0.703
	Reliability	0.883	0.715
Port Human Resources	Training and Education	0.875	0.585
	Employee reliability	0.886	0.608
	Dwell Time	0.830	0.623
Port services	Custom Clearance	0.864	0.680
	Service Reliability	0.869	0.571
	Customer satisfaction	0.886	0.662
	Strategic capabilities	0.854	0.595
	Strategic Direction	0.854	0.662
Port container management	Management related	0.866	0.617
	Operational efficacy	0.834	0.630
Port logistics efficiency	Logistic capability	0.862	0.513
	Throughput	0.869	0.690

The results for composite reliability and convergent validity of all study constructs appear in Table 4.18. The study findings show strong internal consistency across the constructs because all composite reliability values surpass the established threshold value of 0.70 (Hair et al., 2013). The Average Variance Extracted (AVE) demonstrates acceptable convergent validity for all constructs as the values surpass the threshold of 0.5. Port Technology measured through Information Technology achieves high reliability (CR = 0.879) and satisfactory AVE values (0.593), as does Port Charges measured through Service Cost (CR = 0.881 and AVE = 0.651). The research indicators possess reliable measures to detect specific technology functions and cost elements present at the port. Measurement properties of the higher-order constructs prove to be very robust. The reliability values of Port Infrastructure dimensions match the observed AVE values, through 0.533 to 0.685, which indicates scores exceeding 0.850 and reaching up to 0.896. The dimensions within Port

Equipment, along with Port Human Resource and Port Services, present constant reliability and successful convergent validity across their segments. Operational resource assessment is robust because Yard Crane and Quay Crane equipment dimensions possess strong AVE results along with high CR numbers (above 0.86). The measurement model of Port Container Management and Port Logistic Efficiency achieves satisfactory reliability and validity metrics because their planned and operational indicators show strong performance. The measurement model shows stability and readiness for hypothesis testing based on the evidence from Strategic Capabilities (CR = 0.854; AVE = 0.595) and Throughput (CR = 0.869; AVE = 0.690).

4.8.6 Discriminant Validity

Discriminant validity explains to what extent the constructs are different from each other. Three measures assessed it: first, the Fornell and Lacker criterion; second, Cross-loadings; and third, the Heterotrait-Monotrait ratio (HTMT), as suggested by Henseler et al. (2015). Smart PLS provides results for all these criteria of discriminant validity assessment. The present study used the HTMT criterion for reporting purposes, which is widely used in the literature. HTMT is computed as the mean of all the correlations of the indicators measuring various constructs relative to the geometric mean of the average correlations of the indicators measuring the same construct. Smart PLS generated HTMT values, as shown in Table 4.12. The criterion for discriminant validity assessment is that any value above the cutoff point is 0.85 (Kline, 2011) or 0.90 (Ab Hamid et al., 2017) indicates the presence of discriminant validity. The composite reliability values should be above 0.70, although 0.60 is acceptable. Values above 0.9 suggest the indicators are not fully measuring the construct. Yet, adjustments should be considered for any construct with composite reliability above 0.95 (Hulin, 2001; Risher & Hair Jr, 2017). As per Hair Jr et al. (2021b), the minimum value for composite reliability is 0.60, the recommended values are 0.80 to 0.90, and the maximum value is 0.95 to avoid indicator redundancy, which would compromise content validity. As shown in Table 4.12, all values are within limits, showing that discriminant validity was established. The reliability and validity criterion assessment displayed that the measurement model was acceptable. All reliability and validity determinants were fulfilled, and SRMR was 0.075, which was within permissible limits; thus, the model is valid and fit for further process to estimate parameters of the structural model.

Table 4.20: Discriminant Validity Results – Heterotrait-Monotrait Ratio (HTMT)

	PCMMA	PCMOE	PCMSC	PCMSD	PCSC	PEQC	PERB	PEYC	PHRER	PHRTE	PIAC	PICB	PICY	PLELC	PLETP	PSCC	PSCS	PSDT	PSSR
PCMOE	0.703																		
PCMSC	0.857	0.716																	
PCMSD	0.695	0.834	0.829																
PCSC	0.581	0.371	0.620	0.335															
PEQC	0.386	0.605	0.561	0.547	0.241														
PERB	0.518	0.594	0.658	0.463	0.386	0.708													
PEYC	0.587	0.569	0.690	0.526	0.448	0.864	0.729												
PHRER	0.526	0.560	0.506	0.463	0.421	0.563	0.525	0.548											
PHRTE	0.485	0.452	0.440	0.359	0.406	0.443	0.428	0.452	0.868										
PIAC	0.476	0.660	0.585	0.530	0.422	0.851	0.623	0.732	0.501	0.419									
PICB	0.499	0.594	0.631	0.472	0.542	0.698	0.685	0.729	0.524	0.444	0.848								
PICY	0.558	0.647	0.640	0.541	0.561	0.712	0.723	0.770	0.571	0.467	0.850	0.811							
PLELC	0.493	0.830	0.630	0.758	0.366	0.813	0.609	0.603	0.587	0.485	0.738	0.550	0.660						
PLETP	0.502	0.769	0.497	0.612	0.421	0.713	0.601	0.567	0.621	0.453	0.761	0.621	0.658	0.896					
PSCC	0.200	0.293	0.217	0.334	0.117	0.398	0.341	0.170	0.108	0.133	0.336	0.186	0.343	0.471	0.422				
PSCS	0.411	0.428	0.400	0.499	0.447	0.398	0.381	0.349	0.273	0.215	0.501	0.465	0.447	0.478	0.454	0.563			
PSDT	0.290	0.376	0.255	0.370	0.160	0.383	0.240	0.211	0.199	0.189	0.391	0.323	0.421	0.557	0.466	0.869	0.665		
PSSR	0.378	0.486	0.430	0.509	0.346	0.473	0.455	0.420	0.260	0.209	0.521	0.409	0.499	0.601	0.578	0.817	0.796	0.837	
PTIT	0.493	0.603	0.594	0.585	0.492	0.569	0.580	0.515	0.478	0.409	0.588	0.623	0.677	0.663	0.577	0.340	0.469	0.416	0.438

Table 4.21: Containing collinearity statistics (VIF), item-wise, is placed in Appendix E.

The assessment of discriminant validity in Table 4.20 relies on the Heterotrait-Monotrait Ratio (HTMT) as the criterion. Discriminant validity signifies that each measured construct maintains an independent, unique nature compared to the other constructs to validate the theoretical construct identity. Hair et al. (2017) establish that HTMT values under 0.90 validate the discriminant validity between constructs. The analysis demonstrates that all values under 0.90 maintain the evaluation of discriminant validity between Port Technology and Port Infrastructure and the other constructs (such as Port Equipment, etc.) that verify their distinct empirical nature. The analysis shows that the HTMT value measuring the relationship between Port Technology (PCMMA) and Port Container Management Strategic Direction (PCMSD) is 0.695, which is lower than the threshold, while Port Equipment Reliability (PERB) and Port Equipment Yard Crane (PEYC) have an HTMT of 0.729. Both values lie within the acceptable boundaries. The constructs demonstrate moderate correlations since Port Infrastructure Accessibility (PIAC) and Port Infrastructure Container Berth (PICB) hold a value of 0.848 but still fall into the accepted range.

4.9 Assessment of Structural Model

Reliable and valid outer model estimations allow an assessment of the inner (structured) path model estimations (Henseler et al., 2009). Scholars of PLS usually use the bootstrap technique to test the relationship between variables (Gefen et al., 2000). Thus, to conduct this assessment, the amount of variance explained and the statistical significance were evaluated based on six criteria; (i) collinearity assessment, (ii) path coefficient (β) that indicates the strength of the relationship between constructs, (iii) percentage of variance explained or R square (R2), traditional regression score, (iv) assessment of effect size f2 (v) predictive relevance Q2 (vi) q2 effect size.

The next step in the data analysis was to validate the research model by examining the underlying structural relationship. The structural model was evaluated at the higher-order level, i.e., the second level of measurement (Becker et al., 2023). The proposed model was validated under the repeated indicators approach (RIA) using the PLS Algorithm and PLS Bootstrapping functions by the guidelines given by (Al-Okaily et al., 2020). As described in Chapter 3, together 12 hypotheses were developed to achieve the research objectives of this study.

Table 4.22: Discriminant Validity Heterotrait-Monotrait (HTMT) Ratio – HOC

	Port Charges	Port Technology	Port Container Management	Port Equipment	Port HR	Port Infrastructure	Port Logistic Efficiency
Port Charges							
Port Technology	0.492						
Port Container Management	0.537	0.640					
Port Equipment	0.402	0.635	0.717				
Port HR	0.431	0.469	0.563	0.597			
Port Infrastructure	0.549	0.688	0.704	0.907	0.562		
Port Logistic Efficiency	0.296	0.647	0.742	0.782	0.603	0.761	
Port Services	0.301	0.475	0.480	0.462	0.232	0.508	0.618

The analysis of discriminant validity for higher-order constructs (HOCs) by the Heterotrait-Monotrait (HTMT) ratio appears in Table 4.22. The assessment of discriminant validity is essential to show that Port Technology, Port Infrastructure, Port Equipment, Port Human Resources (HR), Port Services, Port Charges, Port Container Management, and Port Logistic Efficiency operate independently from one another. The HTMT criterion shows that values less than 0.90 lead to acceptable discriminant validity according to Hair et al. (2017). The analysed HTMT values indicate successful discrimination between all proposed constructs since they stay under the established threshold of 0.90. The HTMT ratios between Port Technology and Port Container Management relate at 0.640, while Port Infrastructure and Port Logistic Efficiency show a 0.761 HTMT ratio to establish acceptable discriminant validity. The maximum HTMT value exists between Port Infrastructure and Port Equipment (0.907), although it exceeds the accepted cutoff slightly. This minor theoretical justification for the acceptable elevation exists since the conceptual similarities between port infrastructure and equipment and the acceptable measurement indicators from previous tests (composite reliability and AVE) maintain the model's validity. The higher-order discriminant validity assessment is crucial because it supports the distinct resource-category relationships with port logistic efficiency, which the hypotheses (H1 to H13) require. The separation between different resources matches both Resource Dependence Theory (RDT) and Economic Theory of the Port (ETP) because these theories establish that operational outcomes derive from independent resources. The data in Table 4.22 confirm both the theoretical framework and the established structural models for this research.

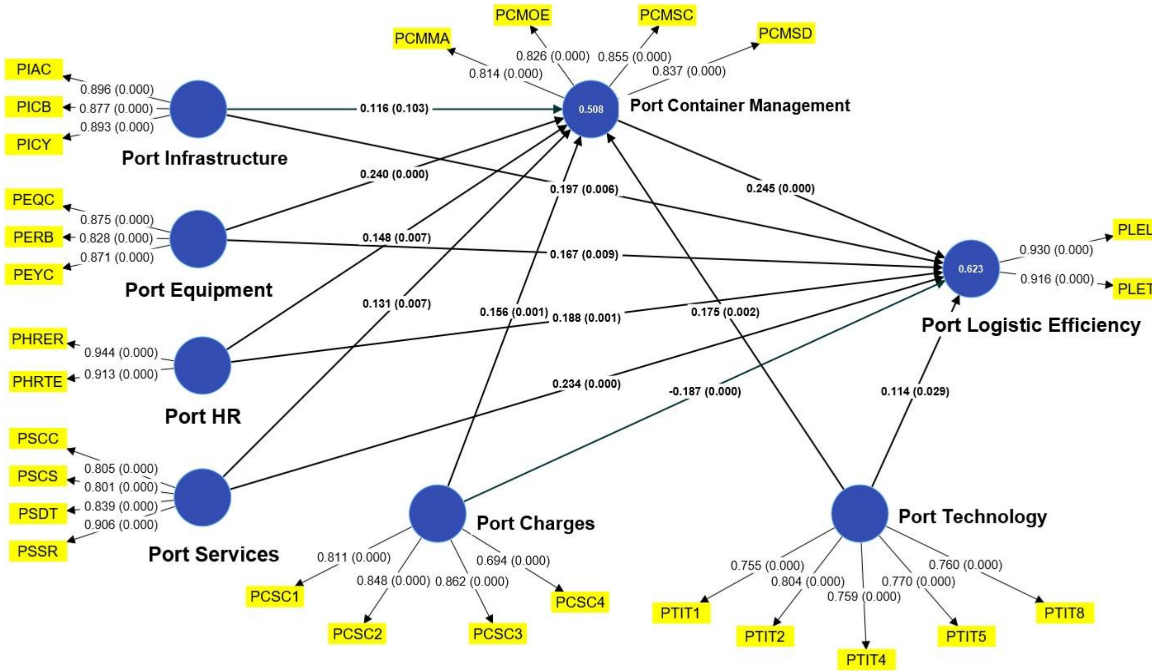


Figure 4.3: Structural model of the study - (Higher order constructs) HOC

4.10 Assessment of Collinearity

The analysis in PLS-SEM is based on OLS regression of each endogenous latent variable on its corresponding construct. Thus, it is vital to evaluate the existence of collinearity between predictors. The issue of collinearity between predictor variables can lead to biased estimates (Hair Jr et al., 2019; Sarstedt et al., 2019b). The variance inflation factor (VIF) values help to examine the existence of multicollinearity generated in Smart PLS. As per (Hanafiah & Applications, 2020); Kock and Lynn (2012), a VIF value higher than 5 indicates high multicollinearity, while other researchers recommend that multicollinearity exists if the VIF is above 10. As per T. Kyriazos and M. J. O. J. o. S. Poga (2023), a VIF value of 1 signifies the non-existence of multicollinearity, while a VIF score over 5 or 10 is viewed as high multicollinearity.

Table 4.21 displays the maximum VIF values for the model in 4.3 that are less than the threshold level. Hence, the present model exhibits no problem of collinearity amongst the predictors.

Table 4.23: Collinearity Assessments

Port Logistic Efficiency (Dependent Variable)	Collinearity statistics (VIF <5)
Port Charges	1.467
Port Container Management	2.034
Port Equipment	2.761
Port Human Resources	1.508
Port Infrastructure	3.103
Port Logistic Efficiency	
Port Services	1.352
Port Technology	1.766

Source: (T. Kyriazos & M. Poga, 2023)

Table 4.21 shows the results of the independent variable assessment for predicting Port Logistic Efficiency. A VIF assessment revealed whether the factors needed attention because values under 5 are recommended by Hair et al. (2017). To ensure reliable regression estimates in the structural model, one must focus on predictor variables with low VIF scores because this indicates minimal correlation between model elements. The tests indicate that every construct maintains VIF values that stay below 5. The port infrastructure and port equipment variables demonstrate moderate correlations with other variables, yet retain acceptable VIF values at 3.103 and 2.761, respectively. The five regression factors of Port Container Management (VIF = 2.034), Port Technology (VIF = 1.766), Port Human Resource (VIF = 1.508), Port Charges (VIF = 1.467), and Port Services (VIF = 1.352) present negligible VIF values, which supports the conclusion that multicollinearity does not affect the analysis.

4.11 Path Coefficients (β)

Each path in the model exhibited hypothesized relationships among two latent variables in the structural model. Structural analysis using path coefficients was performed to confirm the research hypotheses that help to understand the strength of the association between independent and dependent constructs. For this purpose, the Smart PLS algorithm and bootstrapping functions were used. The former helped examine independent-dependent construct relationships, while the latter facilitated significance testing using t-values and p-values. Table 4.14 presents path coefficients, t-statistics, and significance values for all hypothesized paths in the model (Figure 4.6). A minimum of 0.1 path coefficient value is considered for specific impact in the model (Purwanto, 2021).

Table 4.24: Path Coefficients, observed T-values, significance level for hypothesized Paths

Independent variable to Dependent variable	Path coefficient (β)	Observed T statistics (|O/STDEV|)	P values
Port Charges -> Port Container Management	0.156	3.192	0.001
Port Charges -> Port Logistic Efficiency	-0.187	4.307	0.000
Port Technology -> Port Container Management	0.175	3.120	0.002
Port Technology -> Port Logistics Efficiency	0.114	2.129	0.033
Port Container Management -> Port Logistic Efficiency	0.245	4.160	0.000
Port Equipment -> Port Container Management	0.240	3.617	0.000
Port Equipment -> Port Logistic Efficiency	0.167	2.599	0.009
Port HR -> Port Container Management	0.148	2.745	0.006
Port HR -> Port Logistic Efficiency	0.188	3.406	0.001
Port Infrastructure -> Port Container Management	0.116	1.615	0.106
Port Infrastructure -> Port Logistics Efficiency	0.197	2.873	0.004
Port Services -> Port Container Management	0.131	2.683	0.007
Port Services -> Port Logistics Efficiency	0.234	5.921	0.000

Table 4.24 shows that all path coefficients (β-values) are > 0.1, except port charges -> Port Logistic Efficiency, which is -0.187. The β-values for all other hypothesized structural paths range from +0.114 to +0.245, where the sign of the path coefficient indicates the proposed direction of the relationship between two latent variables. It is evident from the above results that all variables are positively related to each other except port charges and Port Logistic Efficiency. The relationship between variables is also significant, except for port infrastructure with Port container management at a 5% confidence level.

4.12 Hypotheses Testing

This segment independently reports the hypothesized relationships under the four foremost types. A standard reporting process was observed to test and report research hypotheses (Elhaik, 2022; Haans et al., 2016). Based on the PLS Algorithm and Bootstrapping process results, the standard reporting included the values of standard beta (β), standard error (SE), t-statistics (t-value), and significance value (p-value).

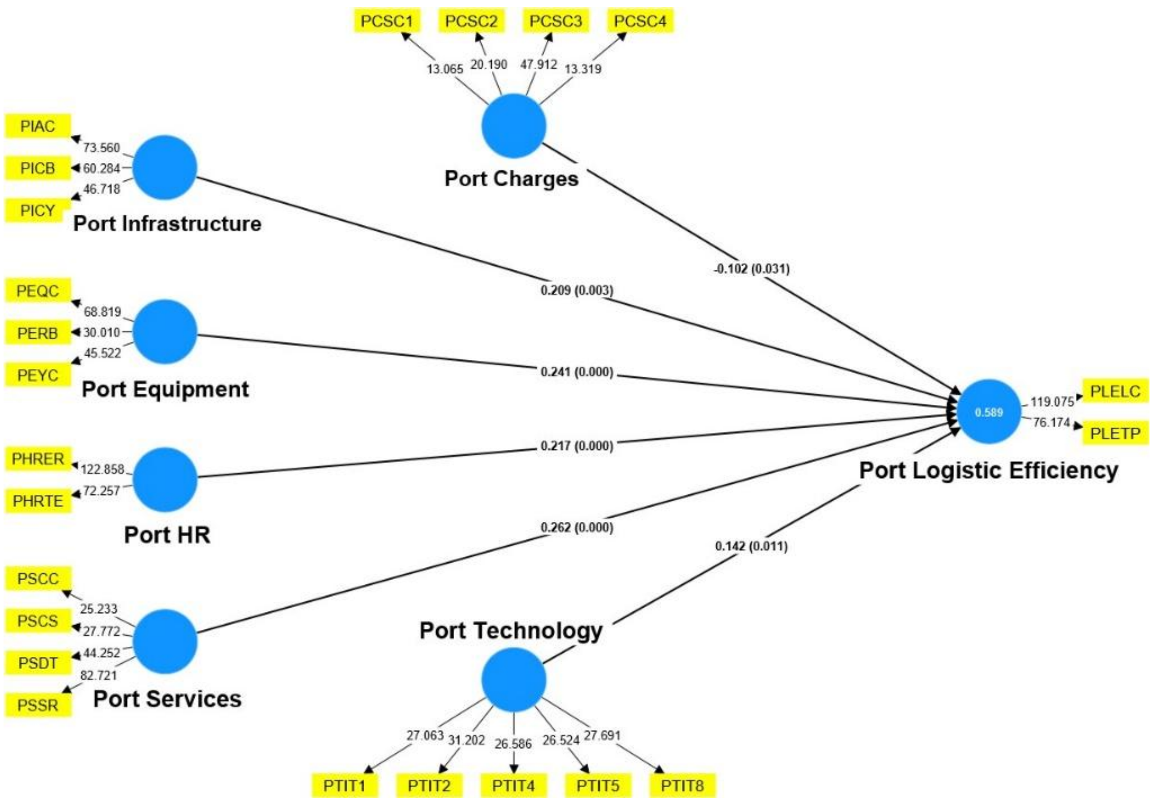


Figure 4.4: Structural model of the study (Higher Order Constructs) – Direct relationship

Table 4.25: Results of hypotheses (H1 to H6)

Hypothesis	Path coefficient (β) = SD x T value	t-value	P value	Decision
H 1: PT -> PLE	0.142	2.494	0.033	Supported
H 2: PI -> PLE	0.209	3.123	0.004	Supported
H 3: PE -> PLE	0.242	3.842	0.009	Supported
H 4: PHR -> PLE	0.218	3.973	0.001	Supported
H 5: PS -> PLE	0.259	6.324	0.000	Supported
H 6: PC -> PLE	0.103	2.101	0.000	Supported

As shown in Table 4.25, the influence of PT on PLE was significant (β: 0.142; t: 2.494, p: <0.05), therefore supporting H1. It was hypothesized that PT, i.e., Port technology, has a strong and positive relationship with PLE, i.e., Port logistic efficiency.

Likewise, in the case of H2, PI, i.e., Port infrastructure, displayed a statistically significant impact on PLE with (β: 0.209, t-value: 3.123, $p < 0.05$), hence supporting H2.

In the case of H3, PE, i.e., Port equipment, demonstrated a statistically significant impact on PLE with (β: 0.242, t-value: 3.842, $p < 0.05$), thus supporting H3.

Similarly, for H4, PHR, i.e., Port human resource, exhibited a statistically significant impact on PLE with (β: 0.218, t-value: 3.973, $p < 0.05$), hence supporting H4.

For H5, PS, i.e., Port services have shown a statistically significant impact on PLE with (β: 0.259, t-value: 6.324, $p < 0.05$), thus supporting H5.

Similarly, in the case of H6, PC, i.e., Port charges displayed a statistically significant impact on PLE with (β: 0.103, t-value: 2.101, $p < 0.05$), thus supporting H6.

From the above deductions, it can be enunciated that hypotheses H1, H2, H3, H4, H5, and H6 conforming to the direct relationships are confirmed.

4.13 Mediation Analysis

The utmost rigorous, strong, and suggested technique for testing the mediation effect is bootstrapping, which is a non-parametric method. This technique is highly suitable for PLS-SEM as it makes no assumptions about the shape of the distribution (Hair et al., 2017). In this approach, researchers mainly focus on testing the indirect effects (Preacher & Kelley, 2011). Following these arguments, this study moved a step forward to statistically assess the mediation effect of port container management (PCM) on port logistics efficiency (PLE) concerning the independent variables.

The causal step procedure of Baron and Kenny was criticized by Preacher, Rucker, and Hayes (2007), who proposed an independent inferential test for an indirect effect to establish mediation. As per Shrout and Bolger (2002), it might not be essential for the direct effect to be significant to achieve mediation analysis. The direct effect may not be established owing to the small sample size or other unneeded factors. Hayes et al. (2017) found that the indirect effect matters in establishing a mediation effect. The causal method by Baron and Kenny (1986) was dominant for testing mediation for a considerable time. This technique includes several stages to establish a mediation effect. Yet, recent literature has discussed various limitations of Baron and Kenny's technique because of its lesser power and occurrence of type 1 error (Williams & MacKinnon, 2008). Another test commonly used to test mediation is the Sobel test. This test assumes of normality of the sampling distribution of the indirect effect. Though distribution assumptions do not hold for the indirect effect. Hence, for testing the mediation, neither is recommended, and neither is used in the current study.

Table 4.26: Inner model

Inner model - List	VIF
Port Charges -> Port Container Management	1.418
Port Charges -> Port Logistics Efficiency	1.467
Port Technology -> Port Container Management	1.704
Port Technology -> Port Logistics Efficiency	1.766
Port Container Management -> Port Logistic Efficiency	2.034
Port Equipment -> Port Container Management	2.644
Port Equipment -> Port Logistics Efficiency	2.761
Port Human Resource -> Port Container Management	1.464
Port Human Resource -> Port Logistics Efficiency	1.508
Port Infrastructure -> Port Container Management	3.076
Port Infrastructure -> Port Logistics Efficiency	3.103
Port Services -> Port Container Management	1.317
Port Services -> Port Logistics Efficiency	1.352

Table 4.27: Specific indirect effects

	β = T x SD	Original sample (O)	Sample mean (M)	Standard dev (STDEV)	T statistics (|O/STDE|)	P values
Port Technology -> Port Container Management -> Port Logistic Efficiency	0.043	0.043	0.042	0.017	2.549	0.011
Port Infrastructure -> Port Container Management -> Port Logistic Efficiency	0.029	0.029	0.028	0.019	1.526	0.127

Port Equipment -> Port Container Management -> Port Logistic Efficiency	0.059	0.059	0.058	0.021	2.835	0.005
Port HR -> Port Container Management -> Port Logistic Efficiency	0.036	0.036	0.035	0.016	2.253	0.024
Port Services -> Port Container Management -> Port Logistic Efficiency	0.032	0.032	0.032	0.015	2.171	0.030
Port Charges -> Port Container Management -> Port Logistic Efficiency	0.038	0.038	0.038	0.017	2.245	0.025

Table 4.27 shows how port resource variables produce their indirect effects on Port Logistics Efficiency (PLE) through Port Container Management (PCM) measurement. Testing the indirect effects of Port Technology, Infrastructure, Equipment, Human Resources (HR), Services, and Charges on PLE requires examining their impact on PCM as per hypotheses H7 to H12. The obtained results show five out of six indirect paths reach statistical significance at $p < 0.05$. Results confirm H7 as the indirect relationship between Port Technology and PLE remains statistically significant through PCM ($\beta = 0.043$, $t = 2.549$, $p = 0.011$) because technology uses improved container management processes to drive efficiency. The analysis demonstrates that Port Equipment ($\beta = 0.059$, $p = 0.005$) together with Port HR ($\beta = 0.036$, $p = 0.024$) create notable indirect effects that run through PCM, thus supporting H9 and H10. The research supports Resource Dependence Theory (RDT) because it demonstrates how organizations improve their results through process improvement by using their equipment and skilled employees as resources. The analysis demonstrates significant indirect impacts between Port Services and Port Charges, which verify H11 and H12 ($p = 0.030$, $\beta = 0.032$, and $p = 0.025$, $\beta = 0.038$). When services delivery and pricing rules external to the firm affect PLE, they do so through internal practices of PCM.

The PCM serves as a substantial mediator between port resources and operational efficiency based on the Economic Theory of the Port (ETP) because port managers determine how resources lead to operational improvements. The analysis establishes that Port Infrastructure does not create a significant impact on PLE ($\beta = 0.029$, $p = 0.127$), which fails to support H8. Studies indicate that infrastructure directly influences port efficiency, but such influence cannot produce significant changes through container management practices only. Results imply that infrastructure mostly affects systems at a central level instead of working operationally.

Table 4.28: Summary of hypotheses H7 to H13

Hypothesis	β	T-value	P value	Decision
H 7: PT -> PCM -> PLE	0.043	2.549	0.011	Supported
H 8: PI -> PCM -> PLE	0.029	1.526	0.127	Not supported
H 9: PE -> PCM -> PLE	0.059	2.835	0.005	Supported
H 10: PHR -> PCM -> PLE	0.036	2.253	0.024	Supported
H 11: PS -> PCM -> PLE	0.032	2.171	0.030	Supported
H 12: PC -> PCM -> PLE	0.038	2.245	0.025	Supported
H 13: PCM -> PLE	0.245	4.160	0.000	Supported

The mediation hypotheses related to Port Container Management (PCM), which affect the relationship between port resources and Port Logistic Efficiency (PLE), appear in Table 4.28. The analysis reveals that five out of six mediation hypotheses hold true because they produce significant indirect effects at a p-value less than 0.05. The research findings demonstrate support for H7 ($\beta = 0.043$, $t = 2.549$, $p = 0.011$) because Port Technology enhances PLE by improving container management practices. Operational outcomes become better when technological capabilities are directed through PCM because the Resource Dependence Theory (RDT) demonstrates this pattern. The analysis indicates statistical significance for indirect effects, which range from 0.032 to 0.059 in H9 (Port Equipment), H10 (Port Human Resources), H11 (Port Services), and H12 (Port Charges). The analysis confirms that resources generate maximum benefits for logistics performance through optimally managed container systems. The research shows that operational efficiency develops through resource deployment and management excellence in addition to resource ownership, according to RDT and the Economic Theory of the Port (ETP). The research did not validate that Port Infrastructure affects PLE through PCM because the relationship remained statistically insignificant ($\beta = 0.029$, $t = 1.526$, $p = 0.127$). The findings indicate that infrastructure directly enables operational capability; however, it fails to substantially improve logistic efficiency when using container management systems. This result indicates that infrastructure benefits exist independently from internal organizational processes as base-level advantages or spatial location advantages. The research findings reveal support for H13 ($\beta = 0.245$, $t = 4.160$, $p = 0.000$) because PCM enhances PLE by improving operations due to container management practices.

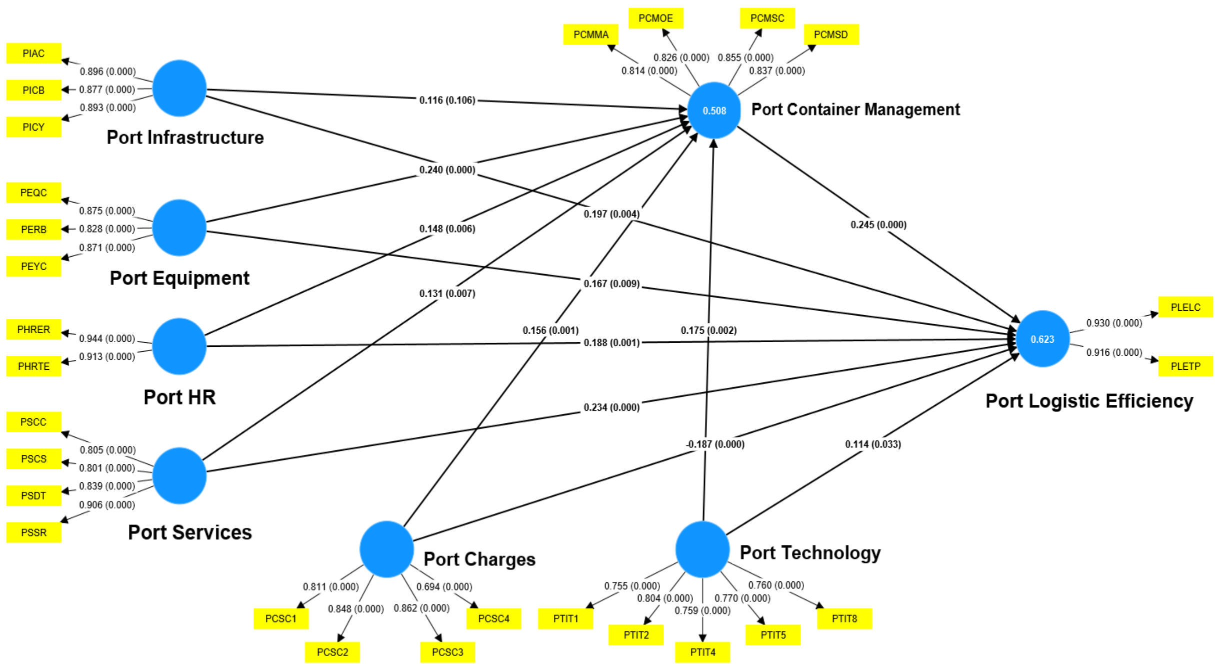


Figure 4.5: Mediation model – HOC

Mediation Effect of Port Container Management on Port Technology and Port Logistics Efficiency

Port Technology Regarding the mediation effect of port container management on the relationship between port technology and port logistic efficiency is significant (β=0.043; t=2.549). The indirect effect 97.5% Bias Corrected: (LL= 0.025, UL=0.109) does not straddle a 0, thus indicating that mediation exists. Hence, we can conclude that port container management is a mediating variable between port technology and port logistics efficiency.

Table 4.29: Summary of mediation hypothesis testing (port technology ~ port container management ~ port logistic efficiency)

No	Relationship	Beta	t-Value	Confidence Interval (BC)		Decision	P value
				LL	UL		
H7	PT -> PCM -> PLE	0.043	2.549	0.025	0.109	Supported	0.011

The variation of the mediation (Full, partial, or no mediation), Variance Accounted For (VAF) approach is used. VAF is the ratio of the indirect to the total effect. In other words, VAF determines the extent to which the mediation process explains dependent variable variance, calculated as indirect effect/ (indirect effect + direct effect).

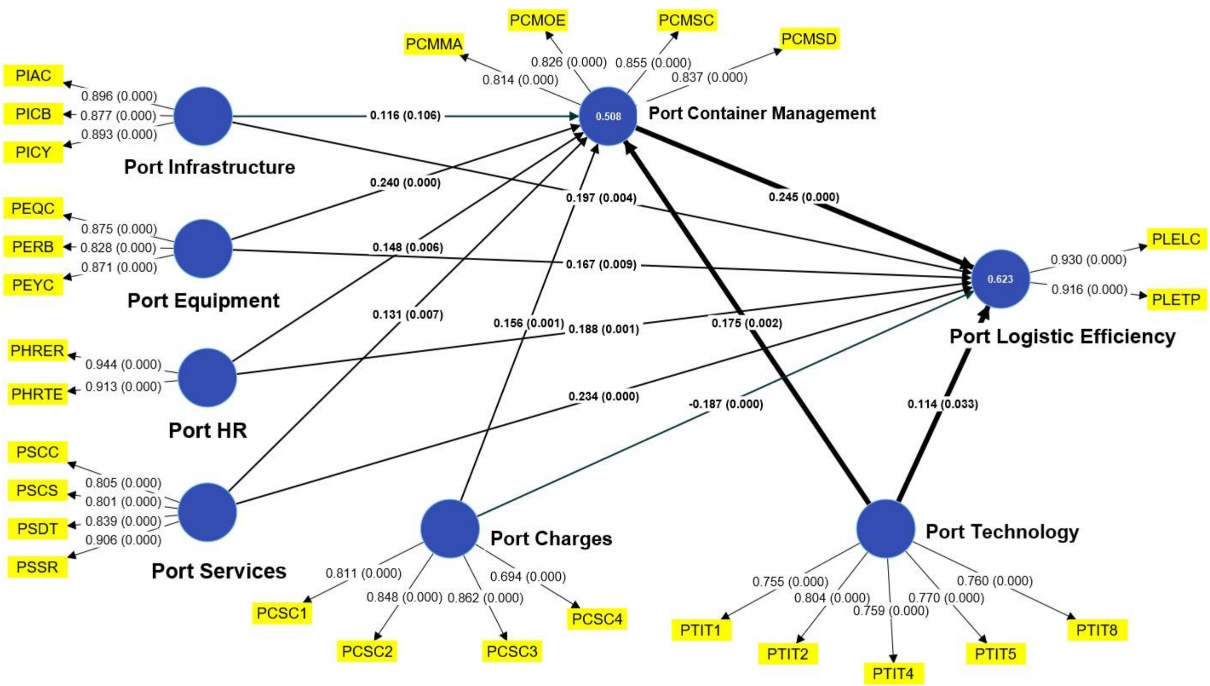


Figure 4.6: Summary of mediation hypothesis testing (port technology ~ port container management ~ port logistic efficiency)

The rule of thumb for mediation evaluation is that if VAF is less than 20%, it shows zero mediation. VAF larger than 20% and less than 80% shows partial mediation, and VAF greater than 80% shows complete mediation (Hair, Hollingsworth, Randolph, Chong, 2017). VAF value for the present study is 0.274, showing 27.4% variation, hence partial mediation (Table 4.20)

Table 4.30: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.175*0.245=0.043	0.043+0.114=0.157	0.043/0.157=0.274	H7: Partial Mediation (20 < VAF< 80)

Mediation Effect of Port Container Management on Port Infrastructure and Port Logistics Efficiency

Port Infrastructure Regarding the mediation effect of port container management on the relationship between port infrastructure and port logistics efficiency is insignificant (β=0.029; t=1.526), whereas the p-value is 0.127. The indirect effect 97.5% Bias Corrected: (LL= 0.025, UL=0.109) does not straddle 0, thus indicating that mediation exists. Hence, we conclude that port container management is a mediating variable between port infrastructure and port logistics efficiency.

Table 4.31: Summary of mediation hypothesis testing (port container management ~ port logistic efficiency)

No	Relationship	Beta	t-Value	Confidence Interval (BC)		Decision	P value
				LL	UL		
H8	PI -> PCM -> PLE	0.029	1.526	0.025	0.109	Not Supported	0.127

The variation of the mediation (Full, partial, or no mediation), Variance Accounted For (VAF) approach is used. VAF is the ratio of the indirect to the total effect. In other words, VAF determines the extent to which the mediation process explains dependent variable variance, calculated as indirect effect/ (indirect effect + direct effect).

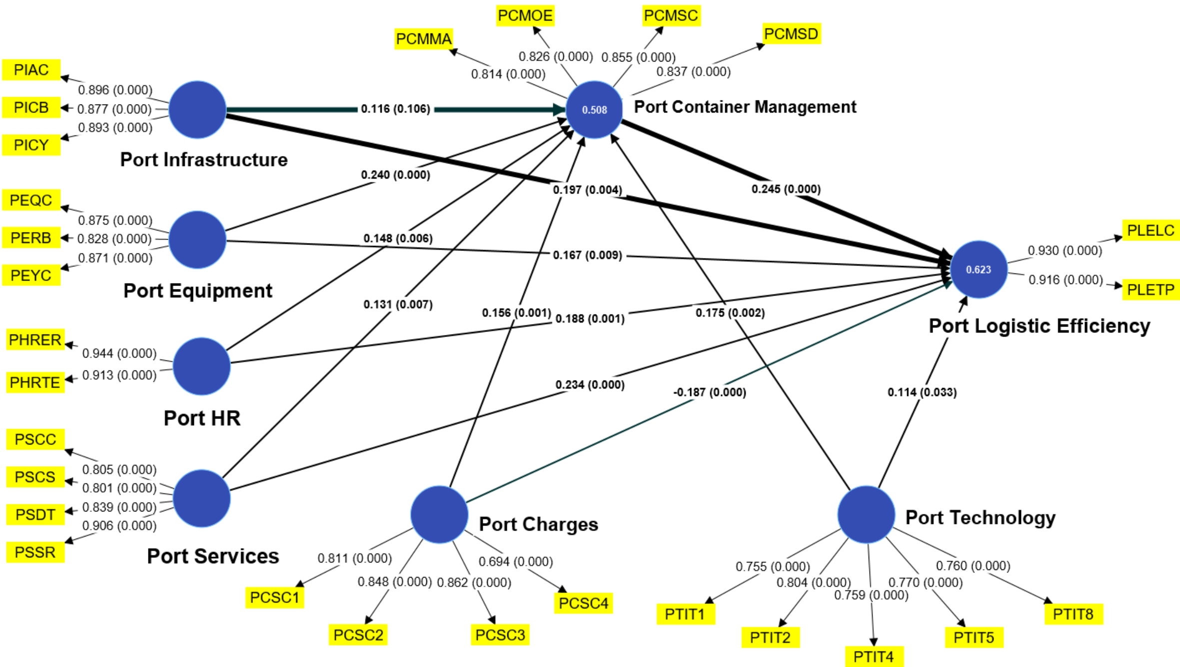


Figure 4.7: Summary of mediation hypothesis testing (port infrastructure ~ port container management ~ port logistic efficiency)

The rule of thumb for mediation evaluation is that if VAF is less than 20%, it shows no significant mediation. VAF larger than 20% and less than 80% shows partial mediation, and VAF greater than 80% shows complete mediation (Hair, Hollingsworth, Randolph, Chong, 2017). VAF value for the present study is 0.124, showing 12.4% variation, hence weak mediation (Table 4.20)

Table 4.32: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.116*0.245=0.028	0.028+0.197=0.225	0.028/0.225=0.124	H8: Weak Mediation (20 < VAF< 80)

Port Equipment Regarding the mediation effect of port equipment on port logistic efficiency, the results indicate that the indirect effect of port container management on the relationship between port equipment and port logistic efficiency is significant (β=0.059; t=2.835). The indirect effect 97.5% Bias Corrected: (LL= 0.025, UL=0.109) does not straddle a 0, thus indicating that mediation exists. Hence, we can conclude that port container management is a mediating variable between port equipment and port logistics efficiency.

Table 4.33: Summary of mediation hypothesis testing (port infrastructure ~ port container management ~ port logistic efficiency)

No	Relationship	Beta	t-Value	Confidence Interval (BC)		Decision	P value
				LL	UL		
H9	PE -> PCM -> PLE	0.059	2.835	0.025	0.109	Supported	0.005

The variation of the mediation (Full, partial, or no mediation), Variance Accounted For (VAF) approach is used. VAF is the ratio of the indirect to the total effect. In other words, VAF determines the extent to which the mediation process explains dependent variable variance, calculated as indirect effect/ (indirect effect + direct effect).

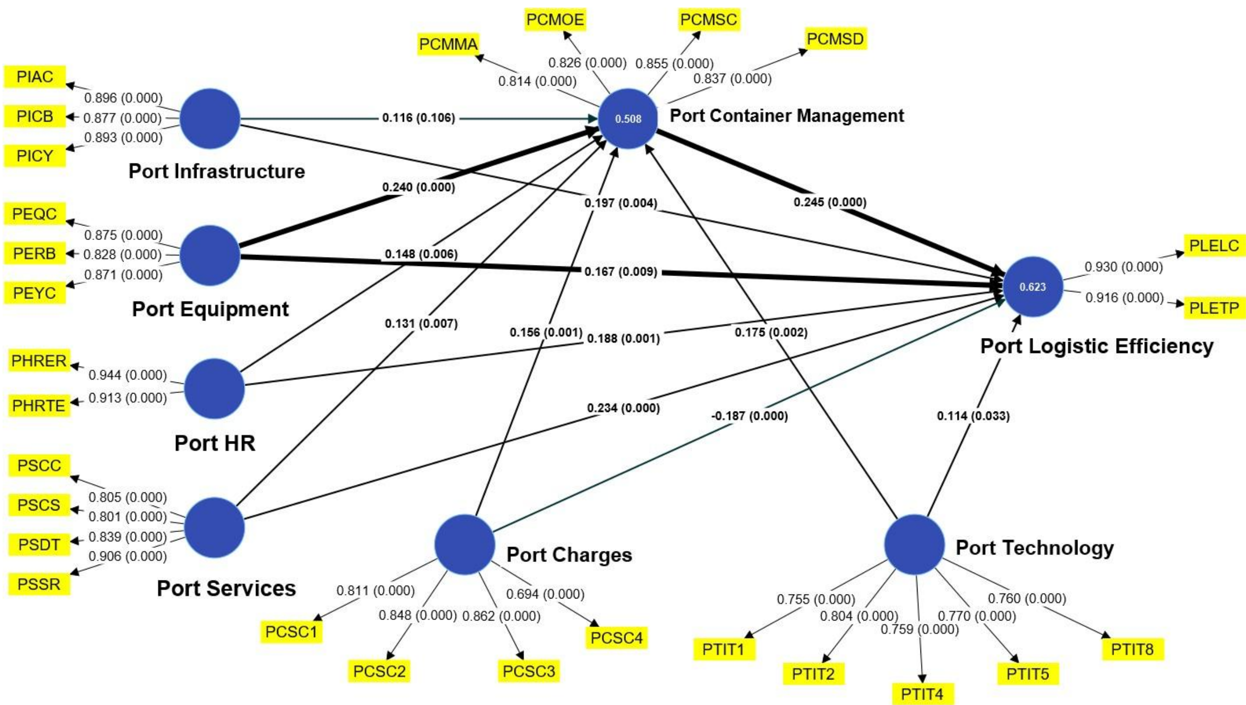


Figure 4.8: Summary of mediation hypothesis testing (port equipment ~ port container management ~ port logistic efficiency)

The rule of thumb for mediation evaluation is that if VAF is less than 20%, it shows zero mediation. VAF larger than 20% and less than 80% shows partial mediation, and VAF greater than

80% shows complete mediation (Hair, Hollingsworth, Randolph, Chong, 2017). VAF value for the present study is 0.261, showing 26% variation, hence partial mediation (Table 4.20)

Table 4.34: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.240*0.245=0.059	0.059+0.167=0.226	0.059/0.226=0.261	H9: Partial Mediation (20 < VAF< 80)

4.12.2 Mediation Analysis of Port Human Resource with Port Container Management

First, we looked at the mediation effect of port human resources on port logistic efficiency. The result indicates that the indirect effect of port container management on port human resources is significant (β=0.036; t=2.253). The indirect effect 97.5% Boot CI Bias Corrected: (LL= 0.012, UL=0.076) does not straddle a 0, thus indicating a mediation exists. Thus, we can conclude that port container management is a mediating variable between port human resources on port logistic efficiency.

Table 4.35: Summary of mediation hypothesis testing (port container management ~ port logistic efficiency)

No	Relationship	Beta	t-Value	Confidence Interval (BC) LL	UL	Decision	P value
H10	PHR -> PCM -> PLE	0.036	2.253	0.012	0.076	Supported	0.024

The variation of the mediation (Full, partial, or no mediation), Variance Accounted For (VAF) approach is used. VAF is the ratio of the indirect to the total effect. In other words, VAF determines the extent to which the mediation process explains dependent variable variance, calculated as indirect effect/ (indirect effect + direct effect).

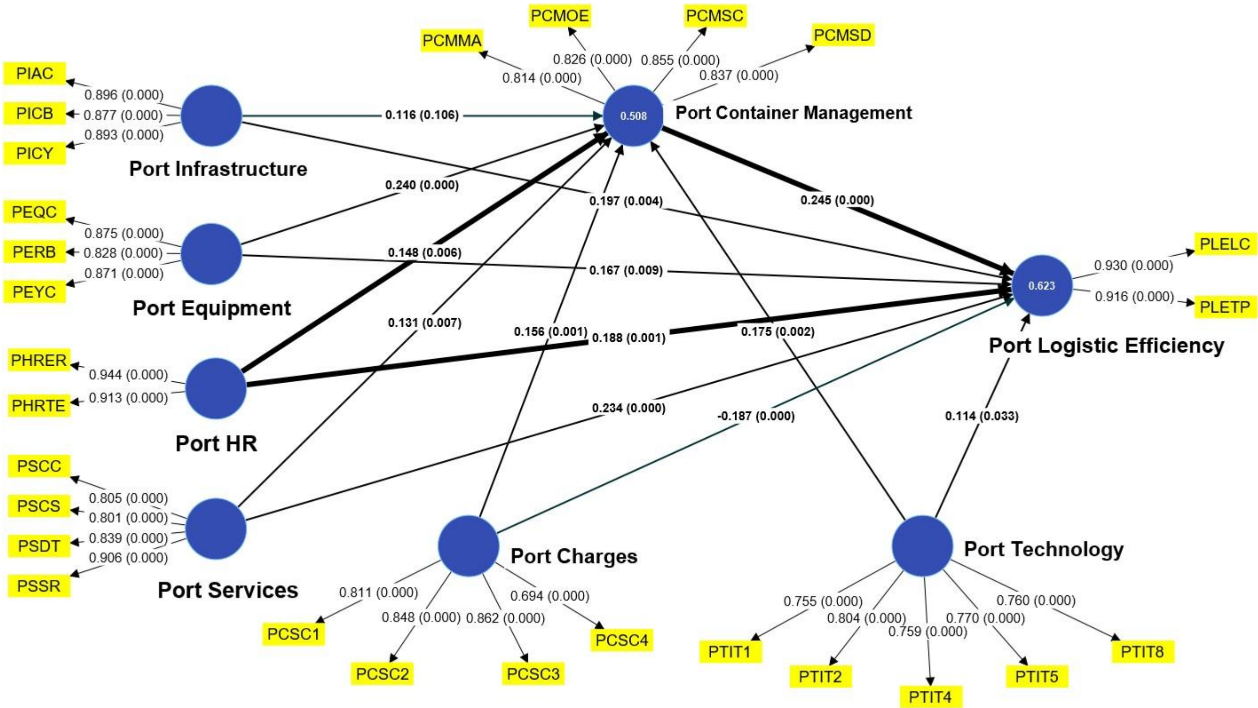


Figure 4.9: Summary of mediation hypothesis testing (port HR ~ port container management ~ port logistic efficiency)

The rule of thumb for mediation evaluation is that if VAF is less than 20%, it shows zero mediation. VAFs larger than 20% and less than 80% showed partial mediation, and VAFs greater than 80% showed complete mediation (Deb et al., 2023; Hair et al., 2017). VAF value for the present study is 0.161, say 16% variation. Generally, a variance below 20% is considered no mediation, yet, being quite close to 20%, it may be considered as partial mediation. Hence, weak mediation (Table 4.20)

Table 4.36: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.148*0.245=0.036	0.036+0.188=0.224	0.036/0.224=0.161	H10: Weak Mediation (20 < VAF< 80)

Mediation Analysis of Port Services with Port Container Management

For the mediation effect of port container management on port services, the results indicate that the indirect effect of port container management on port services is significant (β=0.032; t=2.171). The indirect effect 95% Boot CI Bias Corrected: (LL= 0.008, UL=0.068) does not straddle a 0, thus indicating a mediation exists. Therefore, we can conclude that Port Container Management is a mediating variable between Port Services on Port Logistic Efficiency.

Table 4.37: Summary of mediation hypothesis testing (port container management ~ port logistic efficiency)

No	Relationship	Beta	t-Value	Confidence Interval (BC)		Decision	P value
				LL	UL		
H11	PS -> PCM -> PLE	0.032	2.171	0.008	0.068	Supported	0.030

The variation of the mediation (Full, partial, or no mediation), Variance Accounted For (VAF) approach is used. VAF is the ratio of the indirect to the total effect. In other words, VAF determines the extent to which the mediation process explains dependent variable variance, calculated as indirect effect/ (indirect effect + direct effect).

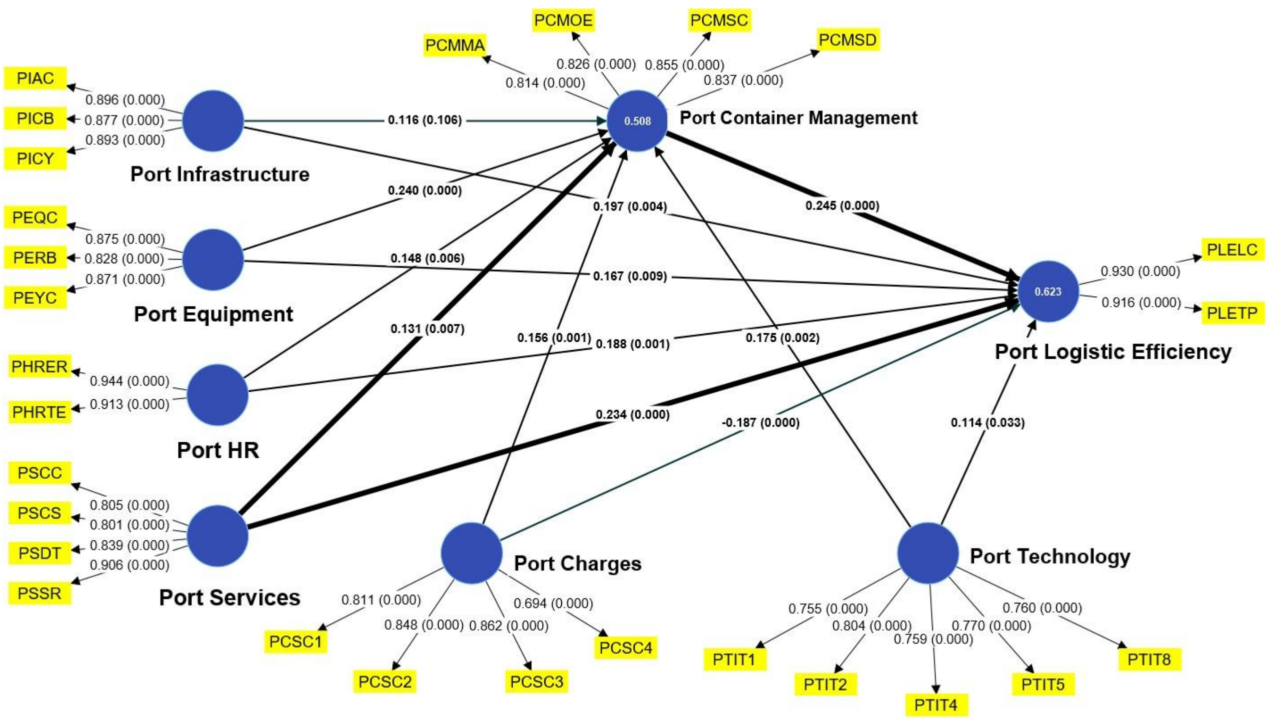


Figure 4.10: Mediation analysis of port container management (PCM) and port services on port logistics efficiency (PLE)

The rule of thumb for mediation evaluation is that if VAF is less than 20%, it shows zero mediation. VAFs larger than 20% and less than 80% show partial mediation, and if greater than 80% show complete mediation (Hair, Hollingsworth, Randolph, Chong, 2017). VAF value for the present study is 0.120, showing a 12% variation, hence weak mediation (Table 4.20)

Table 4.38: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.131*0.245=0.032	0.032+0.234=0.266	0.032/0.266=0.120	H11: Weak Mediation VAF< 80)

Mediation Analysis of Port Charges with Port Container Management

With regards to the mediation effect of port charges on port logistic efficiency, while mediating through port container management was analysed. The results suggest that the indirect effect of port container management is significant, β=0.038; t=2.245, on port logistic efficiency. The indirect effect 95% Boot CI Bias Corrected: (LL=0.012, UL=0.082) does not straddle a 0, thus indicating a mediation exists. Thus, it can be concluded that port container management is a mediation between port charges and port logistics efficiency.

Table 4.39: Summary of mediation hypothesis testing (port container management ~ port logistic efficiency)

No	Relationship	P value	Beta	t-Value	Confidence Interval (BC)		Decision
					LL	UL	
H12	PC -> PCM -> PLE	0.025	0.038	2.245	0.012	0.082	Supported

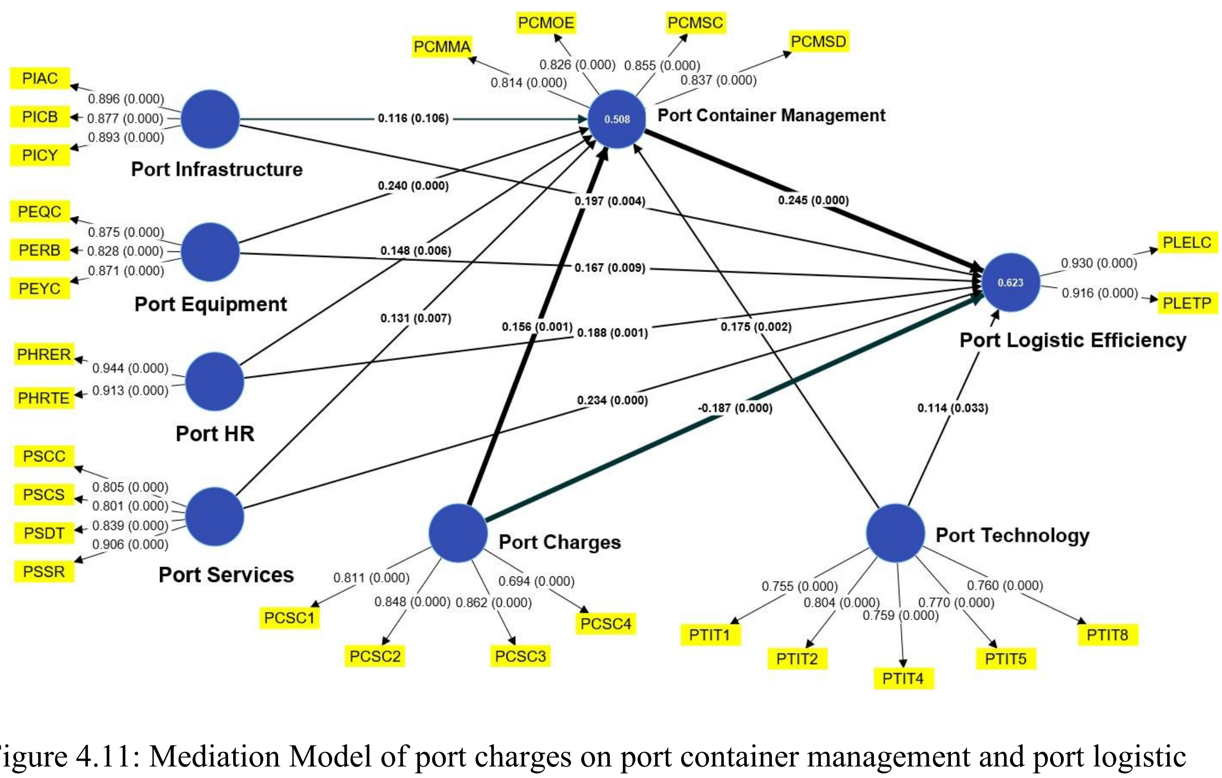


Figure 4.11: Mediation Model of port charges on port container management and port logistic efficiency.

VAF value for present study is -0.255, showing -25% variation; hence, partial Mediation occurred.

Table 4.40: Variance Accounted for Calculation (VAF)

Indirect effect	Direct effect	VAF	Decision
0.156*0.245=0.038	0.038+(-0.187) =-0.149	0.038/-0.149=-0.255	H12: Partial Mediation (20 < VAF< 80)

The study results reveal support for H13 ($\beta = 0.245$, $t = 4.160$, $p = 0.000$) because PCM enhances PLE by improving operations due to container management practices.

4.14 Explanatory Power of the Model

The model's predictive accuracy is evaluated through the coefficient of determination (R^2). R^2 Value shows the model's explanatory power, which is the combined effect of all exogenous variables on endogenous variables. The value of R^2 ranges between 0 and 1, where a higher value shows higher predictive accuracy. There is a different rule of thumb for deciding the acceptable value of R^2. As per Cohen (2013), values of 0.26, 0.13, 0.02, (Chin, 1998) 0.67, 0.33, 0.19, and (Hair et al., 2017) 0.75, 0.50, 0.25 show substantial, moderate, or weak levels of predictive accuracy. R^2 increases with the inclusion of additional explanatory variables; therefore, the R2 adjusted measure is used to control the model complexity (Plonsky & Ghanbar, 2018). R^2 values were estimated for the current study, as displayed in Table 4.41.

Table 4.41: Endogenous constructs and related R^2

Endogenous constructs	R^2	R^2 adjusted
Port container management	0.508	0.499
Port logistics efficiency	0.623	0.614

For the existing model, the R^2 value for Port container management was 0.508, and for Port logistic efficiency was 0.623, showing that endogenous constructs explain a 50.8% variation in Port container management and 62.3% in Port logistic efficiency. The R^2 Value for Port container management is 0.508, showing that Port container management explains 50.8% variations in the IVs (i.e., Port technology, port infrastructure, port equipment, port HR, port services, and port charges). In other words, Port logistic efficiency explained 50.8% of the variations in the IVs and Port container management. The whole finding indicates that the (R^2) value of the exogenous constructs is beyond 0.10, proving the model to be prudent (Hanlon et al., 2001). The model displayed a moderate predictive accuracy in the IVs to determine Port container management and Port logistic efficiency.

4.15 Effect Size f2

In this study, the predictive power of the structural model was examined using a high-level approach introduced by (Shmueli et al., 2019). However, effect sizes were also observed for data completeness, only by reporting the construct-construct effect size. Effect size measures the degree to which path coefficients exist in a population. This measure helps investigate the practical relevance of significant construct-construct effects (Henseler & Schuberth, 2020). The f2 values of 0.02, 0.15, and 0.35 demonstrate weak, moderate, and vigorous effects, respectively (Alsalhe et al., 2020; Cohen, 1992). As shown in Table 4.27 and Figure 4.15 below, the construct-to-construct level's effect size ranged from 0.004 to 0.230. The magnitude of the significant effect for PS, PC, PCM, and PHR was the highest. These results demonstrated the medium effect size of the structural association among port services, port charges, port container management, port human resources, and port logistic efficiency.

Table 4.42: Effect Size of Constructs

Constructs	f2 value	Threshold value	Statistical comments	Remarks
Port Charges	0.210	>0.15	Significant	Medium
Port Container Management	0.174	>0.15	Significant	Medium
Port Equipment	0.011	>0.02	Significant	Medium
Port Human Resources	0.137	>0.15	Significant	Medium
Port Infrastructure	0.040	>0.02	Significant	Medium
Port Services	0.230	>0.15	Significant	Medium
Port Technology	0.028	>0.02	Significant	Medium

Table 4.38 demonstrates the effect size (f^2) of all the independent constructs toward Port Logistic Efficiency (PLE) in the structural model framework. The model's relative predictor influence can be measured by the effect size, which expands upon the significance value of path coefficients. Scientific research shows small, medium, and large effects correspond to f^2 values at 0.02, 0.15, and 0.35 following Cohen’s (1988) guidelines. The investigated constructs show significant effects based on statistical assessments and demonstrate that most of these effects lie between medium levels. The quality of services coupled with port pricing structure demonstrates the maximum impact on PLE at $f^2 = 0.230$ and $f^2 = 0.210$, respectively, because they strongly influence logistic efficiency. The research supports the Economic Theory of Port principles because cost structures and reliable services act as fundamental elements that shape port efficiency results.

The statistical significance of Port Container Management reaches $f^2 = 0.174$, indicating its essential position in the model and underpinning the Resource Dependence Theory (RDT) by revealing the importance of internal capability when using resources. The moderately strong influence of PCM shows that port resources alone do not guarantee logistic efficiency unless ports maintain efficient container flow operations and process control. The data indicate that Port Human Resource ($f^2 = 0.137$), together with Port Infrastructure ($f^2 = 0.040$), provides a measurable contribution but with different strength values. Most studies show that Port Equipment ($f^2 = 0.011$) and Port Technology ($f^2 = 0.028$) impact efficiency evolution positively, although their minimal effect sizes emphasize their need for human expertise integration for complete effectiveness.

4.16 Predictive Relevance Q2

The model's predictive power shows the model's ability to generate new observations. The Higher the predictive power, the better the model can predict the outcome variable PLS provides an out-of-the-sample prediction for the model. Specifically, this study applies the approach suggested by Shmueli et al. (2019) using the existing PLS prediction algorithm in the smart PLS for obtaining the values of root mean squared error (RMSE) to assess the predictive performance of their PLS path model for the indicators and the constructs. The linear regression model (Alsalhe et al.) approach regresses all exogenous indicators on each endogenous indicator to make predictions. The PLS-SEM results should have a lower prediction error about the LM outcomes (e.g., in terms of RMSE) and greater Q2 values than the LM. It would mean that a theoretically established path model improves (or maintains at the same level) the reactive performance of the available indicator data. Once again, this is the scenario for our model. The RMSE values for the PLS model are lower than PLS-LM. Collectively, PCMMA, PCMOE, PCMSC, PCMSD, PLELC, and PLETP have high predictive power.

Table 4.43: Predictive Relevance for Endogenous Constructs

	Q^2 predict	PLS-SEM_RMSE	PLS-SEM_LMAE
PCMMA	0.316	0.830	0.614
PCMOE	0.336	0.818	0.608
PCMSC	0.403	0.775	0.629
PCMSD	0.277	0.853	0.634
PLELC	0.520	0.695	0.545
PLETP	0.451	0.743	0.576

4.17 Importance of Performance Map Analysis

The importance-performance map analysis (IPMA) extends the usual PLS-SEM results by considering the average values of the latent scores (Rehman et al., 2023; Ringle et al., 2016). IPMA analysis helps identify the importance of a construct in predicting a targeting construct and its performance. Three important requirements must be fulfilled to carry out IPMA: Initially, the indicator scales need to be equidistant. In the second place, all the indicator coding should be in a similar direction. A low value on the scale must represent a negative result, and a high value must represent a positive result. Thirdly, outer weight estimates shall be positive.

The present study uses a Likert scale to measure the constructs with a neutral scale that is equidistant. Secondly, the Likert scale ranges from 1 to 5, where one shows strongly disagree, and five is strongly agree, fulfilling the IPMA criteria. Thirdly, the outer weights estimated for the model are positive. Thus, IPMA analysis can be conducted for the current model, which has fulfilled three prerequisites of IPMA.

4.18 Goodness of Fit

In general, model fit is a criterion used to evaluate how well-hypothesized models fit the data and helps identify model misspecification. A standardized mean square residual (SRMR) criterion is suggested in PLS-SEM to measure model fit (Schuberth et al., 2023). SRMR is an absolute fit measure; therefore, the zero value represents a perfect fit. The value of less than 0.08 is considered a good fit (Barrett & differences, 2007). For the present model, the value of SRMR was 0.075, which shows a good fit for the model.

CHAPTER 5

5 DISCUSSION AND CONCLUSION

Continuing from the preceding chapter, this section explains the results of the research objectives. This study aimed to investigate the factors and discuss the results, and whether the hypothesis is supported by the preceding literature. In addition to discussing the results of this study, this section also identifies the important implications of the results for academic research and industry practice that impact container management and port logistics efficiency for improving CT performance. The first segment assesses empirical results based on the purpose of the study. The second segment addresses the contributions of the study and highlights the limitations of the study and directions for future research.

5.1 Discussion of the Findings

This study investigated the outcome of port container management and port logistic efficiency in Karachi port, particularly in the context of CTs. The research model of the study was drawn through the lens of Resource Dependence Theory and Economic Theory of the Port, and requires thirteen hypotheses to be empirically tested in the port segment. The dependent variable of port logistic efficiency is further decomposed to determine its antecedents. Container management was proposed as the mediating variable. A survey approach was adopted, and the data was collected through a questionnaire. The validity of the proposed model was determined by analysing the obtained data through PLS path modelling. The results of the hypothesis findings are summarized below:

Table 5.1: Summary of research hypotheses and important values

Hypothesis	Relationship	β	T-value	P value	Decision
H 1	Port Technology -> Port Logistic Efficiency	0.142	2.494	0.033	Supported
H 2	Port Infrastructure -> Port Logistic Efficiency	0.209	3.123	0.004	Supported
H 3	Port Equipment -> Port Logistic Efficiency	0.242	3.842	0.009	Supported
H 4	Port Human Resource -> Port Logistic Efficiency	0.218	3.973	0.001	Supported

H 5	Port Services -> Port Logistic Efficiency	0.259	6.324	0.000	Supported
H 6	Port Charges -> Port Logistic Efficiency	0.103	2.101	0.000	Supported
H 7	Port Technology -> Port Container Management -> Port Logistic Efficiency	0.043	2.549	0.011	Supported
H 7a	Port Technology -> Port Container Management	0.175	3.120	0.002	Supported
H 8	Port Infrastructure -> Port Container Management -> Port Logistic Efficiency	0.029	1.526	0.127	Not supported
H 8a	Port Infrastructure -> Port Container Management	0.116	1.615	0.106	Not supported
H 9	Port Equipment -> Port Container Management -> Port Logistic Efficiency	0.059	2.835	0.005	Supported
H 9a	Port Equipment -> Port Container Management	0.239	3.617	0.000	Supported
H 10	Port Human Resource -> Port Container Management -> Port Logistic Efficiency	0.036	2.253	0.024	Supported
H 10a	Port Human Resource -> Port Container Management	0.148	2.745	0.006	Supported
H 11	Port Services -> Port Container Management -> Port Logistic Efficiency	0.032	2.171	0.030	Supported
H 11a	Port Services -> Port Container Management	0.131	2.683	0.007	Supported
H 12	Port Charges -> Port Container Management -> Port Logistic Efficiency	0.038	2.245	0.025	Supported
H 12a	Port Charges -> Port Container Management	0.156	3.192	0.001	Supported
H 13	Port Container Management -> Port Logistic Efficiency	0.245	4.160	0.000	Supported

This section discusses the outcomes of this study. First, findings are presented in sequence by the study's objectives and research questions. The chapter commences with a discussion of the relationship among independent variables (IV), mediating variable (MV) and dependent variable (DV). The results are linked with previous research found within the literature to highlight what factors are associated with the integration between IV, MV, and DV. The direct and indirect relationships between them are also discussed to the extent of Research Question 1, Question 2, Question 3, and Question 4.

Response to Research Questions

The first research question is: “Does port technology, infrastructure, equipment, human resources, services, and charges positively impact post logistics efficiency at Karachi port?”

To respond to this research question, it is stated that, based on a rigorous Structural Equation Modeling analysis of stakeholder data, the answer is indeed affirmative. All six resource capabilities, Technology (PT), Infrastructure (PI), Equipment (PE), Human Resources (PHR), Services (PS), and Charges (PC), have a statistically significant direct and positive impact on Port Logistics Efficiency (PLE), as confirmed by the support for hypotheses H1-H6 ($p < 0.05$). This finding is deeply anchored in Resource Dependence Theory (RDT), which posits that organizational performance is contingent on the management of critical external and internal resources. For Karachi Port, this study empirically defines that specific portfolio: its operational efficiency is fundamentally dependent on securing and effectively deploying this comprehensive bundle of technological, physical, human, and financial resources. It demonstrates that no single resource is sufficient; rather, it is their combined management that determines performance.

Through the lens of the Economic Theory of the Port (ETP), which models ports as systems converting inputs into throughput and outputs, these six resources are validated as essential inputs directly linked to the performance output of logistics efficiency. The analysis provides more than a binary confirmation; it quantifies a hierarchy of direct influence. Port Services ($\beta=0.259$, H5) and Port Equipment ($\beta=0.242$, H3) are the strongest drivers, indicating that superior customer-oriented processes and modern cargo-handling machinery yield the highest immediate efficiency returns. Human Resources ($\beta=0.218$, H4) and Infrastructure ($\beta=0.209$, H2) also show strong direct effects, underscoring the role of skilled labor and physical layout. Technology ($\beta=0.142$, H1) and Charges ($\beta=0.103$, H6), while significant, exhibit smaller coefficients, suggesting their direct role, though foundational, may be more supportive. Consequently, strategic resource investments at Karachi Port, particularly in service quality and equipment, are empirically justified as direct levers for enhancing logistics efficiency.

The second research question states, “Do port technology, infrastructure, equipment, human resources, services, and charges have a positive impact on port container management?”

The findings provide strong, nuanced evidence that five of the six resources have a significant positive impact on Port Container Management (PCM). This conclusion is drawn from the significant specific indirect effects in the mediation analysis. Resources such as Technology

(PT), Equipment (PE), Human Resources (PHR), Services (PS), and Charges (PC) were found to exert a meaningful influence on final logistics efficiency precisely through their enhancement of PCM. This demonstrates that a key portion of their value is realized by first optimizing this core operational process. For instance, advanced Technology enables real-time container tracking; modern Equipment speeds up handling; and skilled Human Resources ensure these systems are utilized effectively. This aligns perfectly with the Economic Theory of the Port (ETP), where PCM is the central throughput activity. Resources, conceptualized through RDT as critical dependencies, are the essential inputs that fuel and refine this process, transforming physical and intangible assets into streamlined container flow.

The critical nuance is the exception of Port Infrastructure (PI), whose indirect path via PCM was not statistically significant (H8). This does not diminish infrastructure's importance—its strong direct effect on PLE (H2) confirms its critical role. Instead, it suggests its influence operates through a different, more foundational mechanism at Karachi Port. Infrastructure elements like berth depth, yard layout, and road access are likely to establish the physical and spatial parameters for all operations. Their impact is therefore more about creating the essential capacity and access that enable efficiency, rather than being channeled through the specific managerial and workflow dynamics of daily container handling. This distinction is vital: it indicates that while a new quay crane (Equipment) directly improves container management, a deepened berth (Infrastructure) enhances overall system capacity, benefiting performance in a broader, more direct manner.

The third research question asks that “Does port container management positively impact port logistics efficiency?”

The analysis provides definitive and robust evidence that Port Container Management (PCM) has a strong, direct, and statistically significant positive impact on Port Logistics Efficiency (PLE). Hypothesis H13 was strongly supported with a substantial path coefficient (β=0.245, p=0.000). This finding is the cornerstone for validating the core throughput-performance linkage posited by the Economic Theory of the Port (ETP). It empirically proves that the efficiency of the internal "black box" process, the strategic coordination, movement, storage, and control of containers, is a primary and powerful determinant of the port's overall logistical performance. Effective PCM directly translates into faster vessel turnaround, reduced cargo dwell times, improved yard utilization, and higher reliability, all of which are constitutive elements of PLE.

This result elevates container management from a routine operational concern to a strategic performance driver. It demonstrates that even with optimal resource investments, a port's final efficiency can be severely constrained by ineffective or siloed container management processes. For Karachi Port, this underscores that excellence in this core throughput activity is non-negotiable for achieving competitive advantage. The strength of this direct relationship, which is among the most influential identified in the model, indicates that targeted initiatives to streamline container workflows, enhance data integration, and improve strategic planning within the container management domain are direct investments in the port's overall efficiency and market position. PCM is not merely a passive recipient of resource inputs but an active and potent generator of performance output.

The fourth research question states that "Does port technology, infrastructure, equipment, human resources, services, and charges have a positive impact on port logistics efficiency when mediated by port container management?"

The integrated model offers a sophisticated answer: Yes, for five of the six resources, their positive impact on PLE is significantly mediated by Port Container Management (PCM). This is a pivotal finding that validates the proposed synthesis of RDT and ETP. Formal mediation analysis confirmed significant specific indirect effects for Port Technology (PT), Equipment (PE), Human Resources (PHR), Services (PS), and Charges (PC). This reveals a dual-pathway performance mechanism: these resources enhance final efficiency not only directly but also, and crucially, by first building a superior operational capability in container management. For example, Port Equipment's total effect is the sum of its direct effect (β=0.242 from H3) and its indirect effect mediated through PCM (β=0.059 from H9).

This mediation quantifies how PCM acts as a critical value-adding intermediary and a force multiplier. It transforms raw resource inputs into amplified performance outputs by ensuring they are utilized within a highly effective and synergistic process. The practical implication for Karachi Port is profound: investing in a new technology system or equipment will yield direct benefits, but concurrently investing in process re-engineering, digital integration, and workforce training to leverage those assets within the container management system will unlock significantly greater total returns. The exception remains Port Infrastructure (PI), whose value is realized through more direct pathways. Ultimately, this conclusively demonstrates that the integrated RDT-ETP model is valid: RDT explains the what (critical resources), and ETP explains the how (the conversion process via

PCM). For port managers, it mandates a dual-focused strategy where resource upgrades and process optimization are pursued in tandem to maximize efficiency gains.

5.2 Discussion on Findings

Findings and detailed discussion of each hypothesis are mentioned below:

It was hypothesized in H1 that port technology has a positive impact on port logistics efficiency. Earlier, the subject of port technology has received a great deal of scholarly attention in the academic domain, and various studies have examined the impact of port technology on port logistics efficiency, e.g., Adabere et al. (2021); B. Jiang et al. (2023); Min (2022); Bassa et al. (2021). However, little has been discussed about the port technology relationship with port logistics efficiency at Karachi port, which is evolving and expanding in terms of concept, dimensions, and applicability. Investigating the relationship between port technology and port logistics efficiency of Karachi port distinguishes the study from earlier studies by testing this theoretical paradigm using data from Pakistan's port sector. As compared to other industries, the port and maritime sectors have been found to lag in terms of digitization, as demonstrated in Al-Fatlawi and Motlak (2023), (de Moura, 2022), (Inkinen et al., 2021).

In the present study, results in Table 5.1 show that port technology has a positive impact on port logistic efficiency ($\beta=0.142$; $t=2.494$; $p=0.033$), which is consistent with the findings of (Bassa et al., 2021); (Min, 2022) and (Adabere et al., 2021). Also, the value of $R^2=0.623$ reflects the strong predictive power of port technology on port logistic efficiency.

In their study, Filom, Amiri and Razavi (2022) found that the competitiveness of a seaport highly depends on its access to real-time information, especially in terms of logistics practices, about berth availability, container movement, and yard capacity, which helps port management to make accurate decisions. The study deliberated on the role of information technology (IT) in enhancing port logistics performance. Machange and Yussuf (2024) discovered that the application of IT in container ports can enhance the pace of customs clearance and smoothen logistic activities. Martín-Navarro et al. (2020) uncovered that there are many business processes within the port activity that can be improved through the use of more efficient technologies like IT, which can help coordinate and automate critical processes such as customs declaration. Bassa et al. (2021) found that the effect of paperless IT-based customs clearance at Ghana Seaports has a positive impact on customer satisfaction, operational cost reduction, and logistics.

Min (2022) found that modern equipment with integrated IT systems has a close relation with seaport facilities and efficiency. Adabere et al. (2021) found that IT has a positive direct effect on port operational efficiency. Hence, in the competitive environment of seaports, the adoption of IT practices has become essential. B. Jiang et al. (2023) discovered that IT helps seaports to compete and enhance their logistic efficiency, reliability, transparency, and safety in their management and processes. Seo et al. (2023) revealed that with a better IT system, the CT management can electronically communicate (IDE) with shipping lines and logistic stakeholders by increasing data accessibility for strategic planning. Ilola (2024) found that internal communication and team cohesion in the organization can be achieved with the help of the port IT system. Automation of port equipment and processes is dependent on the compatibility and reliability of its IT system, while ports can work faster and reduce workforce requirements (Clemente et al., 2023).

In his study, Weerasinghe et al. (2024) discovered that the terminal operating system (TOS) facilitates port managers in decision-making to plan berth allocation, ship loading /unloading, yard stowage space utilization, and optimum use of port resources. In his study, Sahraoui et al. (2023) found that TOS allows an increase in the productivity level from the quay crane to the gate by allowing decisions to be made based on real-time data. TOS helps port management to make strategic decisions through real-time operational analysis. Yet, in contrast with the port authority, the results highlight a lack of flexibility by the stevedoring companies, which require time to adapt to the constraints. Aslam et al. (2024) discovered that the IT system helps identify, track, and load/unload containers to achieve quick ship turnaround time, berth allocation, truck turnaround time, container stowage plan, and gate management etc.

Traditional container seaports (e.g., Karachi port) can improve efficiency by adopting technology where essential and employing skilled port managers for coordination (Zohaib et al., 2023). RDT provides a concept of sharing resources offered by other firms against a benefit. Interested firms willing to invest in the port's technological systems or gadgets can be invited. Hence, our investigation’s findings align with previous studies’ results.

In second hypothesis, it was hypothesized in H2 that port infrastructure has a positive impact on port logistic efficiency. In the past, the subject of port infrastructure has received a great deal of scholarly attention in the academic realm, and various studies have explored the relationship between port infrastructure and port logistics efficiency e.g. (Duzbaievna Sharapiyeva et al., 2019; Hlali, 2024; Liang & Liu, 2020; Munim & Schramm, 2018; Ndalu & Okene, 2024). The study results at Table 5.1 assert that port infrastructure has a positive effect on port logistic efficiency (β=0.209; t=3.123; p=0.004), which is consistent with the findings of (Sahoo et al., 2024); (Sénquiz-Díaz, 2021). Results for the study by (Liang & Liu, 2020) were almost similar to this study's results. The hypothesis and results were supported, i.e., Port infrastructure connectivity has a positive impact on logistic performance' i.e., $p<0.001$, Cronbach alpha 0.805, CR 10.866. Also, for the present study, the value of $R^2=0.623$ reflects the strong predictive power of port infrastructure on port logistic efficiency, which also exhibited a positive and significant relationship.

Some of the landmark studies that discussed infrastructure emphasized it to be of critical importance for ports. It covers the seaside, the yard area and the land-side connectivity (Belcore et al., 2023). From the seaside, the channel accessibility, width, depth, navigation safety, channel length and the berth where the ship is to dock are important factors port infrastructure (Juma & Meli, 2023). Behdani et al. (2020) found that the land side has in and out gates for trucks and intermodal rail and road connections for the movement of containers from and to the port. Some authors have written about the state of infrastructure at Karachi port. For example Sumbal et al. (2024) discovered that the rail and road connectivity at CTs in Karachi port is inadequate. Nearly non-presence of rail services compels over 96% containers to be transported by road (Haque & Anwar, 2024). Except for the recently established South Asia Pakistan Terminal (SAPT), Karachi port's infrastructure has been developed in phases over a long time, and not as part of a master plan (Mahfooz & Imtiaz, 2023). Due to irregular development within the port, the available area cannot be optimally utilized. During Karachi port visit, a manager at KICT informed that partial terminal space allocated by KPT along west wharf road is quite narrow and poses difficulty for RTG cranes to move the containers, and is hence scarcely utilized. Terminal gates at KICT and KGTL (former PICT) have capacity limitations and manual vehicle entry processes which contribute to congestion during peak times (Mahfooz & Imtiaz, 2023). The visiting trucks at CTs do not have a waiting area in the port. Hence, they stop on roadside, causing congestion, environmental pollution, and unplanned delays (Stoop et al., 2023).

Acciaro et al. (2014) affirmed that port infrastructure has positive implications for port efficiency and is linked to global connectivity. Mabinga and Mwalukasa (2024) asserted that Infrastructure improvements show substantial positive impacts, as indicated by significant t-values ($p < 0.01$), affecting port capacity, security, throughput and efficiency. Findings emphasize the significance of strategic investments in infrastructure and technology to boost port efficiency. In his study, Liu (2020), explored the relationship between the level of port infrastructure and port efficiency in

Chinese ports. Port infrastructure components i.e., channel length, width, depth, breakwater, and turning radius, have a positive impact on port logistic efficiency (Bakker et al., 2024). A CT comprises of quayside, storage area and entrance gates, which have a positive impact on port logistic efficiency (Essel et al., 2022). In his study Johansson (2022) emphasized that the competitiveness of a seaport heavily relies on its quality of infrastructure, which has a positive impact concerning its logistic efficiency. Result of the study by Munim and Schramm (2018) found that appropriate logistics performance in the port related to improvement of port infrastructure quality is extremely important for developing countries. Results for the studies by (Munim & Schramm, 2018, Yeo et al., 2020, Rui Liang & Ziyang Liu, 2021) are almost like this study's results, as all saw positive relationship between improved port infrastructure and logistics performance. Moreover, this study corroborates the essence of the concept of RDT which is based on the idea that resources can be shared with firms willing to contribute against benefit. KPT may consider inviting private firms to invest in port infrastructure development to streamline logistic movements, against profit sharing. Hence, the study results align with the findings of previous studies.

The third hypothesis H3 supported that port equipment has a positive impact on port logistics efficiency. Improved utilization of port equipment can enhance port logistics efficiency and productivity. All container ports (automated or traditional) adopt varying levels of automated equipment and processes to achieve enhanced operational efficiency and productivity. The terminal operating system helps port managers to plan and decide allocation of port equipment and other resources for loading, unloading, and stacking operation. The port functioning can be improved by better usage of port equipment due to managerial skill. In preceding studies, the topic relating to port equipment has received ample scholarly attention in the academic domain; and several studies have examined the impact of port equipment on port efficiency. The current study based on data from the port sector of Pakistan has the novelty due to its unique variables and model. However the results are consistent with earlier studies on other ports, by SHENG and KIM (2021), (Ng Corrales et al., 2020), (Wendler-Bosco & Nicholson, 2020), (Bucak et al., 2020), (D. Song, 2021), Jamain et al. (2022), (Liu & Deng, 2022), Kizilay and Eliiyi (2021), (Jobran & Kara, 2022), Gekara and Thanh Nguyen (2018), (Gattuso & Pellicanò, 2023), Iris and Lam (2019), (Al-Fatlawi & Motlak, 2023),

In their study, SHENG and KIM (2021) calculated the efficiency of Shanghai Port's seven CTs, by DEA model. The input variables included equipment (cranes and trucks), infrastructure, and human resources, while the output variable was throughput. Three CTs were identified as efficient while four were comparatively inefficient. This study analyzed Shanghai Port's efficiency by looking at the relationship between facility factors and cargo throughput. For efficient ports, the variable ‘equipment’ had a positive impact on port efficiency. Timely availability of handling equipment to ship and minimizing crane idle time reduces ship turnaround time and has a positive impact on port efficiency (Raj et al., 2024), (Barata et al., 2022). According to the study by Zeng and Yang (2009), integration of the quayside operation model has a positive relation and contributes to the ship handling time. Jamain et al. (2022) found that the quay cranes, yard cranes, and prime movers have a positive impact on port logistic efficiency. In their study Liu and Deng (2022) found that the overall port logistics efficiency of Chongqing port indicates a graduated progress due to constant enhancement of managerial skills and resource development in the period under consideration.

In their research Q. Li et al. (2022), Vicrihadi et al. (2021). Kizilay and Eliiyi (2021) found that each crane provides service to a specific ship within a designated timeframe, highlighting the function of individual cranes to increase port efficiency. Besides, integrated quayside operations improve ship handling time. Jobran and Kara (2022) found that introduction of automatic cranes and container handling equipment has contributed to overall port efficiency. Gekara and Thanh Nguyen (2018) stated that manual container handling cranes can be automated using technology, leading to increased productivity and reduced operational costs (Gattuso & Pellicanò, 2023). Iris and Lam (2019) discovered that employment of automatic cranes and equipment enhances port efficiency and cuts operating cost (Al-Fatlawi & Motlak, 2023). Port concept of logistics is much related to port performance (Q. Li et al., 2022). Improvement of operational performance needs regular preventive maintenance of loading-unloading equipment and training of employees (Vicrihadi et al., 2021).

As per RDT concept, the shortfall or replacement of port equipment may be processed by the CT operators through firms who may be willing to invest in port equipment against monetary benefit. The equipment productivity should also be gauged by the employees working at the port. As per study results at Table 5.1, port equipment has a positive impact on port logistic efficiency (β= 0.242; t=3.842; p=0.009), which is consistent with the findings of (Nyema, 2014) and (Ng Corrales et al., 2020). Also, the value of R^2=0.623 reflects the strong predictive power of port technology on port logistic efficiency. Hence, the study results are consistent with the findings of earlier study results.

The fourth hypothesis H4 supported that port human resources have a positive impact on port logistics efficiency. A well-trained and knowledgeable workforce and skilled managers can improve the functioning and productivity of a container port. Past studies have exhibited that the association between port human resource and port logistics has not gained the limelight. However, recent studies by (K. X. Li et al., 2023), (Mohd Salleh et al., 2021), (Amin & Shahwan, 2020), (González-Laxe et al., 2024) have received a fair amount of scholarly attention in the academic realm. Several studies have explored the concept of port human resources with port logistic outcomes. Results of the present study at Table 5.1 display that port human resources are statistically significant and positively influence port logistic efficiency with (β=0.218; t-value=3.973; p=0.001). the hypothesis was endorsed and supported by results of the study by (Baraza, 2021), Q. Li et al. (2022) and (Othman, El Gazzar, et al., 2022) which also portrayed that that the human resource performance have a positive relationship with port logistic efficiency.

Port Human resources, with their level of professionalism and skills, are believed to contribute positively to the organisational performance. Results of the present study based on the data from the maritime port sector of Pakistan are consistent with previous study conducted by Othman, El Gazzar, et al. (2022) which revealed that a skilled, trained, and educated human resource contributes to improving port performance. An area wanting attention in Karachi port is the development of managerial skills, and decision-making traits. First, decision making is quite useful in traditional ports, as it depends a lot on the timely and correct decision by the port managers during CT operations. Second, if the port manager is unable to take a decision, then the top management should be able to resolve the matter. Yet, if the top management is also unable to take a decision, then the problem remains unresolved and becomes irritant. For example, the stranded containers at Karachi Port and the KDLB, labour union issue compel port managers to operate with constraints (Akhtar, 2024).

The container ports have complex operations and processes, which are interlinked with each other within the CT. Emerging problems need to be resolved on the spot by experts. If a highly skilled resource is required to address an issue but is not available with the port, then RDT concept can be utilized. RDT suggests engagement with other firms to obtain the required resources for a specific job, by offering financial incentive. Also, the value of R^2=0.623 reflects the strong predictive power of port human resource on port logistic efficiency. Thus, the study results align with the findings of previous study results.

It was hypothesized in H5 that port services have a positive impact on port logistic efficiency. In past studies the subject of port services has received considerable level of scholarly interest in the academic domain, and various studies have examined the impact of port services on port efficiency e.g., (Bichou & Gray, 2004), (Filom, Amiri, & Razavi, 2022), (Khaslavskaya & Roso, 2020), (Wendler-Bosco & Nicholson, 2020). Some studies have also discussed about the logistic efficiency of ports, which is still evolving, e.g., (Catherine et al., 2024), (Q. Li et al., 2022), (Munim & Schramm, 2018), (Tongzon & Oum, 2007). Catherine et al. (2024) found that improved port services can lower operating costs, reduce custom clearance and dwell time, leading to reliability, customer satisfaction, higher throughput, and global efficiency of port logistics. Relationship among port services and logistic efficiency can vary due to the degree of port services (Munim & Schramm, 2018). Optimistic port services can improve the effects on port logistic efficiency (Naz et al., 2022). Q. Li et al. (2022) found that ports foster innovative services to maintain positive effect on logistic efficiency. Machange and Yussuf (2024) learnt that lack of Integrated IT system delays custom clearance processes, affecting port logistic efficiency. Though some studies on logistics are available in Pakistan's context, they are scarce for Karachi port. For example Sumbal et al. (2024) examined the logistics industry of Pakistan through the lens of World Bank's logistics performance indicators and its impact on CPEC. The key challenges were government inefficiencies (e.g. KPT), least use of IT and an incapable workforce (e.g. Karachi port). Khadim et al. (2021) anticipated that logistics growth in Pakistan has a positive impact on its economic growth. Shoukat and Xiaoqiang (2023) found that intermodal transportation is 82.6% cheaper than road freight transportation. Zohaib et al. (2023) detected that logistic efficiency can be improved by technological change for data exchange and information flow in port for increased throughput and logistics.

The current study findings at Table 5.1 reveal that port services have a positive impact on port logistic efficiency (β=0.259; t=6.324; p=0.000), which is consistent with the findings of (Munim & Schramm, 2018) and (Bichou & Gray, 2004). Moreover, the value of R^2=0.623 reflects the strong predictive power of port services on port logistics efficiency. As per the resource dependency theory, dearth of resources tempts organizations to approach interested firms to invest in required resources or services against benefit. This enables availability of added resources to attain enhanced resource utilization, productivity and logistic efficiency.

This research has made a valuable contribution to existing literature in the context of port services and logistics by virtue of its unique model and variables. Moreover, the study differentiates itself from other research works, as its survey data was obtained from the port sector and logistics stakeholders of Pakistan blended with the local environment and analyzed using smart PLS4. This study is an articulate research attempt to validate different variables in a peculiar environment of port services that positively influence port logistics efficiency. Hence, the study's research objective aimed to determine the effect of port services on port logistic efficiency was achieved, which is evident from the study results shown in Table 5.1 (β=0.259;

t=6.324), portraying that port services have a positive effect on logistic efficiency, in the context of Karachi port. Therefore, hypothesis H5 is supported due to the study results.

It was hypothesized in H6 that port charges have a positive impact on port logistic efficiency. Earlier the subject of port charges has received a great deal of scholarly attention in the academic field, and several studies have examined the impact of port charges on port efficiency, for example, (Sánchez et al., 2003), (Bichou & Gray, 2004), (Iannone, 2012), (Tongzon & Heng, 2005), (Tongzon & Heng, 2005), (Ayesu et al., 2023), (Lezhnina & Balykina, 2021). However, addition in the literature about port charges and their relationship with port logistics efficiency is evolving and expanding in terms of their concept, dimensions and applicability. Examining the relationship between port charges and port logistics efficiency distinguishes this study from previous studies by testing this theoretical paradigm using data from Pakistan's maritime port sector.

Similarly, port charges were significant factors for port efficiency which usually relate to ship docking, cargo handling, and auxiliary services (Kaliszewski, 2020). Agüero-Tobar et al. (2023) found that port tariff, transport expenses, cargo handling costs, and service charges were critical components to assess port efficiency (Talley, 2006b). Lesser port charges would attract shipping lines and logistic firms to operate from that port. Chang et al. (2008) found that most cargo clearing firms pick a shipping company initially and subsequently decide about seaports for operation. Hence, seaports concentrate on the shipping lines instead of other seaport customers as the seaport selection is finalised by shipping lines. Nguyen et al. (2020) found that attractiveness of a CT is its capability to offer better services at competitive charges compared to its contenders s. Therefore, our findings align with previous studies' results.

In the current study, port charges act as an antecedent of improving logistic efficiency and our results at Table 5.1 reveal that port charges have a positive impact on port logistic efficiency ($\beta=0.103$; $t=2.101$; $p=0.000$), which is consistent with the findings of; (Ricardianto et al., 2023) and (Kammoun & Abdennadher, 2023). On the contrary results of the study by Kammoun and Abdennadher (2023) also revealed that European seaports' efficiency tends to reduce with inter-port competition intensity, owing mainly to over-investment strategies adapted to attract surplus client requests. Hence a balanced port charges strategy is more feasible to maintain positive influence on logistic efficiency, in the context of Karachi port. Thus, hypothesis H6 is supported in view of the study results.

It was hypothesized in H7 that port technology has a positive impact on port logistic efficiency when mediated by port container management. Improving port container management necessitates better port logistics efficiency and should be considered as an accomplishment for port operations rather than an additional cost. The existing literature in port container management also considers it to be an effective strategy for achieving port logistics efficiency (B. Jiang et al., 2023), (Li, 2022) and (Adabere et al., 2021).

The present study validated the mediating effect of port container management on port technology and port logistic efficiency, as shown in Table 5.1 (β=0.043; t=2.549; p=-0.011). The study results have significant importance to the maritime port industry, which strives hard to develop technology to help improve communication, integration, cost reduction, container management, efficient logistic operations, and throughput, which are consistent with past studies (Dalaklis et al., 2022); (Lind, 2020) and (Panayides & Song, 2013). The maritime port's performance increases if it aligns its technological development with key stakeholders such as shipping lines, logistic firms, port regulators, and port operators. The study results are also consistent with Kaliszewski (2020) and Song (2021), suggesting that organizations are mostly driven by competition; thus, container ports aim to foster modern technology to achieve higher productivity for better container management in the CT. A negative innovative climate may have an unfavorable effect on the relationship between port technology and port logistics efficiency, by hindering employees' ability to operate and implement new technological concepts (Naz et al., 2022). As per resource dependency theory, organizations may approach other firms to participate in the technology upgradation of the container port for efficient processes against benefits. This arrangement is advantageous for the parent firm as well as the participating company.

The hypothesis linking these variables was supported and statistically significant with a partial mediation effect, as per Table 5.1 (β=0.043; t=2.549; p=-0.011) in the current study. The result of the study contributes uniquely to the existing literature by indicating a valid mediating mechanism of port container management between port technology and port logistic efficiency. The results further enrich the existing argument that innovative container management can strengthen the relationship between port technology and port logistic efficiency and enhance productivity as evidenced by earlier studies (Steenken et al. 2004; (Senarak, 2020); Vrakas, 2021; Yau, 2020)

Past studies on port technology and logistic efficiency have been conducted for container ports in the West, Far East, and developing countries like India, Sri Lanka, and

UAE (Wang, 2021; Acciaro, 2020). This research has made a valuable contribution to the literature on port operations, logistics, and container management, and its relationship with technology in the context of Karachi port. This study has contributed to existing literature by virtue of its unique model, variables and data analysis with smart PLS4. The study also distinguishes itself from other research works, due to its survey data obtained from the port industry and logistics stakeholders of Pakistan working with Karachi port. Hence, the study's objective aimed to determine the effect of port technology on logistic efficiency by mediating through container management was achieved, which is evident from the study results. Hence, hypothesis H7 is supported. H7a and H13 further reinforce the analysis results of H7.

It was hypothesized in H8 that port infrastructure has a positive impact on port logistic efficiency when mediated with port container management. This advocates that a port with competent container management capability may experience a strong effect of port infrastructure on port logistic efficiency compared to a CT with weak container management ability. Port container management plays a key role in supporting port infrastructure, contributing to higher port performance in the prevailing environment (Parola, 2017; Notteboom, 2022). Contrary to this Karachi Port lacks infrastructure development of the required level as it poses challenges to the smooth functioning of the port. A probable reason is the expansion of Karachi port infrastructure in phases, in the absence of a complete masterplan. Hence the study outcomes revealed that the relation concerning port infrastructure and port logistic efficiency when mediated with port container management is not supported as reflected by the resultant statistical values in Table 5.1, i.e. (β=0.029; P= 0.127; t=1.526).

Liu (2020) found that improved infrastructure can help with effective container management and logistics efficiency at the port. According to Cullinane et al. (2023) the development of effective intermodal facilities for port-hinterland connectivity relieves pressure on the stowage yard, reduces dwell time, and increases throughput. Sinha, (2022) found that adequate infrastructure is crucial for effective CT operations, by preventing congestion, reducing dwell time, facilitating yard storage, trade growth, and improved connectivity for larger vessels.

The SAPT terminal at Karachi port has modern infrastructure, but only one road link, shared with the oil trucks supply chain network, which harms its logistic efficiency (McGinnis, 2022). The rail connectivity at Karachi port CTs is poor and hence scarcely used, which harms the container management process (Guerrero et al., 2022). The 4.2 million TEU designed capacity of Karachi port can be achieved by maintaining container dwell time below 5.5 days, provided the 6000 to 8000 stranded containers are removed from the port. By ensuring this, the port capacity issue can be resolved for the short term. For the medium term, KGTL and KICT may be offered added land by KPT, or the CTs upgrade their RTGs for a higher stack height. For the long term, a vertical tower-style container storage facility may be developed to enhance storage capacity, as proposed by Zaerpour et al. (2019) in his study.

The study's findings are aligned with earlier literature that infrastructure plays a critical role in the overall operational efficacy of the port (Parola, 2017; Notteboom, 2022). However, due to Karachi Port’s ineffective infrastructure, built in phases over decades, needs to be streamlined. The existing CTs were crafted by allocating available space from general-purpose berths to different CT operators. In 1980s, the American President Liner company opened the first CT in Karachi port. After their departure in the mid-1990s, the terminal, with some added space, was leased to Hutchison Port Holdings in 1998 and named KICT. The added port space is narrow and inapt for YC operations, while the in/out gates have capacity limitations and a manual process (interview with a senior manager, KICT). Custom clearance is slow due to a lack of technology and reliance on physical checking of container cargo. This results in delay, congestion, and increased dwell time, which leads to logistic constraints and overall port inefficiency.

This study validated the arguments presented above, that port container management does not have a positive impact on infrastructure at Karachi port and port logistic efficiency as shown in Table 5.1 (β=0.029; P= 0.127; t=1.526), which portrays that Port Container Management has no mediating effect on Port Logistic Efficiency, in the context of Karachi container port. Therefore, hypothesis H8 is not supported due to no mediation as per the study results.

Although the research objective was supported theoretically in examining the relationship of container management between port infrastructure and port logistic efficiency, its mediating role was not found significant in the context of Karachi container port infrastructure. It requires further deliberation and in-depth study to explore underlying factors to be developed in Karachi port infrastructure to an appropriate level for container management to support port logistic efficiency. In its present state, H8 is not supported. H8a and H13 further reinforce the analysis results of H8.

It was hypothesized in H9 that port equipment has a positive impact on port logistic efficiency when mediated with port container management. The result of the study reveals a significant influence of port container management on the relationship between port equipment and port logistic efficiency with evident study results as shown in Table 5.1 ($\beta=0.059$; $t=2.835$; $p=0.005$). The results support the arguments of the earlier studies (Li, 2022; Alavi, 2018) that innovative container management processes promote communication, workflow information, authorisation and resource utilization that may result in improved productivity and logistic efficiency. The current study validated the mediating effect of port container management on port equipment and port logistic efficiency, as per results at Table 5.1, which portrays that port container management has a mediating effect on port logistic efficiency, especially in the context of maritime container port sector.

This research study has made a valuable contribution to the literature on the relationship of port equipment with logistic efficiency when mediated with container management in the context of Karachi port, by obtaining input from Pakistan's maritime sector. The study has also contributed to the present literature due to its unique research model, variables and data analysis using smart PLS4. The study results validate our research objective aimed at determining the positive influence of port equipment on logistic efficiency by mediating with container management. This study gives high importance to the maritime sector, where container management is a source of competitive advantage. In line with RDT, many container ports strive to improve their operating capability by approaching other firms to invest in augmenting their port equipment such as cranes and yard trucks, in return of financial benefit. Moreover, the port container management process encourages decision-making by port managers for improved resource utilization and procedures to accomplish higher productivity targets. Hence, hypothesis H9 is supported because of the study results. H9a and H13 further reinforce the analysis results of H9.

It was hypothesized in H10 that port human resources have a positive impact on port logistic efficiency when mediated with port container management. This indicates that the effect of better container management can have a positive impact on the performance of human resources concerning port logistic efficiency.

The study by Smith and Green (2020) highlighted that employee will not display innovative performance unless they are given the liberty to optimize the existing processes of their allocated work and the independence to complete it. Laing (2021) found that employees' training and education play an immense role in improving their productivity and motivation. Caesar (2023) found that the seaport employees focused on their work have the aptitude to improve and are more likely to be retained.

As per RDT concept, specialized human resources may not be hired due to high cost. Rather, their services be obtained from a firm willing to offer it against financial benefit (Chindondondo, 2021). Consistent with the literature, present study results show that the indirect effect of port human resources is significant on port logistic efficiency as per study results at Table 5.1, i.e., ($\beta=0.036$; $t=2.253$; $p=0.024$). The dock labour at KDLB lacks productivity and is a burden on Karachi port due to unreasonable attitude and demands (interview with manager KDLB, in his office).

Mabinga and Mwalukasa (2024) determined a statistically significant positive effects of human resources competence on port's operational efficiency, customer satisfaction and productivity. Findings emphasize the importance of strategic investments in skilled personnel, infrastructure, and technology to boost port efficiency. Azzani et al. (2024) and Mira (2019) found the mediating role of port container management in the relationship between human resource practices and port performance. L. H. Nguyen (2024b) revealed that receiving well-structured training at a container port exhibits a high level of engagement, reliability and organizational commitment.

The present study validated the arguments that port human resources have a positive impact on port logistic efficiency when mediated with port container management, as shown in Table 5.1 ($\beta=0.036$; $t=2.253$; $p=0.024$). It portrays that port container management has a mediating effect on the relationship between port human resources and port logistic efficiency, in the context of Karachi port. This study has contributed to the current literature by virtue of its unique model, variables and data analysis using smart PLS4. The study also distinguishes itself from other research works, due to its survey data collected from the respondents related to maritime port industry and logistics sector of Pakistan working in Karachi port environment. Hence, hypothesis H10 is supported due to mediation as per the study results. H10a and H13 further reinforce the analysis results of H10.

It was hypothesized in H11 that port services have a positive impact on port logistic efficiency when mediated with port container management. Therefore, the relationship involving port services and port logistic efficiency can be enhanced or diminished based on the level of innovation in container management within the port. Positive and supportive port container management can optimize the effects of port services on port logistic efficiency. On the other hand, a negative or restrictive port container management may harm the relationship between port services and port logistic efficiency by hindering employees' ability to generate and implement new sustainable ideas (Naz et al., 2022). As per RDT concept, the maritime ports wanting to expand operations, approach interested firms for investment in the port services sector against financial benefit. The purpose is to improve port container management to enhance resource utilization, cut costs, and increase productivity, thus enhancing economic and environmental performance. Maritime ports are driven mainly by competition; therefore, these organizations aim to foster innovative port container management to maintain the ranking and reputation of their port services and performance. The Economic Theory of the Port (ETP) offers a structured lens through which ports can analyze how external dependencies, and economic functions influence their logistics performance.

In this study the hypothesis linking these variables was supported and statistically significant with a weak mediation effect as per study results at Table 5.1 (β=0.032; t=2.171; p=0.030). The study results are consistent with the results of earlier studies (Yeo, 2020), (Chen, 2023), (Fitrianto, 2024), (Li, 2022), (Jiang, 2023). The results uniquely contribute to the literature by indicating a valid mediating mechanism of port container management between port services and port logistic efficiency. The results further enrich the existing argument that port container management can strengthen the relationship between port services and port logistic efficiency, providing the necessary resources to implement productivity targets and fostering a culture of continuous improvement as evident from earlier studies (H. Jiang et al., 2023) (Balsi, 2021), (Bonamigo, 2023).

Earlier studies on port services and port logistic efficiency have been conducted on maritime ports in various countries. However, this study has a valuable contribution in the context of novel port services and port logistic efficiency's relationship in the Pakistani environment. This study has contributed to the current literature by virtue of its unique research model, variables and data analysis using smart PLS4. The study also differentiates itself from other research works, as its survey data has been collected from the respondents related to maritime port and logistics sector of Pakistan working in the local environment. The maritime port sector constantly faces challenges of competitive market share, efficiency, and productivity. Thus, the study's research objective aimed to determine the effect of port services on port logistic efficiency, mediated by port container management, was achieved, as evident from the study results at Table 5.1 (β=0.032; t=2.171; p=0.030), which portrays that port container management has a mediating effect on logistic efficiency, in the context of Karachi port. Thus, hypothesis H11 is supported due to mediation as per the study results. Moreover, H11a and H13 further reinforce the analysis results of H11.

It was hypothesized in H12 that port charges have a positive impact on port logistic efficiency while mediated through port container management. This suggests that a maritime port with strong container management processes may experience a stronger impact of port charges on port logistic efficiency. The study suggests that port container management has a global effect on port charges, as container management will lead to dynamic behavior and contribute to port logistic efficiency.

Results of the present study indicate that port container management has a significant impact on port charges and port logistic efficiency as reflected by the statistical values at Table 5.1 (β=0.038; t=2.245; p=0.025). It was found that port container management mediates the relationship between port charges and port logistic efficiency. The study findings are consistent with previous literature, (Fitrianto, 2024) that better port container management permits greater throughput, and competitive port charges attract more shipping lines to operate from the port thus boosting its logistic efficiency (Ayesu, 2023).

The study's research objectives aimed to determine the effect of port charges on port logistic efficiency, while mediated by port container management, which was achieved, as evident from the study's results at Table 5.1 (β=0.038; t=2.245; p=0.025), which portray that port container management has a mediating effect on the relationship between port charges and port logistic efficiency, in the context of Karachi port. The study has made a major contribution to the literature due to the findings and results about the relationship between port charges and port logistic efficiency when mediated by container management in the setting of Karachi port and by obtaining data from respondents of the maritime sector in Pakistan. This study has also contributed to the literature due to its unique research model, variables and data analysis using smart PLS4. Hence, hypothesis H12 is supported due to mediation as per the study results. H12a and H13 further reinforce the analysis results of H12.

It was hypothesized in H13 that Port container management has a positive impact on port logistic efficiency. Therefore, the relationship between port container management and port logistic efficiency can be increased or decreased based on the level of innovation in container management within the port. Positive and effective port container management can improve the outcomes of port logistic efficiency. On the other hand, negative or restricted port container management may harm the relationship and hence the outcome of port logistic efficiency. As per resource dependency theory, the lack of resources induces organizations to approach other interested firms to invest in port resources against financial benefit. Enhanced resources can help improve the port's container management ability by judicious resource utilization, cost reduction, and increased productivity, thus improving its efficiency and throughput. Maritime ports are mainly driven by competition. Hence, they aim to foster innovative port container management through strategic planning after studying the environment and exploiting available resources by practical decision-making through trained managers, to maintain a good reputation and performance.

The hypothesis linking these variables was statistically supported as per study results at Table 5.1 (β=0.245; t=4.160; p=0.000), in the present study. Yet, little is known about container management and its relationship with port logistic efficiency which is evolving and expanding in terms of its concept, dimensions, and applicability. Investigating the relationship between container management and port logistic efficiency distinguishes this study from previous studies by testing this theoretical paradigm using data from Pakistan's port sector.

The study results contribute uniquely to the existing literature by indicating a valid relationship between port container management and port logistic efficiency. The results further enrich the existing argument that better port container management can strengthen the relationship with port logistic efficiency, through judicious resource management and fostering a culture of continuous improvement as evident from earlier studies (Jamain et al., 2022), (D. Song, 2021), (Paraskevas et al., 2024) and (Hirata et al., 2022). Triska et al. (2024) found that in smart ports, intelligent logistic solutions can be employed to improve container management, traffic flows, and capacity of the terminals. Kammoun and Abdennadher (2022) assessed the efficiency of thirty European container ports. The study revealed handling costs as the key measure for port effectiveness. The North European ports were found to be highly competitive and inefficient due to over-investment and effective use of inputs.

Earlier studies on port container management and port logistics efficiency have been conducted on maritime ports of various countries. This study has made a valuable contribution in the context of novel port container management and port logistics efficiency in Pakistan's environment. The maritime port sector constantly faces challenges of competitive market share, efficiency, and productivity. Thus, the study's research objective aimed to determine the impact of port container management on port logistic efficiency was achieved, as evident from the study results at Table 5.1 (β=0.245; t=4.160; p=0.000), which portrays that port container management has a positive impact on logistic efficiency, in the context of Karachi port. Therefore, hypothesis H13 is supported as per the study results.

A comparison of Karachi port productivity was done by collecting data from various CTs at Karachi to compare them among themselves. Karachi port was also compared with 24 other ports for four factors. The work is presented in Appendix I. Port productivity has been compared by summarizing the inputs by only presenting the highest, lowest, and average productivity values of ports in Table I-2. The productivity values for Karachi port have been compared with the average values of other ports. Moreover, the Industrial Benchmark of each productivity factor has also been listed in Table I-2. The productivity ranking of all 25 ports is shown for each factor in Table I-1. It is revealed that the ranking for Karachi port is on the lower side, for example, for Quay Crane productivity per hour it was 22, Yard Crane it was 21, for TEU per Quay meter it was 15, and for storage yard space in hectares it was 20. This shows that Karachi port's average productivity ranking is 19.5 (say 20) among the 25 considered ports. While comparing the three CTs at Karachi port in Appendix I, Table I-3, SAPT was ahead of others, KICT was in second place, while PICT (now KGTL) was in third place. The main advantage of SAPT was the newer infrastructure and equipment, longer and deeper berths, and large stowage capacity. The handling charges by CT, KPT, and KDLB (the Labour union) are also compiled. It can be noted that a sizable amount in USD is being lost to KDLB.

5.3 Contribution of the study

Theoretical Contribution

This study presents novel and unique knowledge that offers an innovative theoretical contribution by incorporating Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP) into a combined empirical model. By presenting Port Container Management (PCM) as a mediating construct, the research stretches both theories, displaying that in what manner resource conditions, managerial skills, and operational practices are in cooperative form. This contributes to the port management literature by transferring consideration from isolated factors to a unified, resource-oriented context. The study evaluates the container handling capacity of Karachi port and identifies the bottlenecks hampering port operations. The study has the novelty of examining port resources and their relationship with container management and port logistics efficiency. Pertinent theories such as RDT and ETP have been employed to establish relationships.

Practical contributions

The study portrays implications for decision makers, traders, shipping lines, and logistics firms, which can help integrate Karachi port operations and contribute to growth in trade. Fresh intake for CTs should be chosen while considering capability and job aptitude. Additional resources must be curtailed, and overhead expenses should be reduced to save unnecessary expenditure. The use of energy is decreased to cut utility charges and pollution in the port. The study proposes a comprehensive port improvement plan in Appendix F, which can be useful for other container ports.

Contributions to Port Management and Logistics Efficiency

In this study, there is more knowledge in port management about Karachi Port and general trends in logistics. It outlines how different port resources, such as technology, infrastructure, equipment, and employees, play a direct role in logistics (Q. Li et al., 2022; Lopes et al., 2025). Confirming what earlier studies have found, why operator and equipment efficiency is so important. Importance is placed on how container management helps speed up the process and ease congestion; an example of this can be seen at SAPT. Also, the authors use RDT and ETP to demonstrate that developing ports can balance outside factors while prospering economically. Insights into Karachi Port detail several issues specific to this port, such as restrictions on its infrastructure, difficulties with berth usage, long dwell times, customs delays, and remnants of unshipped containers, which may not affect other ports. Though the results apply mainly to the port investigated, the study also highlights several points that can be used in other ports as well. One example is that managing resources more effectively can help logistics companies achieve greater efficiency without costing too much. By collaborating, the authorities and logistics providers at ports improve their overall performance. The use of KPIs is mentioned as a method that can be applied in any type of organization to regularly track progress.

Furthermore, the study explains that infrastructure and technology are crucial, showing that upgrading outdated equipment can enhance the efficiency of these ports. Researchers also found that having skilled human resources and port operations are very important and provides quality service. A good example in this area is that the way ports use containers can help with port efficiency, making it worthwhile for crowded or delayed ports to review their handling of containers. Overall, applying RDT and ETP in the research helps create a useful structure for other ports to study the impact of their resource supplies and roles in the economy on their logistics systems. All in all, this study, developed in Karachi, still provides useful suggestions and insights for ports and terminals all over the world.

5.4 Enhancing Generalizability in Single Case Port Studies

We can learn a lot about Karachi port, but to use the results for other ports, we need to be aware of differences in regulations, economic aspects, and the quantum of trade. Applying different strategies for each port can lead to true improvements. Although the results from one container port may differ from another, both ports may have similarities in handling goods, since most container terminals use identical processes and resources (Carvalho et al., 2025; Vrakas, Chan, & Thai, 2021). The study also alerts contextual variances, like rules, trade size, and financial situations, which must be measured. To apply the study in different situations, analyzing related container ports helps identify common trends and aspects that are specific to each (Weerasinghe et al., 2024). Relating these findings to established theories in port logistics can help explain their greater significance. When research methods are effective and replicable, they can be validated in different locations. It has been highlighted that using resources more smartly can help most ports save expenses and meet higher demand (Paraskevas et al., 2024). Partnered control by port officials and logistics firms, systematic monitoring using key performance indicators, and improvements to traditional port resources through new technology can all make logistics operations more successful. It is also made clear that strong management, experienced staff, and excellent logistics services are essential for good outcomes at CTs (L. H. Nguyen, 2024b). Also, how containers are managed is important since it directly impacts ports' function, meaning that those with congestion can consider revising their system for managing containers to reduce overcrowding. The vital role of infrastructure, equipment, technology, and HR in improving logistics performance. The influence of operative container management on decreasing bottlenecks and improving proficiency. Lastly, applying theoretical frameworks such as Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP) offers a structured lens through which ports can analyze how external dependencies and economic functions influence their logistics performance.

Karachi Port's case enriches international port research by showing how legacy ports in developing countries can enhance logistics efficiency despite structural constraints. Applying RDT and ETP, the study demonstrates how operational resources and container management shape performance in environments characterized by limited capacity, high costs, and governance challenges. Because similar constraints affect many emerging ports worldwide, the findings provide globally relevant insights and address a significant gap in the port logistics literature.

5.5 Implications of the study

This study contributes to the body of knowledge on management in general and port/CT management in particular. More studies on the operations of Western container ports are available, but fewer studies have been done to analyze the logistics efficiency of container ports in developing countries. Earlier studies conducted on the working of Karachi port are either much older or have been done with different aims and objectives. Nevertheless, the model used in this study has not been used earlier for a western or eastern port. The findings will therefore be useful to all, particularly the container ports of developing countries. The modernization and automation of container ports to achieve higher productivity have been the focus of previous studies. However, the complex managerial role, despite modern and automated equipment at container ports, has not been given due focus in past studies, particularly for Karachi port. This study has rejuvenated the bridge relationship between port management, port resources, and logistic efficiency. Despite port automation, the output level can vary according to the skill and capabilities of the port management, supported by the management team. The study raises significant implications for the management and experts. The findings suggest that the top management's decision-making, strategic outlook, resource allocation, communication skills, and competence play a key role in enhancing port productivity. The outcomes of this quantitative study provide an opportunity for the port management to review their policies, integration processes, and container management procedures within the container port and with logistic stakeholders to guarantee seamless port operations. The findings of this study will also help the management of other ports to improve coordination in CT operations, thus achieving better container management to accrue maximum benefit from port resources.

5.5.1 Theoretical Implications

Building on the institutional perspective, the findings of this study emphasize the applicability and logical influence of RDT in the context of port resources, container management, port logistics, and throughput at the container port. Recognized systems resist change, yet sustainability demands change occurrence, which needs managerial motivation for alteration in employee behavior and attitude. This study theoretically and empirically rationalized organizational practices, focusing on management capabilities to enhance the output by better container management due to engaged behavior and innovation in their assigned tasks to attain sustainable goals and better association with all stakeholders. The study endorsed the relationship between port resources, container management, port logistics, and throughput. The managerial capabilities, expertise, and skills can improve port performance.

Infrequent studies exist on the relationship between automated CT operations and managers. The study gives practitioners insights into adopting best practices to improve services and throughput. Better terminal performance would attract fresh applicants with knowledge and skills for recruitment, which can help attain a competitive advantage. Good performance bonuses and rewards encourage employees to utilize their abilities, reduce carbon footprints, increase employee retention, and decrease employee turnover.

5.5.2 Practical Implications

The study suggests recommendations for all stakeholders contributing to Karachi port operations, container management, and logistics. Fresh intake for CTs will be made by considering their acumen level and job aptitude. This will help avoid job layoffs after much investment of time and training costs have been made. Ports must invest in critical infrastructure, particularly by building a raised thruway to ease road bottlenecks and improve freight movement. Develop a rail system inside the port, comprising links to depots like Pipri, to link carriage methods and increase efficacy. The use of energy resources and gas emissions will be reduced to curtail utility charges and pollution. Sustainability is supported by proper waste disposal and green processes to cut the carbon footprint.

5.5.3 Contextual Implications

The items adapted from instruments of earlier studies have been used, which were designed for other ports. This study has unique variables, which have not been used together in a single study, even for ports outside Pakistan. The research can be advanced by adding sustainability as a moderator to evaluate its impact on port operations, logistics, and throughput. Previous studies on the Karachi CT context are either old or different. This study has unique variables and a model with the novelty of obtaining data from the local respondents in the maritime port sector of Pakistan. The items were adapted from the instruments of past studies, which were validated in Pakistan's context in the current study. This work contributes to the existing literature by addressing the research gap by including all management tiers for evaluating port resources, container management, and port logistics efficiency in a single study. The current study developed a prudent model of antecedents-outcomes of container port operations by using SmartPLS4 to determine the joint impact of the antecedents, which had rarely been assessed earlier. The research design can be replicated in other ports to assess logistics efficiency and improve strategic contexts. The lessons drawn, particularly on infrastructure and governance, apply to ports in diverse areas and fiscal settings.

The current study used the concept of container management practices for measuring the variables, which are rarely used in existing literature. Similarly, from a contextual perspective, earlier studies on Karachi port efficiency are limited to general shipping, oil tankers, and port services. The studies specific to CTs at Karachi are either old or done from a different perspective. Yet, a study with the constructs and variables as used in the present study has not been done earlier for Karachi or any other world port. Hence, the present study has proposed and tested a holistic framework to enhance port efficiency, providing deep insight into container port operations with enriched contributions to literature. The study research model to evaluate CTs at Karachi port, with SmartPLS4, had not been done earlier, which is a contribution to the literature.

5.6 Limitations of the Study

Like several other studies, this work also has limitations that need to be worked upon in future research. The limitations of this study positively present opportunities for future research associated with container management and port logistic efficiency. Yet, the findings in this study could be generally interpreted and applied to port management and logistics, despite certain limitations. The relation of container management and port logistic efficiency is different at varying managerial levels, and when viewed with diverse sets of independent variables. The research that has been done uses a sample of managerial employees, so it is thought to be limited in generalization. Hence, in further studies, it is recommended to use a more wide-ranging and diverse sample for all levels of employees at the container port and related companies. This study adopted a cross-sectional method due to limited time and resources. Though data gathering took more than eight months, examining an actual change necessitates a longitudinal study, which might need longer time and extra resources. This study's generalizability also has limitations as inferences were made with fewer countries; hence, future research may be undertaken with container ports in several countries for a more objective comparison. Moreover, dry ports in Pakistan and their possible impact on Karachi port may also be considered. The sustainability of Pakistani ports compared to industry benchmark maybe evaluated to formulate a strategy to cut pollution and ensure waste disposal. The feasibility of a new seaport between Gwadar and Karachi may be studied to offer flexibility in maritime trade. In summary the study is limited by its Karachi-specific context, data availability, cross-sectional design, and the rapidly changing nature of the maritime sector.

A drawback is that the participants took part because of their availability. Future research may utilize random or systematic probability samples, applying stratification to collect data from various groups evenly. The study only considers Karachi Port. Although the detailed findings are important, they may not suit ports with different environments, managements or systems. Further research should look at how ports of various sizes, under different structures and with different facilities operate. Moreover, the results coming from only managerial population are hard to generalize. Due to this, the findings cannot be easily used in the global port industry. Though a counter argument is that the study findings can be generalized to a certain extent due to various similarities in equipment and processes of CTs worldwide. Also, the managers being well informed are apt respondents. Even though CTs can have different locations, sizes, equipment, governance, and facilities, the productivity benchmarks to assess port performance are similar.

5.7 Recommendations for Future Research Direction

To ensure external validity, future research can involve larger groups and include a wider range of participants and should conduct studies at various ports to check whether the results are always the same. Because it only takes a quantitative approach, some meaningful observations about experiences and context may be inaccessible. This problem could be solved by using approaches that use statistics as well as interviews and focus groups. Interpreting the findings can be improved by including additional details with a sequential explanatory design. This study evaluates the influence of CT's top management on the port logistic efficiency, yet the top management's role and ability to improve multimodal land transportation system, development of container transportation by barges, and inland waterway transport system, may also be studied. Corresponding studies may identify the constraints faced by port authorities and CT management in their impartial behaviour towards Karachi dock labour (under KDLB), despite their hindrance of port operations. In this study, the hierarchical research model having one mediating variable and reflective-reflective parameters was analysed with SmartPLS4 software. Future research may evaluate the hierarchical model of container ports with a combination of moderating and mediating variables having formative and reflective parameters. Further studies should also identify dimensions of top management of container ports through qualitative and quantitative research.

There is a need to have Integrated Resource Planning, and align technological, infrastructural, and human resource investments with operational workflows to strengthen logistics efficiency. For Container Management Improvement, develop and monitor robust PCM systems as a core operational function for all port processes. Regarding digital transformation, adopt IoT, RFID, and TOS solutions to improve container tracking, yard operations, and vessel turnaround. For training and capacity building, regularly train human resources to support efficient equipment use and service delivery. With respect to policy and governance, implement performance-based tariffs and streamlined customs processes to reduce dwell times and operational bottlenecks. For further research, test the integrated RDT–ETP model in other developing ports to validate generalizability and refine operational strategies.

This study used cross-sectional data; thus, it is proposed that future studies should consider longitudinal data and apply mixed methods to have a realistic and in-depth view. A longitudinal study could examine the association among multi-layered port management, the port workers, the logistic partners, and the port authority. The current model may be used to study other ports as well. A new construct, Green Practices, may be added to the existing model for research on Pakistani ports. Future research may examine the effect of dry ports on seaport integration in developing countries. Future research may also be extended to other geographical areas and include factors such as road, rail transport networks for laden and empty containers. Future research may also study university-government-industry linkage for synergy and innovative ideas to further improve port efficiency. Simulation modeling may be used to assess infrastructure quality, yard management, or digital novelties on throughput. Managerial skill examines how leadership and planning impact port performance through expert assessments. Technological studies are undertaken to discover stakeholders' willingness to accept technologies like automated logistics systems.

The research gives practical guidance for Karachi Port and adds key ideas to the field of port logistics and management in general. Several suggestions for improvement in the way Karachi Port works have been presented. To relieve traffic and support better transit of goods, it is important to build an elevated expressway. Dredging the main channel to 15 meters will allow larger container ships to visit the port, which will increase its throughput. If the length of the rail network within the port is expanded and it is linked to Pipri depot, it will result in higher efficiency of logistics. Unclaimed containers at the Karachi Port Trust (KPT) should be cleared, as they occupy precious port space without revenue. The World Bank's 2006 proposal to part with Karachi Dock Labour Board (KDLB) must be considered by the government. Port managers must be trained for decision-making, leading teams, dealing with emergencies, and strategic thinking. Better intermodal rail-road linkage, simpler customs clearance process, efficient yard management, gate automation, and skilled employees prominently improve port performance. The port charges must be kept competitive while offering incentives for transshipment to attract shipping. The proposed port improvement framework can help enhance port performance and productivity, particularly for developing countries. Port managers and workers must be well-trained for resource utilisation and safety for effective port operations. Application of Resource Dependence Theory (RDT) and the Economic Theory of the Port (ETP) to analyse Karachi Port offers an example that can easily be replicated to explore how external factors and economic activities shape the efficiency of logistics in other ports across the world.

5.8 Conclusion

In conclusion, this study sheds light on the resources available for the functioning of port and the impact of container management on port logistics efficiency. The result of this study will allow a better understanding of the port management for improved utilization of available resources to attain higher productivity. The results will also help develop required training programs for capacity building and safety awareness of the port employees. Firstly, the study contributes to research and practice that recognizes the impact of container management on port logistics efficiency, thereby improving port productivity. The second contribution is the preparation and validation of an instrument formed by adapting items from various studies after an extensive literature review, to measure the identified port resources and the impact of container management on port logistics efficiency. Third, the study advances the research work by identifying container management as a construct to measure port logistics efficiency with quantitative data (N = 332). Notwithstanding the limitations, this research offers diverse insights into the aspect of container management on port logistics efficiency through the effective role of the top management. The limitations of this study suggest fertile avenues for future research. This multifaceted construct/variable of container management related to the effective role of top management has the potential to provide future research prospects for diverse work on container ports in different regions around the world. For a clearer understanding, the ensuing paragraphs summarize how each research objective was achieved through the study.

5.8.1 Analysis of Research Objectives and Findings

Wider objective is to improve port container management to enhance port logistics efficiency. This all-embracing objective is entirely accomplished, as the results validate that PCM is not only a robust direct driver of efficiency but also a critical path process through which many other port factors apply their impact.

The research systematically addressed its objectives to advance the understanding of Karachi Port's logistics efficiency. The first objective (RO1) is to determine which port resource capabilities impact logistics processes. It successfully identified six foundational resource capabilities, Technology, Infrastructure, Equipment, Human Resources, Services, and Charges, that have a statistically significant direct impact on efficiency, thereby supporting and extending Resource Dependence Theory through empirical validation in a developing-economy context. Building on this, the second objective (RO2) is to assess how port resources (technology, infrastructure, equipment, human resources, services, and charges), dimensions influence Karachi Port’s logistics performance. It assessed their relative influence, establishing a clear hierarchy where Port Services and Port Equipment emerged as the strongest direct drivers, providing a quantified, evidence-based guide for managerial prioritization. The third objective (RO3) is to examine how port resource capabilities shape container management effectiveness. It then examined how these resources shape the core operational process, finding that five of them significantly enhance Port Container Management (PCM), while Infrastructure played a distinct, more foundational role, thus validating and adding nuance to the input-throughput logic of the Economic Theory of the Port (ETP). The fourth objective (RO4) is to evaluate the impact of port technology, infrastructure, equipment, human resources, services, and charges on port logistics efficiency. concurrently confirmed the baseline significance of each resource's direct path to performance, reinforcing a fundamental premise in port literature. The pivotal theoretical integration was achieved in the fifth objective (RO5), which validated an integrated RDT and ETP port performance model within the Karachi Port operational environment. This was converted into performance (from RDT and ETP) via PCM, proving the two theories are complementary. Finally, the sixth objective (RO6) is to determine the extent to which resource capabilities indirectly influence logistics efficiency through enhanced container management. It quantified the mediated pathway, revealing that PCM acts as a critical force multiplier by creating a dual-pathway mechanism for five resources. This key finding transforms the conceptual resource-efficiency relationship into a complex process model and provides the empirical foundation for the practical imperative of a dual-track investment strategy.

Summary of how each research objective was achieved.

Regarding RO1, a survey analysed with SEM confirmed that all six resource capabilities (Technology, Infrastructure, Equipment, Human Resources, Services, Charges) directly and positively impact logistics (PLE), answering RQ1. For RO2, SEM analysis quantified the influence, establishing a hierarchy: Services (β=0.259) and Equipment (β=0.242) were strongest, followed by Human Resources, Infrastructure, Technology, and Charges, providing a nuanced answer to RQ1. Regarding RO3, mediation analysis revealed that resources enhance Port Container Management (PCM), which in turn strongly improves PLE (β=0.245). This shows *how* resources shape the core throughput process, answering RQ2 and RQ3. For RO4, the direct hypothesis testing (H1-H6) provided definitive, quantitative evidence that each resource has a significant positive impact on PLE, completing the empirical evaluation for RQ1. With respect to RO5, the full SEM model was statistically validated using the integrated RDT-ETP framework, confirming it as a robust tool for explaining performance dynamics at Karachi Port. For RO6, the formal mediation analysis quantified significant indirect effects for five resources (PT, PE, PHR, PS, PC), proving container management is a critical pathway through which resources indirectly boost efficiency, answering RQ4.

Synthesis on the Mediating Role of Port Container Management

The analysis confirms that Port Container Management (PCM) plays a critical mediating role, supported by a strong, significant direct path to Port Logistics Efficiency (H13: β=0.245). Five of the six key resources (Technology, Equipment, Human Resources, Services, and Charges) show a meaningful portion of their impact on efficiency channelled through enhanced PCM, transforming the resource-efficiency relationship from a simple direct link into a dual-pathway process. The total effect of a resource is now understood as the sum of its direct and indirect mediated effects, with PCM acting as a force multiplier that amplifies the value of resource investments by translating them into superior throughput operations. Theoretically, this provides robust empirical validation for the Economic Theory of the Port (ETP), demonstrating that container management is the measurable mechanism converting resources into performance and strengthening the integrated RDT-ETP model. Practically, this underscores for port managers that investing in resources alone is insufficient; parallel and prioritized investment in optimizing the container management system, through process re-engineering, digital integration, and aligned workforce training, is essential to fully realize efficiency gains and maximize return on all other asset investments.

This conclusion synthesizes the study's core achievement: successfully validating an integrated model that explains Karachi Port's logistics performance. The analysis demonstrates that superior efficiency is achieved not by resources alone, but through a dual-pathway mechanism. The key takeaway is that six resource capabilities, Technology, Infrastructure, Equipment, Human Resources, Services, and Charges, directly boost performance, with Services and Equipment being the most impactful. However, the study's pivotal finding is that Port Container Management acts as a critical mediator. For most resources, a significant portion of their benefit is realized indirectly by first enhancing this core operational process, which then substantially improves overall efficiency.

This validates the combined Resource Dependence Theory (RDT) and Economic Theory of the Port (ETP) framework, showing that resources (RDT) are converted into performance (ETP) through internal throughput. The practical imperative for port management is clear: adopt a dual-investment strategy. This means simultaneously upgrading high-impact resources *and* deliberately optimizing container management processes through digitalization and training. By strengthening this vital link between what it has and how it operates, Karachi Port can effectively transform its resource base into a sustained competitive advantage.

Summary of key findings, implications, and recommendations.

This study conclusively demonstrates that Port Logistics Efficiency at Karachi Port is directly driven by six critical resource capabilities: Technology, Infrastructure, Equipment, Human Resources, Services, and Charges, with Port Services (β=0.259) and Equipment (β=0.242) having the strongest measurable impact. Crucially, the analysis identifies Port Container Management (PCM) not only as a powerful direct driver of efficiency but also as the essential mechanism for five of the six resources; a significant portion of their benefit is channelled *through* enhanced container management. From the theoretical and practical implications point of view, the study validates the integrated RDT-ETP model, confirming that resources (RDT) are converted into performance (ETP) via core internal processes. The practical imperative for port management is a dual-track strategy: prioritizing investment in high-impact resources like service systems and modern equipment, while simultaneously and deliberately optimizing the container management process through digitalization and training. This integrated approach ensures resource investments are fully leveraged, providing a clear pathway for Karachi Port to achieve sustainable operational efficiency and regional competitiveness.

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A. APPENDIX: LIST OF SHIPPING LINES AND CLEARING FIRMS

Table List of shipping lines and clearing agent firms in Pakistan

Name, Address and Contact Numbers	Name, Address and Contact Numbers	Name, Address and Contact Numbers
1 Al-Hamd International Container Terminal (Pvt) Ltd. 2nd Floor, Dean Arcade, Block-8, Kehkashan, Clifton, Karachi-74000, Tel: +92-21-35862305 – 08 Fax: +92 21-35169550 Email: ceo@aictpk.com Website: www.aictpakistan.com	21 Gulf Maritime Services (Pak) (Pvt) Ltd. Suite No. T-04/05, 1st Floor Hakimsons Building 19-West Wharf Road Karachi-74000 Tel:32311912/32313087 Fax:32314830 Email: gmsl@super.net.pk Website: www.gulfmarine.com	41 Seven Ocean Services (Pvt) Ltd. Office # 4, Ground Floor Mules Mansion Near Jackson Police Station Kemari # 1, Karachi-75620 Tel: 32850499/32852188 Fax: 32851969 Email: bhola@cyber.net.pk Website: sos.net.pk
2 Aaras Shipping Lines (Pvt) Ltd. 701, 7th Floor, Business Plaza Mumtaz Hassan Road Off: I.I.Chundrigar Road Karachi-74000 Tel: 32415450 Fax: 32420412 Email: info@aarasshipping.com Website: www.aarasshipping.com	22 Hussain Trading Agencies (Pvt) Ltd. HTAL House, 36-38, Timber Pond kemari Karachi-75620 Tel:32852501-08 Fax:32851175 Email: htal@hussaintrading.com Website: www.hussaintrading.com	42 Shoaib Shipping Agencies (Pvt) Ltd. Suite No.108, Commerce Center Hasrat Mohani Road Karachi-74000 Tel:32628120/38450627 Fax:32630832/35870562 Email: jawed@shoaibshipping.com Website:www.msshipping.com.pk
3 Alpine Marine Services (Pvt) Ltd. 34, A/2, 2nd Floor, Haider House Beach Luxury Hotel Road, Lalazar Drive, Off: M.T.Khan Road, Karachi-74000 Tel:35611051-52 Fax:35611081-82 Email: info@alpinemarine.com Website: www.alpinemarine.com	23 Inservey Pakistan (Pvt) Ltd. GF-7-10, KDLB Building 58-West Wharf Road Karachi-74000 Tel: 32314023-29 Fax: 32314115 Email: inservey@mega-in.com Website: www.mega-in.com	43 Sinopak Shipping Lines (Pvt) Ltd. F.F.1, Block 47-C, Main Khayaban-e-Sehar Chota Shahbaz Commercial, Phase-V Defence Housing Authority Karachi-75500 Tel: 35243129-30 Fax: 35243130 Email: info@sinopak.com Website: www.sinopak.com
4 Asia Marine (Pvt) Ltd. Rahimtoola House 38-C, Khayaban-e-Shahbaz, Phase-VI Defence Housing Authority, Karachi. Tel:35243301-06 Fax:35243307 Email:aml@cyber.net.pk Website: www.rahimtoolagroup.com	24 Inshipping (Pvt) Ltd. GF-5, KDLB Building 58-West Wharf Road Karachi-74000 Tel: 32204080-82 Fax: 32313839 Email: inship@cyber.net.pk Website: www.mega-in.com	44 Sinotrans Logistics Pakistan (Pvt) Ltd. 3-R, 3rd Floor, Bahria Complex-III M.T.Khan Road Karachi-74000 Tel: 35642730-36 Fax: 35642724 Email: taimurb@sinotrans.com.pk Website: www.sinotrans.com.pk
5 Bulk Shipping & Trading (Pvt) Ltd. Level 2, 34-A/2, Lalazar Drive Opp: Beach Luxury Hotel Karachi-74000 Tel:35643371-74 Fax:35643370 Email:bulkshipping@bulkshipping.com.pk Website:www.bulkshipping.com.pk	25 Ispi Corporation (Pvt) Ltd. M.M.Ispahani Building 31-West Wharf Road No.4 Karachi-74000 Tel:32313931-32 Fax:32313115 Email: ispi@ispipk.net Website: www.ispipk.net	45 Star Integrated Shipping Agency Pakistan (Pvt) Ltd. House No.C-118, Block-2 Clifton Karachi Tel: 35291808-10 Fax: 35291805-06 Email: irfan.vazeer@pk-starcont.com Website: www.pk-starcont.com
6 Bulk Shipping Agencies (Pvt) Ltd. Level 2, 34-A/2, Lalazar Drive Opp: Beach Luxury Hotel Karachi-74000 Tel: 35643371-72 Fax: 35643370 Email: bulkshipping@shipping.com.pk	26 "M" International Services (Pvt) Ltd Mariners Fairway, 43-Timber Pond P.O.Box No.4668 Keamari, Karachi-75620 Tel:32858050-53 Fax:32858054 Email: mahmoodi@mintship.com Website: www.mintship.com	46 Super Shipping Services (Pvt) Ltd. C-17, Block-2, Kehkashan Clifton Karachi-75600 Tel:35835512-15 Fax:35834560/35871736 Email: supershipping@pacificexim.com Website: www.pacificexim.com
7 Coastal Shipping Services 1010-1011, 10th Floor Business Centre, Mumtaz Hassan Road Off: I.I.Chundrigar Road Karachi-74000 Tel:32426912-13 Fax:32426914/32434696 Email:project@cyber.net.pk Website:www.cssgroup-pk.com	27 M.S.Shipping Agencies (Pvt) Ltd. 902, Horizon Tower, Block No.3 Clifton Karachi Tel:35292462 Fax:35292463 Email: info@msshipping.com.pk Website: www.msshipping.com.pk.	47 Swift Shipping (Pvt) Ltd. Harbour House 37-A, 2nd Floor, Lalazar Avenue, Beach Hotel Road, Off M.T.Khan Road, Karachi Tel:32315962-64 Fax: 32315967 Email: info@swiftshipping.net Website: www.swiftshipping.net
8 Cosco Shipping Lines Pakistan (Pvt) Ltd. Office No, 801 to 808, 8th floor, Plot No. 10, Block 4, Clifton Diamond Building, Clifton Block 4, Karachi Tel:35610164-66 Fax:35610769/35610276 Email:cosco@coscosaeed.com Website:www.coscosaeed.com	28 M.M.Marine Services (Pvt) Ltd. M.M.Towers, 1st Floor 3-C, Khayaban-e-Ittehad, Phase-II, Ext. Defence Housing Authority Karachi-75500 Tel:35891770/35891765 Fax:35895328/35899162 Email:moulvi@cyber.net.pk	48 Tradelink International Suite # 409, Progressive Plaza Beaumont Road Karachi-75530 Tel:35638641-42 Fax:35638643-44 Email: tradekhi@gmail.com Website: www.tradelink.net.pk

9 Crystal Sea Services (Pvt) Ltd. Suite No.1010, 10th Floor Business Centre Mumtaz Hassan Road Karachi-74000 Tel:32426912-13 Fax:32426369 Email:crystalsea@cssgroup-pk.com Website:cssgroup-pk.com	29 M.M.Ispahani Limited M.M.Ispahani Building 31, West Wharf Road No.4 P.O.Box No.13145 Karachi-74000 Tel:32311317-18 Fax:32311070 Email:mmi@ispahani.net Website:www.ispahani.net	49 Trans Maritime (Pvt) Ltd. Suite # 103-104, 1st Floor Progressive Plaza 5-Civil Lines Beaumont Road Karachi-75530 Tel: 35688533 Fax: 35680611
10 Dynamic Shipping Agencies (Pvt) Ltd. Suite No.1201-1202, 12th Floor Emerald Tower, Plot No. G-19 Block-5, Main Clifton Road Opposite 2 Talwar Karachi-74000 Tel: 111-372-111 Fax: 35157913 Email: info@dynamicshipping.com Website:www.dynamicshipping.com	30 Maritime Agencies (Pvt) Ltd. 513-520, 5th Floor, Muhammadi House I.I.Chundrigar Road Karachi-74000 Tel:32422703-04 Fax:32415931/32400189 Email:maritime@klinepakistan.com Website: www.klinepakistan.com	50 Transport Services International (Pvt) Ltd. C-17, Block-2, Kehkashan Clifton Karachi-75600 Tel:35835512-15 Email: transport@pacificexim.com Website:www.pacificexim.com
11 East Wind Shipping (Pvt) Ltd. Suite-103, Level-1, Marine Point DC-1, Block-9, KDA Scheme 5 Kehkashan, Clifton Karachi-75600 Tel:35309275 Fax:35309279 Email:operation@eastwindshipping.com Website:www.eastwindshipping.com	31 Northstar International (Pvt) Ltd. Unicorn House M.C.F./1-5, Khayaban-e-Iran Clifton Karachi-75600 Tel:35871168-69 Fax:35870923/35870674 Email:rizwan@unicorngroup.pk Website:www.unicorngroup.pk	51 United Marine Agencies (Pvt) Ltd. 8th Floor, Bahria Complex-IV Chaudhry Khaliq-us-Zaman Road Gizri, Clifton Karachi-75600 Tel:35147919 Fax:35147947 Email:sohail.shams@umapk.com Website: www.umapakistan.com
12 Eastern Sea Transport (Pvt) Ltd. Eastern House, 9-Timber Pond kemari Karachi-75620 Tel:32851945-56 Fax:32851354/32852064 Email:info@easterngroup.cos.com Website:www.easterngroupcos.com	32 Ocean Express Agencies (Pvt) Ltd. Harbour House 37-A, 2nd Floor, Lalazar Avenue, Beach Hotel Road, Off M.T.Khan Road, Karachi Tel:32202762-67 Fax:32310670/32200018 Email: into@oceanxpr.net Website:www.oceanxpr.net	52 Waterlink Pakistan (Pvt) Ltd. 4-A, Kehkashan Town Houses Block-5, Clifton Karachi-75600 Tel: 111-111-550 Fax: 35838688 Email: captmustafa@waterlinkpak.com Website: www.waterlinkpak.com
13 Forbes Shipping Company (Pvt) Ltd. Suite No.8-9, Ground Floor KDLB Building, 58-West Wharf Road Karachi-74000 Tel: 32314025-29 Fax: 32314115 Email: forbesshipcorporate@mega-in.com Website: www.mega-in.com	33 Ocean world (Pvt) Ltd. Suite No.409, Progressive Plaza Beaumont Road, Civil Lines Karachi-75530 Tel:35638641-42 Fax:35638643-44 Email:oceanworld@cyber.net.pk	53 Wilhelmsen Ships Service (Pvt) Ltd. Suite No.308, 3rd Floor, Dean Arcade, Block-8 Clifton Karachi-75600 Tel:35873189-91 Fax:35873192 Email:sg-ali-ahmed@wilhelmsen.com Website:www.wilhelmsen.com/shipsservice
14 G.M.Logistics (Pvt) Ltd. Suite No.403-404, 4th Floor Progressive Plaza Beaumont Road, Civil Lines Karachi-75530 Tel:35657690-95 Fax:35657706 Email:asim@gmlog.com Website:www.gmlog.com	34 Pacific Delta Shipping (Pvt) Ltd. Seedat Chambers, 3rd Floor Dr.Ziauddin Ahmed Road Karachi-74000 Tel:35637583-84 Fax:35687701 Email:pacific@pacificdeltapk.com	54 WMA Shipcare Services (Pvt) Ltd. Suite No.704, 7th Floor, Tahir Plaza Plot No.A/20, Block No.7-8 K.C.H.S.U, Shahrah-e-Faisal Karachi-75400 Tel: 34391450-34391517 Fax: 34391518 Email: info@wmashipcare.com Website:www.wmashipcare.com
15 GAC Pakistan (Pvt) Ltd. 1st Floor, Bahria Complex IV, Main Chaudhry Khaliq-uz-Zaman Road, Gizri, Clifton Karachi Tel:32311010 Fax:32310714/2310736 Email: pakistan@gac.com Website:www.gacworld.com	35 Project Shipping Building # 14-C, Level-2 Zamzama Commercial Lane No.6 D.H.A., Phase-V Karachi-75500 Tel:35295060-63 Fax:35295059 Email:mail@projectshipping.com.pk Website:www.projectshipping.com.pk	55 X-Press Feeders Pakistan (Pvt) Ltd. 2nd KDLB Building 58-West Wharf Road Karachi-74000 Tel: 32202374-75 Fax: 32202377 Email: info@x-pressfeeders.com.pk Website: www.x-pressfeeders.com.pk
16 General Maritime (Pvt) Ltd. Suite No.403-404, 4th Floor Progressive Plaza Beaumont Road, Civil Lines Karachi-75530 Tel:111-403-404 Fax:35657706 Email: asim@gmlpk.combr /> Website:www.gmlpk.com	36 Rahmat Shipping (Pvt) Ltd Room No.803-804, 8th Floor Business & Finance Centre I.I.Chundrigar Road Karachi-74000 Tel:32474301-06 Fax:32474308 Email:sohail@rahmat.com.pk Website:www.rahmat.com.pk	56 Yaaseen Shipping Lines (Pvt) Ltd 10th Floor, Sheikh Sultan Trust Building Beaumont Road Karachi-75530 Tel:35688057-59 Fax:35681539 Email:yaakar@khi.comsats.net.pk Website: www.yslpk.com

17 General Shipping Agencies (Pvt) Ltd. GSA House, 19-Timber Pond kemari Karachi-75620 Tel:32850190-93 Fax:32851528/32850185 Email:mail@gsa.com.pk Website:www.gsa.com.pk	37 Riazeda (PvT) Ltd 105-113, 1st Floor Chapal Plaza Hasrat Mohani Road Karachi Tel:32401181-85 Fax:32439570 Email:faizan@riazeda.com.pk Website:www.riazeda.com.pk	
18 Globelink Pakistan (Pvt) Ltd. 36-Timber Pond kemari, Karachi-75620 Tel:111-298-298 Fax:32851678/32851981 Email:general@globelinkpk.com Website:www.globelinkpk.com	38 Seabiz International (Pvt) Ltd. 1-A, 1st Floor, Sattar Chambers 29-West Wharf Road Karachi-74000 Tel:32201619-22 Fax: 32311717 Email:seabiz@cyber.net.pk	
19 Golden Shipping Lines (Pvt) Ltd. Suite No.7, 2nd Floor Sattar Chambers West Wharf Road Karachi-74000 Tel: 32311970-73 Fax: 32311974/32310465 Email:admin@golden-shipping.com Website:goldenshipping.com	39 SeaCare Pakistan (Pvt) Ltd. Office No.314, Park Avenue P.E.C.H.S., 24-A, Block-6 Main Shahrah-e-Faisal, Karachi-75400, Tel: 34313341-42, Fax: 34313340 Email: seacare@cyber.net.pk Website: seacare.com.pk Email:ttlcom@transgroup.pk	
20 GreenPak Shipping (Pvt) Ltd. Ground Floor, Beaumont Plaza Beaumont Road, Civil Lines Karachi-75530 Tel:111-123-477 Fax:35223516 Email:greenpak@greenpakshipping.com Website: www.greenpakshipping.com	40 Sealog (Pvt.) Ltd. GF-7-10, KDLB Building, 58-West Wharf Road, Karachi-74000 Tel: 32314281-2 Fax: 32314438	

Source: https://www.urdupoint.com/business/directory/karachi/1094/clearing-forwarding-agents.html

B. APPENDIX: QUESTIONNAIRE SURVEYS

Greetings,

This survey is part of a PhD Research on IMPACT OF CONTAINER MANAGEMENT ON PORT LOGISTICS EFFICIENCY OF KARACHI PORT. With an industrial focus on PICT, KICT and SAPT Container Management, survey data will also be collected from KPT and Shipping and clearing firms.

The research is supervised by Dr Ali Imtiaz, Associate Professor in Management Sciences Department, Bahria University and conducted by Mr Farrukh Mahfooz, PhD Scholar, Bahria University. The aim of this research is to develop a new logistics efficiency improvement framework for container ports and terminals.

There is no risk related to this study. The confidentiality of individual contributions and contact details is guaranteed. The questionnaire is for academic research only, and its completion should take about 40 to 45 minutes of your time. Your input will be of great value. Your participation in this survey is voluntary. If you have any query about the questionnaire or difficulties answering any question, then please contact the researcher. If you know of others who may be interested in this study, then kindly share this questionnaire with them.

Thank you,

Farrukh Mahfooz
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DEMOGRAPHICS

SECTION A: RESPONDENT/ORGANISATION PROFILE

1. Gender

☐ Male

☐ Female

2. Position in the present organization

☐ Top/Senior management

☐ Middle management

☐ Lower management

2. Your department in the organization.

☐ General Manager

☐ Operations

☐ Human Resource

☐ Information Technology

☐ Infrastructure

☐ Equipment

☐ Services

☐ Finance

3. Current Organization.

☐ Karachi Port Trust (KPT)

☐ Pakistan International Container Terminal (PICT)

☐ Karachi International Container Terminal (KICT)

☐ South Asia Port Terminal (SAPT)

☐ Shipping and clearing firms

☐ Others ________________

4. Work experience in port port-related position

☐ Less than 2 years

☐ 3 to 8 years

☐ 9 to 15 years

☐ 16 to 25 years

☐ More than 25 years

5. Age group.

- ☐ Between 20 and 24 years
- ☐ Between 25 and 34 years
- ☐ Between 35 and 44 years
- ☐ Between 45 and 54 years
- ☐ Between 55 and 60 years
- ☐ Above 60 years

6. Highest Educational Qualification.

- ☐ Bachelors
- ☐ Masters
- ☐ MS/MPhil
- ☐ PhD

RESPONDENT PROFILE

Respondent Name: ______________________________ (optional)

Job Title: ______________________________ (optional)

Telephone: ______________________________ (optional)

Email: ______________________________ (optional)

If you have any queries about this survey, please contact: Mr Farrukh Mahfooz, Tel: +923325799848

Email: 01-280181-006@student.bahria.pk; farrukhmahfooz58@gmail.com

All fields in Section A are mandatory.

SECTION B: PORT TECHNOLOGY QUESTIONS

Regarding Port Technology, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	No	Item statement	Strongly Agree	Agree	Neither disagree	Disagree	Strongly Disagree
Information Technology (IT)							
PTIT-1	1.	Our seaport container terminal has modern and efficient terminal operating system (TOS) which can also track container location.					
PTIT-2	2.	Our seaport container terminal IT system can provide quality information for accurate decision-making.					
PTIT-4	3.	Our seaport container terminal IT system produces error-free invoices and enables online payment.					
PTIT-5	4.	Our seaport container terminal IT system is integrated and covers all operations and management applications.					
PTIT-8	5.	Our seaport terminal has efficient establishment of an EDI system to share container operations data with stakeholders in the supply chain.					

SECTION C: PORT INFRASTRUCTURE QUESTIONS

Regarding Port Infrastructure, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly gree
Accessibility and Connectivity (AC)							
PIAC-1	6.	Our seaport container terminal has adequate seaside and channel accessibility.					
PIAC-3	7.	Our seaport container terminal has adequate physical infrastructure such as berths, yards, stacking areas, distribution centres, exit gates, and hinterland connection networks.					
PIAC-4	8.	Our seaport has adequate channel reliability.					
PIAC-5	9.	Our seaport container terminal has adequate landside accessibility and connectivity for hinterland transport (road and rail).					
PIAC-6	10.	Our seaport container terminal has adequate accessibility and capability of entrance and departure gate operations.					

		Container Berth (CB)					
PICB-9	11.	Our seaport container terminal has an adequate number of operational berths for incoming container ships.					
PICB-11	12.	Our seaport container terminal has adequate berth reliability.					
PICB-12	13.	Our seaport container terminal has adequate berth length to dock ships of the required size.					
PICB-13	14.	Our seaport container terminal has an adequate depth alongside the berth to dock ships of the required size.					
		Container Yard (CY)					
PICY-14	15.	Our seaport container terminal has adequate land area for container operations and logistics management.					
PICY-15	16.	Our seaport container terminal has adequate container storage capacity in the yard area.					
PICY-16	17.	Our seaport container terminal has adequate container handling and management capacity in the yard area.					
PICY-17	18.	Our seaport container terminal experiences occasional congestion related to customs documentation, container scanning, and vehicle gate operations.					

SECTION D: **PORT EQUIPMENT QUESTIONS**

Regarding Port Equipment, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item statement	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
		Quay Crane (QC)					
PEQC-1	19.	Our seaport container terminal has an adequate number of operationally efficient Quay cranes.					
PEQC-2	20.	Our seaport container terminal Quay Crane's design has an adequate container loading service rate.					
PEQC-3	21.	Our seaport container terminal Quay Crane's design has an adequate container unloading service rate.					
		Yard Crane (YC)					
PEYC-4	22.	Our seaport container terminal has an adequate number of operationally efficient yard gantry cranes.					
PEYC-5	23.	Our seaport container terminal has an adequate loading service rate for container vehicles.					
PEYC-6	24.	Our seaport container terminal has an adequate unloading service rate for container vehicles.					
		Equipment Reliability (RB)					
PERB-8	25.	Our seaport container terminal has an adequate number of terminal equipment.					

PERB-10	26.	Our seaport container terminal has reliable equipment.					
PERB-12	27.	Our seaport container terminal regularly maintains the equipment with planning, without causing operational delays.					

SECTION E: **PORT HUMAN RESOURCE QUESTIONS**

Concerning Port Equipment, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
			5	4	3	2	1
Training and education (TE)							
PHRTE-3	28.	Our seaport container terminal offers professional training and education to employees for capacity building and attain productivity targets.					
PHRTE-4	29.	Our seaport container terminal offers training and education to employees to achieve safe and efficient operations.					
PHRTE-5	30.	Our seaport container terminal offers training to employees which improves their confidence and work quality.					
PHRTE-7	31.	Our seaport container terminal operations have adequately skilled operators due to regular training.					
Employees Reliability (ER)							
PHRER-10	32.	Our seaport container terminal operations have capable employees.					
PHRER-11	33.	Our seaport container terminal operations have reliable employees.					
PHRER-12	34.	Our seaport container terminal operations have trustworthy employees.					
PHRER-13	35.	Our seaport container terminal operations have trained employees who respond swiftly to customer inquiries and needs.					
PHREP-14	36.	Our seaport container terminal management offers training and incentives to employees to attain productivity targets.					

SECTION F: PORT SERVICES QUESTIONS

Regarding Port Services, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Dwell Time (DT)							
PSDT-1	37.	Our seaport terminal takes on average 7 to 9 days dwell time to clear containers from the port.					
PSDT-2	38.	Our seaport terminal yard storage capacity increases when container dwell time is reduced.					
PSDT-3	39.	Delay in the custom clearance process is a key contributor to increased dwell time.					
Custom Clearance (CC)							
PSCC-5	40.	Our seaport container terminal has an effective custom clearance process with realistic charges.					
PSCC-6	41.	Our seaport IT system performance influences the pace of the custom clearance process.					
PSCC-7	42.	Our seaport custom clearance efficiency affects container terminal productivity.					
Service Reliability (SR)							
PSSR-8	43.	Our seaport container terminal has highly reliable services.					
PSSR-9	44.	Our seaport container terminal has reliable multi-modal interface and supply chain services.					
PSSR-10	45.	Our seaport container terminal delivers services on time (minimizing delays) with high delivery reliability.					
PSCR-11	46.	Our seaport container terminal employees give quick responses to customer requests.					
PSCR-12	47.	Our seaport container terminal employees give quick responses to customer complaints and refund processes.					
Customer Satisfaction (CS)							
PSCS-16	48.	Services provided by our seaport meet all the customer needs					
PSCS-17	49.	Our seaport container terminal has an efficient ship clearance process for departing ships.					
PSCS-18	50.	The cargo owners feel that their cargo is safe and secure at our container terminal.					

PSCS-19	51.	Overall, our customers are highly satisfied with the port services.					

SECTION G: **PORT CHARGES QUESTIONS**

Regarding Port Charges, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Port Service Charges (SC)							
PCSC-1	52.	Our seaport container terminal offers competitive charges against the services provided					
PCSC-2	53.	Our seaport infrastructure charges (berth charge and channel charge, etc.) are competitive.					
PCSC-3	54.	Our seaport shipping service charges (mooring, pilotage, towage) are competitive.					
PCSC-4	55.	Our seaport container cargo handling services and storage in the yard are cheaper than competitors.					

SECTION G: **PORT CONTAINER MANAGEMENT (PCM) QUESTIONS**

Regarding Port Container Management, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Investing Strategic Capabilities (SC)							
PCMSC-1	56.	Our senior management has developed and communicated a clear strategic vision of our seaport container terminal					
PCMSC-2	57.	Our senior management ensures that actual performance is in line with the seaport's strategic objectives.					
PCMSC-3	58.	Our senior management pays attention to highly experienced staff for work quality and to reduce dependencies.					
PCMSC-5	59.	Our senior management views shipping lines as strategic partners in mutually designing the flow of containers and information.					

Defining strategic direction (SD)							
PCMSD-7	60.	Our senior management regularly analyses external and internal environments to identify strengths and weaknesses, which affect our seaport's future work.					
PCMSD-8	61.	Our seaport management has a strategy of green sustainable development, focusing on port infrastructure and environmental protection.					
PCMSD-10	62.	Our senior management ensures a balance between supervision and the independence necessary to perform work.					
Management-related factors (MA)							
PCMMA-12	63.	Our seaport demonstrates efficient terminal operations and management with ICT support.					
PCMMA-13	64.	Our seaport container terminal management ensures adequate training for capacity building of employees, including incident-handling capability.					
PCMMA-15	65.	Our seaport container terminal management collects customer feedback about their services and reflects on their improvement.					
PCMMA-16	66.	Our seaport management continuously improves customer-oriented terminal operations and processes based on the feedback received.					
Activities related factors (OE)							
PCMOE-20	67.	Our seaport terminal gate management offers efficient container cargo receipt and delivery operations.					
PCMOE-21	68.	Our seaport terminal custom clearance process is quick and aligned with container operations productivity targets.					
PCMOE-22	69.	Our seaport has adequate container track and trace capability for efficient terminal management at a low cost.					

SECTION G: **PORT LOGISTICS EFFICIENCY (PLE) QUESTIONS**

Regarding Port Logistics Efficiency (PLE), please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
		Logistic Capability (LC)					
PLELC-3	70.	Our seaport ICT system offers accurate and real-time container shipment data enabling efficient logistic operations.					
PLELC-4	71.	Our seaport container terminal has adequate operability for ship-road interface.					
PLELC-5	72.	Our seaport container terminal has adequate operability for the ship-rail interface.					
PLELC-6	73.	Intermodal landside transport facilities are available at our container terminal (rail and road)					
PLELC-7	74.	Our seaport terminal has the ability to serve Very Large Container Ships (up to 13500 TEUs)					
PLELC-8	75.	Our seaport terminal has the ability to serve Post-Panamax Container Vessels (below 8000 TEUs)					
		Container Throughput (TP)					
PLETP-10	76.	Our seaport's current annual throughput is nearly half of its designed capacity.					
PLETP-11	77.	Our seaport container terminal can attain higher throughput with wise use and better management of existing resources.					
PLETP-12	78.	Container terminal efficiency can be measured by the level of increase in inputs and throughput.					

Residual questions

SECTION B: **PORT TECHNOLOGY QUESTIONS**

Regarding Port Technology, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item statement	Strongly Agree	Agree	Neither agree nor disagree	Dis-agree	Strongly disagree
Information Technology (IT)							
PTIT-3	79.	Our seaport container terminal IT system can provide required information for container flow forecasting					
PTIT-6	80.	Our seaport container terminal IT system provides real-time data which facilitates efficient container operations and management.					
PTIT-7	81.	Our seaport container terminal has state-of-the-art IT system which support logistics and supply chain goals.					
PTRF-9	82.	Our seaport uses RFID for container tracking and inventory control.					
PTRF-10	83.	Our seaport uses RFID for faster and cheaper container identification process and container security.					

SECTION C: **PORT INFRASTRUCTURE QUESTIONS**

Regarding Port Technology, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement					
Accessibility and Connectivity (AC)							
PIAC-2	84.	Our seaport channel depth, length, and width are adequately maintained for the safe operation of ships.					
PIAC-7	85.	Our seaport container terminal has adequate entrance gate reliability.					
PIAC-8	86.	Our seaport container terminal has adequate departure gate reliability.					
Container Berth (CB)							
PICB-10	87.	Our seaport container terminal has adequate berth accessibility.					
Container Yard (CY)							

PICY-18	88.	Our seaport experiences occasional congestion related to customs documentation and container scanning procedure.					
PICY-19	89.	Our seaport container terminal experiences negligible congestion related to the ship's berth or ship's work.					

SECTION D: **PORT EQUIPMENT QUESTIONS**

Regarding Port Equipment, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement	5	4	3	2	1
Port Equipment Reliability (RB)							
PERB-7	90.	Our seaport container terminal has an adequate number of operationally efficient container vehicles.					
PERB-9	91.	Our seaport container terminal has 24-hour working hours and its container handling equipment is always ready to engage.					
PERB-11	92.	Our seaport container terminal regularly modernizes the equipment for proper functioning.					

SECTION E: **PORT HUMAN RESOURCE QUESTIONS**

Regarding Port Equipment, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement					
Commitment and loyalty (CL)							
PHRCL-1	93	Our seaport container terminal dock labour is available for employment when needed due to their commitment.					
PHRTE-2	94	Our seaport offers professional education to employees which increases their organisational commitment and loyalty.					
Training and Education (TE)							

PHRTE-6	95	Our seaport container terminal has a formal safety and security training programme and conducts a regular training test (monthly)					
Knowledge, Skill (KS)							
PHRTE-8	96	Our seaport container terminal employees possess suitable knowledge and skill to perform safely and efficiently.					
Employee Reliability (ER)							
PHRER-9	97	Our seaport container terminal operations have sufficient employees					

SECTION F: **PORT SERVICES QUESTIONS**

Regarding Port Services, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement	5	4	3	2	1
Dwell Time (DT)							
PSDT-4	98	Dwell time is an indicator to assess container terminal efficiency.					
Customer Satisfaction (CS)							
PSCS-13	99	Our seaport container terminal has experienced negligible cargo damage incidents.					
PSCS-14	100	Our seaport container terminal has experienced cargo loss incidents					
PSCS-15	101	Our seaport container terminal provides quick service to ships with negligible waiting time.					

SECTION G: **PORT CHARGES QUESTIONS**

Regarding Port Charges, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement					
Port Service Charges (SC)							
PCSC-5	102	Our seaport container terminal ancillary service charges are reasonable					
PCSC-6	103	Changes in our local terminal charges do not impact on demand for our container shipping services.					

PCSC-7	104	Our seaport container terminal offers lesser service charges than competitors.					
PCSC-8	105	Our seaport container terminal levies demurrage charges on container cargo after completion of the initial free grace period.					

SECTION G: PORT CONTAINER MANAGEMENT (PCM) QUESTIONS

Regarding Port Container Management, please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S #	Item statement					
		Investing Strategic Capabilities (SC)					
PCMSC-4	106	Our seaport has clear rules, wholesome policies and job description for optimal working and safety of employees. Change in the long-term policy is given appropriate time.					
PCMSC-6	107	Our senior management works with logistic stakeholders to improve service at a low cost.					
		Defining Strategic Direction (SD)					
PCMSD-9	108	Our senior management empowers human resources by giving them essential power and authority to complete their work.					
		Management-related factors (MA)					
PCMMA-11	109	Our seaport container terminal operations and management have a comprehensive level of ICT applications.					
PCMMA-14	110	Our seaport container terminal management demonstrates a good understanding of customers' needs.					
PCMMA-17	111	Our seaport managers decide container handling charges and asset allocation which are key factors for terminal performance and efficiency.					
PCMMA-18	112	Our seaport managers possess adequate management skills as per market practices and requirements of container ports.					
PCMMA-19	113	Our seaport managers are afforded apt training courses to improve management skills as per market practices and requirements of container ports.					

Activities Process-related factors (OE)							
PCMOE-23	114	The average truck turnaround time at our seaport terminal is aligned with the container cargo loading and unloading service rate on inland carriers.					
PCMOE-24	115	Ships sail frequently at our seaport container terminal.					
PCMOE-25	116	The management of our container terminal quay cranes is efficient and aligned with operational productivity targets.					

SECTION G: **PORT LOGISTICS EFFICIENCY (PLE) QUESTIONS**

Regarding Port Logistics Efficiency (PLE), please select (√) the most appropriate option for each question from 1 to 5. The scale is 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.

Code	S No	Item	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Logistic capability (LC)							
PLELC-1	117	Our seaport container terminal logistic efficiency is aligned with our productivity targets.					
PLELC-2	118	Our seaport handles container cargo within quoted time.					
Container Throughput (TP)							
PLETP-9	119	The annual container throughput of the seaport is a key factor to assess port logistic efficiency.					
PLETP-13	120	On average 2-3 container ships call at our seaport every day, throughout the year.					

C. APPENDIX: SAMPLE SIZE REFERENCE

Table 7.1 Sample sizes for different sizes of target population at a 95 per cent confidence level (assuming data are collected from all cases in the sample)

	Margin of error			
Target population	**5%**	**3%**	**2%**	**1%**
50	44	48	49	50
100	79	91	96	99
150	108	132	141	148
200	132	168	185	196
250	151	203	226	244
300	168	234	267	291
400	196	291	343	384
500	217	340	414	475
750	254	440	571	696
1 000	278	516	706	906
2 000	322	696	1091	1655
5 000	357	879	1622	3288
10 000	370	964	1936	4899
100 000	383	1056	2345	8762
1 000 000	384	1066	2395	9513
10 000 000	384	1067	2400	9595

Source: Saunders 2017, p335

D. APPENDIX: TABLE FOR COLLINEARITY STATISTICS (VIF)

Items	VIF	Items	VIF	Items	VIF	Items	VIF
PCMMA12	1.924	PEQC3	2.557	PIAC3	1.420	PLETP12	2.637
PCMMA12	1.748	PERB10	2.333	PIAC4	1.534	PSCC5	2.136
PCMMA13	2.179	PERB10	1.728	PIAC4	1.450	PSCC5	1.481
PCMMA13	1.942	PERB12	1.863	PIAC5	1.333	PSCC6	1.568
PCMMA15	2.334	PERB12	1.760	PIAC5	1.553	PSCC7	1.680
PCMMA15	1.738	PERB8	1.911	PIAC6	1.795	PSCC7	2.003
PCMMA16	2.421	PERB8	1.674	PIAC6	1.610	PSCS16	1.739
PCMMA16	1.441	PEYC4	2.174	PICB11	1.874	PSCS16	2.457
PCMOE20	2.061	PEYC4	1.629	PICB11	1.304	PSCS17	2.245
PCMOE20	1.590	PEYC5	2.348	PICB12	2.556	PSCS18	1.923
PCMOE21	1.214	PEYC5	1.996	PICB13	2.935	PSCS18	2.755
PCMOE22	3.054	PEYC6	1.580	PICB13	3.143	PSCS19	1.437
PCMOE22	1.612	PEYC6	1.912	PICB9	2.599	PSDT1	2.002
PCMSC1	2.182	PHREP14	1.571	PICB9	2.388	PSDT1	1.468
PCMSC1	1.941	PHREP14	1.784	PICY14	2.222	PSDT2	1.260
PCMSC2	2.324	PHRER10	2.527	PICY14	2.057	PSDT3	1.473
PCMSC2	2.037	PHRER10	1.787	PICY15	1.833	PSDT3	1.973
PCMSC3	1.436	PHRER11	2.384	PICY15	1.632	PSSR10	1.673
PCMSC3	2.195	PHRER11	2.548	PICY16	2.500	PSSR10	2.349
PCMSC5	2.384	PHRER12	2.200	PICY17	1.369	PSSR11	1.871
PCMSC5	1.238	PHRER12	1.958	PLELC3	1.316	PSSR11	2.144
PCMSD10	1.629	PHRER13	2.161	PLELC4	1.302	PSSR12	1.676
PCMSD10	1.942	PHRER13	1.759	PLELC4	1.530	PSSR12	1.808
PCMSD7	2.173	PHRTE3	1.482	PLELC5	2.110	PSSR8	1.572
PCMSD7	1.682	PHRTE3	1.566	PLELC5	1.851	PSSR8	1.701
PCMSD8	1.321	PHRTE4	2.099	PLELC6	2.853	PSSR9	1.341
PCMSD8	1.969	PHRTE4	1.929	PLELC6	2.867	PTIT1	1.849
PCSC1	1.869	PHRTE5	2.445	PLELC7	2.191	PTIT2	1.799
PCSC2	2.205	PHRTE5	2.110	PLELC7	3.358	PTIT4	1.747
PCSC3	1.855	PHRTE6	1.557	PLELC8	3.194	PTIT5	1.798
PCSC4	1.474	PHRTE6	1.939	PLELC8	3.107	PTIT8	1.718
PEQC1	1.225	PHRTE7	3.224	PLETP10	1.281		
PEQC1	1.795	PHRTE7	2.246	PLETP10	3.424		
PEQC2	2.724	PIAC1	1.802	PLETP11	2.202		
PEQC2	2.520	PIAC1	1.959	PLETP11	2.282		
PEQC3	2.743	PIAC3	1.657	PLETP12	2.353		

E. APPENDIX: KOLMOGOROV-SMIRNOV & SHAPIRO-WILK TESTS OF NORMALITY

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PTIT-1	.358	332	.000	.705	332	.000
PTIT-2	.274	332	.000	.786	332	.000
PTIT-3	.364	332	.000	.755	332	.000
PTIT-4	.266	332	.000	.758	332	.000
PTIT-5	.272	332	.000	.797	332	.000
PTIT-6	.347	332	.000	.732	332	.000
PTIT-7	.229	332	.000	.851	332	.000
PTED-8	.332	332	.000	.742	332	.000
PTRF-9	.230	332	.000	.891	332	.000
PTRF-10	.183	332	.000	.901	332	.000
PIAC-1	.277	332	.000	.778	332	.000
PIAC-2	.342	332	.000	.714	332	.000
PIAC-3	.262	332	.000	.792	332	.000
PIAC-4	.347	332	.000	.754	332	.000
PIAC-5	.352	332	.000	.755	332	.000
PIAC-6	.254	332	.000	.794	332	.000
PIAC-7	.278	332	.000	.785	332	.000
PIAC-8	.285	332	.000	.775	332	.000
PICB-9	.316	332	.000	.744	332	.000
PICB-10	.279	332	.000	.781	332	.000
PICB-11	.343	332	.000	.742	332	.000
PIBL-12	.322	332	.000	.745	332	.000
PIDB-13	.322	332	.000	.754	332	.000
PITA-14	.267	332	.000	.789	332	.000
PICY-15	.345	332	.000	.749	332	.000
PICY-16	.254	332	.000	.782	332	.000
PICG-17	.367	332	.000	.778	332	.000
PICG-18	.290	332	.000	.857	332	.000
PICG-19	.290	332	.000	.857	332	.000
PEQC-1	.360	332	.000	.716	332	.000
PEQC-2	.202	332	.000	.839	332	.000
PEQC-3	.227	332	.000	.841	332	.000
PEYC-4	.339	332	.000	.734	332	.000
PEYC-5	.327	332	.000	.773	332	.000
PEYC-6	.260	332	.000	.792	332	.000
PECV-7	.332	332	.000	.757	332	.000
PERB-8	.336	332	.000	.748	332	.000
PERB-9	.316	332	.000	.736	332	.000
PERB-10	.246	332	.000	.786	332	.000
PERB-11	.332	332	.000	.769	332	.000
PERB-12	.339	332	.000	.773	332	.000
PHRCL-1	.324	332	.000	.833	332	.000
PHRCL-2	.380	332	.000	.754	332	.000
PHRTE-3	.351	332	.000	.780	332	.000
PHRTE-4	.352	332	.000	.724	332	.000
PHRTE-5	.297	332	.000	.814	332	.000
PHRTE-6	.295	332	.000	.817	332	.000

PHRKS-7	.268	332	.000	.794	332	.000
PHRKS-8	.362	332	.000	.732	332	.000
PHRER-9	.322	332	.000	.767	332	.000
PHRER-10	.357	332	.000	.739	332	.000
PHRER-11	.364	332	.000	.728	332	.000
PHRER-12	.351	332	.000	.753	332	.000
PHRER-13	.267	332	.000	.796	332	.000
PHREP-14	.290	332	.000	.804	332	.000
PSDT-1	.301	332	.000	.848	332	.000
PSDT-2	.281	332	.000	.771	332	.000
PSDT-3	.270	332	.000	.810	332	.000
PSDT-4	.210	332	.000	.874	332	.000
PSCC-5	.220	332	.000	.875	332	.000
PSCC-6	.313	332	.000	.826	332	.000
PSCC-7	.290	332	.000	.810	332	.000
PSSR-8	.355	332	.000	.761	332	.000
PSSR-9	.254	332	.000	.849	332	.000
PSSR-10	.281	332	.000	.812	332	.000
PSCR-11	.289	332	.000	.797	332	.000
PSCR-12	.360	332	.000	.768	332	.000
PSCD-13	.363	332	.000	.762	332	.000
PSCD-14	.303	332	.000	.819	332	.000
PSSD-15	.327	332	.000	.749	332	.000
PSCS-16	.286	332	.000	.803	332	.000
PSCS-17	.337	332	.000	.737	332	.000
PSCS-18	.343	332	.000	.714	332	.000
PSCS-19	.360	332	.000	.749	332	.000
PCSC-1	.249	332	.000	.811	332	.000
PCSC-2	.234	332	.000	.844	332	.000
PCSC-3	.349	332	.000	.794	332	.000
PCSC-4	.376	332	.000	.753	332	.000
PCSC-5	.280	332	.000	.831	332	.000
PCSC-6	.216	332	.000	.894	332	.000
PCSC-7	.324	332	.000	.821	332	.000
PCSC-8	.234	332	.000	.832	332	.000
PCMSC-1	.255	332	.000	.800	332	.000
PCMSC-2	.256	332	.000	.793	332	.000
PCMSC-3	.349	332	.000	.775	332	.000
PCMSC-4	.256	332	.000	.812	332	.000
PCMSC-5	.299	332	.000	.794	332	.000
PCMSC-6	.356	332	.000	.748	332	.000
PCMSD-7	.251	332	.000	.803	332	.000
PCMSD-8	.252	332	.000	.805	332	.000
PCMSD-9	.319	332	.000	.793	332	.000
PCMSD-10	.277	332	.000	.845	332	.000
PCMMA-11	.317	332	.000	.782	332	.000
PCMMA-12	.308	332	.000	.790	332	.000
PCMMA-13	.320	332	.000	.783	332	.000
PCMMA-14	.318	332	.000	.782	332	.000
PCMMA-15	.348	332	.000	.779	332	.000
PCMMA-16	.308	332	.000	.809	332	.000
PCMMA-17	.233	332	.000	.820	332	.000
PCMMA-18	.363	332	.000	.751	332	.000
PCMMA-19	.339	332	.000	.769	332	.000
PCMOE-20	.320	332	.000	.762	332	.000

PCMOE-21	.294	332	.000	.851	332	.000
PCMOE-22	.262	332	.000	.820	332	.000
PCMOE-23	.255	332	.000	.835	332	.000
PCMOE-24	.348	332	.000	.748	332	.000
PCMOE-25	.260	332	.000	.809	332	.000
PLEPE-1	.369	332	.000	.739	332	.000
PLEPE-2	.349	332	.000	.770	332	.000
PLEPE-3	.339	332	.000	.776	332	.000
PLELC-4	.225	332	.000	.879	332	.000
PLELC-5	.239	332	.000	.880	332	.000
PLELC-6	.249	332	.000	.793	332	.000
PLELC-7	.224	332	.000	.850	332	.000
PLELC-8	.270	332	.000	.786	332	.000
PLETP-9	.263	332	.000	.796	332	.000
PLETP-10	.240	332	.000	.865	332	.000
PLETG-11	.277	332	.000	.832	332	.000
PLETG-12	.267	332	.000	.820	332	.000
PLESV-13	.240	332	.000	.879	332	.000

a. Lilliefors Significance Correction

Table Exploratory Factor Analysis (EFA) Rotated Component Matrix

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PTIT1	0.65																			
PTIT2	0.81																			
PTIT4	0.73																			
PTIT5	0.64																			
PTIT8	0.66																			
PIAC1		0.664																		
PIAC3		0.715																		
PIAC4		0.551																		
PIAC5		0.682																		
PIAC6		0.647																		
PICB9			0.674																	
PICB11			0.728																	
PICB12			0.672																	
PICB13			0.695																	
PICY14				0.592																
PICY15				0.785																
PICY16				0.724																
PICY17				0.535																
PEQC1					0.77															
PEQC2					0.82															
PEQC3					0.77															
PEYC4						0.859														
PEYC5						0.852														
PEYC6						0.778														
PERB8							0.810													
PERB10							0.753													
PERB12							0.739													
PHRTE3								0.837												
PHRTE4								0.829												
PHRTE5								0.812												
PHRTE7								0.797												
PHRER10									0.830											
PHRER11									0.736											
PHRER12									0.814											
PHRER13									0.748											
PHREP14									0.564											
PSDT1										0.647										
PSDT2										0.811										

PSDT3										0.778										
PSCC5											0.640									
PSCC6											0.812									
PSCC7											0.580									
PSSR8												0.796								
PSSR9												0.794								
PSSR10												0.768								
PSSR11												0.784								
PSSR12												0.769								
PSCS16													0.675							
PSCS17													0.725							
PSCS18													0.675							
PSCS19													0.649							
PCSC1														0.718						
PCSC2														0.670						
PCSC3														0.762						
PCSC4														0.673						
PCMSC1															0.553					
PCMSC2															0.679					
PCMSC3															0.589					
PCMSC5															0.720					
PCMSD7																0.675				
PCMSD8																0.639				
PCMSD10																0.533				
PCMMA12																	0.594			
PCMMA13																	0.665			
PCMMA15																	0.647			
PCMMA16																	0.697			
PCMOE20																		0.638		
PCMOE21																		0.711		
PCMOE22																		0.738		
PLELC3																			0.632	
PLELC4																			0.717	
PLELC5																			0.709	
PLELC6																			0.684	
PLELC7																			0.558	
PLELC8																			0.626	
PLETP10																				0.757
PLETP11																				0.651
PLETP12																				0.703

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 20 iterations.

F. APPENDIX: PROPOSED PORT IMPROVEMENT PLAN

In order to improve the logistics efficacy of Karachi Port by better container management, a broad framework leveraging prevailing seaport resources, covering technology, infrastructure, equipment, human resources, services, and charges, is needed. The subsequent strategic thought is proposed. Firstly, the incorporation of port technology, including Information Technology (IT) systems, Internet of Things (IoT) and Artificial Intelligence (AI), needs to be considered. This makes it essential to develop digital integration of Electronic Data Interchange (EDI) to speed up real-time data exchange between participants (seaport and vessel), improve coordination, and reduce delays. The amalgamation of major seaport equipment, other resources and customs with Terminal Operating Systems (TOS), to rationalize operations and reduce ships time in port. Computerization of gates will assist in curtailing dwell time and increasing seaport capacity and efficiency. Implementing AI to calculate projected cargo volumes and improve resource allocation. AI operated systems can improve traffic flow management and automate CT operations, resulting in increased efficiency and capacity. However, it can be costly to implement including trained HR.

Secondly, the infrastructure plays a key role in improving port efficiency. At the outset strategic decisions must be taken to enhance port capacity by upgrading the prevailing infrastructure to meet international specifications, focusing on chokepoints in freight clearance and carriage inside and outside the port. Improve the ground slots and examine compliance processes. Develop Karachi port resources and capacity. Implement strategies to manage and reduce congestion within port areas, such as improving traffic flow and coordination among port users and authorities. Upgrading Karachi port facilities (Dawn 26 July 2024). Depth of channel is increased to permit visits of larger ships. Karachi port capacity be enhanced by increasing ground slots and stack height. (KPT, 2024).

Thirdly, regarding the upgradation of Equipment, investment is required in remote-controlled cranes and Automated Guided Vehicles (AGVs) to enhance loading and unloading efficiency. The remote-controlled cranes in SAPT have improved terminal productivity. (The Express Tribune, 8 March 2024). A thorough maintenance schedule for existing equipment to ensure operational readiness, reliability and prolong asset life cycle be managed.

Fourthly, regarding capacity building of HR, regular training courses for port managers need to be conducted to improve skills for strategic planning, and stakeholder management, decision making, risk and crisis management, automated container handling methods, safety protocols, and use of IT to enhance productivity. Manage regular training sessions focused on advanced container handling techniques, safety protocols, and IT system usage to enhance workforce competency. Implement reward systems to motivate employees toward achieving efficiency targets and to maintain high service and safety standards.

Fifthly, for the Service Improvement, review customs clearance procedures to reduce delays. Integrating TOS with IT and EDI to facilitate efficient operations (The News, 6 Feb 2025). Offer round-the-clock services to accommodate global shipping schedules, reduce vessel waiting time, and ship turnaround time. The bottlenecks in the customs clearance process need to be improved. Various transportation services should be available for port users.

Sixthly, Charges should be periodically reviewed and adjusted. Port charges must remain competitive. The recent increase in port charges by KPT after two decades aims to address operational costs and infrastructure upgrades but may affect ship visit trends. Incentive discounts be introduced or rebates for high-volume clients, for off-peak hour operations or transshipment to balance workload, reduce congestion and enhance throughput.

Seventhly, Stakeholder Relationship must be improved by communication. Forums are established for constant dialogue between shipping lines, freight firms, trucking companies, railway officials, and regulatory bodies to address challenges and align operational improvements. Engage in PPPs to attract investment for infrastructure and technological advancements. Proposed $1 billion investment by Hutchison Port Holdings aims to upgrade port operations, enhance efficiency, and automation (Reuters, 28 Feb 2025).

Lastly, identify and examine KPIs, for example, berth occupancy rates, dwell times, and ship turnaround times, to assess operational efficiency. Implement systems to gather feedback from port users and stakeholders, facilitating continuous improvement and responsiveness to emerging challenges. All safety incidents must be reported, analyzed, and processed jointly by KPT and CTOs. Finalized outcomes should be circulated among stakeholders to avoid recurrence. The dock labour issue must be resolved to cut unnecessary costs and improve port efficiency. Non-custom cleared/stranded containers must be disposed of to regain available container yard stowage capacity. With the systematic implementation of the above framework, Karachi Port can improve its container management processes, leading to better logistics efficiency and a strengthened position in the global maritime industry.

Table: Related Interventions at Karachi Port Terminals (KGTL/KICT/SAPT)

Intervention	KGTL (Karachi Gateway Terminal Ltd)	SAPT (South Asia Pakistan Terminal)	KICT (Karachi International Container Terminal)
Aim	UAE commits $220 million to deepen berths for 13000 TEU ships, extend quay to 800m, & increase storage to 1 million TEU. (Business 2 Mar 2025)	Hutchison Ports plans to better logistics connectivity, digitization, infrastructure, dredging, and road network, leading to a regional hub (Business 2 Mar 2025)	Hutchison Ports commits $1 billion to improve logistics connectivity, road networks, and upgrade to an automated terminal (Business 2 Mar 2025)
Dredging & berth deepening	**Planned/Ongoing** Major dredging agreement (4 Sep 2025)	**Not planned.** Routine dredging to maintain the required depth.	**Not planned.** Major dredging by KGT. Berth structure is a concern
Equipment procurement/ modernization (cranes, RTGs, yard gear)	**Planned/Being implemented,** equipment upgrade commitments linked with KGTL investment.	**Partial** private terminals report modern equipment at some berths	**Plan** to upgrade quay cranes, rubber-tired gantry (RTG), electric trucks, and digitize gate operations. Also, training in port operations, management, and AI.
Digitalization/Port Community System (PCS)/TOS integration	**Planned** investments in PCS integration.	**Proposed** TOS and EDI at terminals; PCS integration across the port community.	**Proposed** terminal-level TOS exists; PCS implementation appears incomplete.
Automation/remote control equipment	**Planned/Proposed** automation cited in investment plans is likely to delay due to political instability).	**Planned/Proposed** proposals for automation exist; implementation is awaited.	**Planned/Partial** some automation at terminals claimed, yet full automation is not evident.
Yard & terminal operational improvements (layout, storage)	**Ongoing/Planned** yard expansion and quay/yard work are included in KGTL plans.	**Ongoing/Partial** terminal improvements are reported sporadically.	**Ongoing/Partial** yard and operational upgrades reported variably.
Organizational restructuring/HR reforms	**Planned** training and restructuring commitments	**Planned** training for the employees' capacity-building	**Scheduled** training and skill development programs

Note: Investment delays due to political instability and currency fluctuation.

G. APPENDIX: KPT REFERENCE INFORMATION

Figure: Karachi port aerial image. Source: Google Maps

Table. Karachi Port various cargo handled (2021 – 2023)

	2021-2022	2022-2023
Liquid cargo million tons (import cargo)	35.54 million tons	29.08 million tons
Liquid bulk cargo Import	14.07 million tons	10.29 million tons
Dry cargo million TEUs	2.21 million TEUs	1.93 million TEUs
Containers (import) TEUs	1.10 million TEUs	0.97 million TEUs
Export containers	1.11 million TEUs	0.97 million TEUs
Export cargo	16.17 million tons	12.78 million tons
Dry cargo Import and Export	36.64 million tons	30.63 million tons

Source: KPT Head Office

Containers and Ships handled at Karachi port container terminals

YEAR	Ships	EMPTY			LADEN			TOTAL			
		Import TEU	Export TEU	Total	Import TEU	Export TEU	Total	Import TEU	Export TEU	Total	US$ (mil)
P I C T:											
2012-13	456	39,182	81,545	120,727	356,869	213,951	570,820	305,051	295,496	600,547	.0m
2013-14	451	44,168	93,650	137,818	316,505	231,317	547,822	360,673	324,967	685,640	
2014-15	400	36,407	130,241	166,648	367,667	212,868	580,535	404,074	343,109	747,183	
2015-16	360	32,435	177,833	210,268	412,378	220,218	632,596	444,813	398,051	842,864	
2016-17	326	20,432	166,896	187,328	409,137	219,142	628,279	429,569	386,038	815,607	
2017-18	302	25,884	159,249	185,133	336,771	195,481	532,252	362,655	354,730	717,385	
2018-19	194	28,413	111,989	140,402	236,394	197,324	433,718	264,807	309,313	574,120	
2019-20	194	35,848	91,245	127,093	220,154	199,397	419,551	256,002	290,642	546,644	
2020-21	255	32,948	167,419	200,367	300,437	199,549	499,986	333,985	366,968	700,953	
2021-22	222	28,206	150,800	179,006	294,337	197,152	491,489	322,543	347,952	670,495	
2022-23	156	19,434	108,270	127,704	231,306	146,639	377,945	250,740	254,909	505,649	
2023-24		9,266	28,740	38,006	70,620	51,306	121,926	79,886	80,045	159,931	
K I C T:											
2012-13	325	17,135	194,252	211,387	435,872	253,185	689,057	453,007	447,437	900,444	
2013-14	309	10,065	226,389	236,454	431,767	220,727	652,494	441,932	447,116	889,048	
2014-15	347	10,309	274,956	285,265	469,356	200,447	669,803	479,665	475,403	955,068	
2015-16	345	9,192	357,117	366,309	543,390	188,021	731,411	552,582	544,138	1,096,720	
2016-17	247	8,890	358,829	367,719	503,466	139,232	642,698	512,356	498,061	1,010,417	
2017-18	246	14,051	325,202	339,253	398,045	138,563	536,608	412,096	463,765	875,861	
2018-19	224	21,841	219,128	240,969	337,993	114,748	452,741	359,834	333,876	693,710	
2019-20	295	20,455	149,771	170,226	273,727	103,867	377,594	294,182	253,638	547,820	
2020-21	316	24,690	167,196	191,886	342,570	150,642	493,212	367,260	317,838	685,098	
2021-22	348	21,085	167,046	188,131	349,661	170,662	520,323	370,746	337,708	708,454	
2022-23	293	18,762	141,325	160,087	298,941	137,834	436,775	317,703	279,159	596,862	
2023-24		12,721	40,497	53,218	118,131	63,252	181,383	130,852	103,749	234,601	
SAPTL:											
2012-13											
2013-14											
2014-15											
2015-16										**6503**	
2016-17	275	3,287	89,522	92,809	122,408	49,160	171,568	125,695	138,682	264,377	
2017-18	329	2,677	148,188	150,865	331,956	158,034	489,990	334,633	306,222	640,855	
2018-19	291	9,704	254,666	264,370	423,767	186,273	610,040	433,471	440,939	874,410	

2019-20	279	12,606	233,187	245,793	424,054	201,431	625,485	436,660	434,618	871,278	
2020-21	285	12,490	242,250	254,740	435,060	208,758	643,818	447,550	451,008	898,558	
2021-22	293	8,108	186,434	194,542	386,190	237,171	623,361	394,298	423,605	817,903	
2022-23	419	11,114	213,881	224,995	282,075	213,334	495,409	393,189	427,215	820,404	
2023-24		10,775	60,720	71,495	157,998	111,807	269,805	168,773	172,527	341,300	
	Karachi Port Total TEUs handled										
Year	Ships					KPT TEU	Total Karachi port TEU	Import TEU	Export TEU	Total CT TEU	
2012-13								802776	776646	1579422	
2013-14	817						1,590,779	835258	803037	1638305	
2014-15	790						1,724,213	951718	877595	1829313	
2015-16	738						1,956,368	1020663	964389	1985052	
2016-17	757						2,108,516	1116583	1132084	2248667	
2017-18	973						2,251,694	1097995	1100653	2198648	
2018-19	777						2,161,352	1045797	1052058	2097855	
2019-20	743						1,992,153	1054785	1025214	2079999	
2020-21	869						2,297,722	1155106	1179934	2335040	
2021-22	861						2,205,220	1047076	1038558	2085634	
2022-23	758						1,931,854	929826	925731	1855557	
2023-24	877						2,277,000	1068135	1030606	2098741	

STATEMENT KARACHI PORT OPERATIONS DURING LAST TEN YEARS FROM 2013 - 14 TO 2022 - 23 (JULY - APRIL)

TYPE OF CARGO	2013 - 14	2014 - 15	2015 - 16	2016 - 17	2017 - 18	2018 - 19	2019 - 20	2020 - 21	2021 - 22	2022 - 23 (JULY-APR)	
	Imports										
Dry General Cargo	12,641,112	14,503,854	18,069,802	18,575,451	18,530,499	16,551,559	15,358,308	18,170,647	17,456,409	13,034,238	
Dry Bulk Cargo	5,994,959	6,353,471	8,122,023	10,058,530	9,116,137	3,399,783	2,711,061	6,499,704	4,016,302	2,871,903	
Dry Cargo	18,636,071	20,857,325	26,191,825	28,633,981	27,646,636	19,951,342	18,069,369	24,670,351	21,472,711	15,906,141	
Liquid Bulk rgo	11,706,849	12,142,748	14,067,103	14,003,912	14,022,722	12,911,280	9,136,955	11,799,149	14,067,121	8,593,426	
Total	30,342,920	33,000,073	40,258,928	42,637,893	41,669,358	32,862,622	27,206,324	36,469,500	35,539,832	24,499,567	
	Exports										
Dry Cargo	8,324,222	7,206,036	7,429,036	7,490,122	9,334,955	8,889,922	8,841,112	9,689,498	11,032,419	7,314,427	
Dry Bulk	1,281,902	1,609,041	973,393	1,049,455	2,173,557	3,903,042	5,130,221	5,583,661	4,134,777	2,155,659	
Dry Cargo	9,606,124	8,815,077	8,402,429	8,539,577	11,508,512	12,792,964	13,971,333	15,273,159	15,167,196	9,470,086	
Liquid go	1,400,923	1,607,007	1,383,769	1,316,010	1,507,740	1,237,870	662,799	537,216	1,001,618	752,883	
Total	11,007,047	10,422,084	9,786,198	9,855,587	13,016,252	14,030,834	14,634,132	15,810,375	16,168,814	10,222,969	
	Total Imports & Exports										
Dry Cargo	20,965,334	21,709,890	25,498,838	26,065,573	27,865,454	25,441,481	24,199,420	27,860,145	28,488,828	20,348,665	
Dry Bulk	7,276,861	7,962,512	9,095,416	11,107,985	11,289,694	7,302,825	7,841,282	12,083,365	8,151,079	5,027,562	
Dry Cargo	28,242,195	29,672,402	34,594,254	37,173,558	39,155,148	32,744,306	32,040,702	39,943,510	36,639,907	25,376,227	
Liquid go	13,107,772	13,749,755	15,450,872	15,319,922	15,530,462	14,149,150	9,799,754	12,336,365	15,068,739	9,346,309	
Grand	41,349,967	43,422,157	50,045,126	52,493,480	54,685,610	46,893,456	41,840,456	52,279,875	51,708,646	34,722,536	
	CONTAINER HANDLING										
Import	810,553	896,159	1,005,665	1,077,061	1,118,261	1,067,984	1,000,942	1,155,360	1,092,189	793,631	
Export	780,226	828,054	950,703	1,031,455	1,133,433	1,093,368	991,211	1,142,362	1,113,031	807,223	
T o t a l	1,590,779	1,724,213	1,956,368	2,108,516	2,251,694	2,161,352	1,992,153	2,297,722	2,205,220	1,600,854	
	SHIP HANDLING										
Container	817	790	738	757	973	777	743	869	861	758	
Bulk Cargo Ships	172	193	222	244	244	144	162	281	233	136	
Gen. Cargo Ships	229	255	374	379	334	226	173	169	211	141	
Oil Tankers	456	494	559	541	577	504	414	494	526	339	
Total	1,674	1,732	1,893	1,921	2,128	1,651	1,492	1,813	1,831	1,374	

H. APPENDIX: PORT HANDLING CHARGES CONSOLIDATED DATA

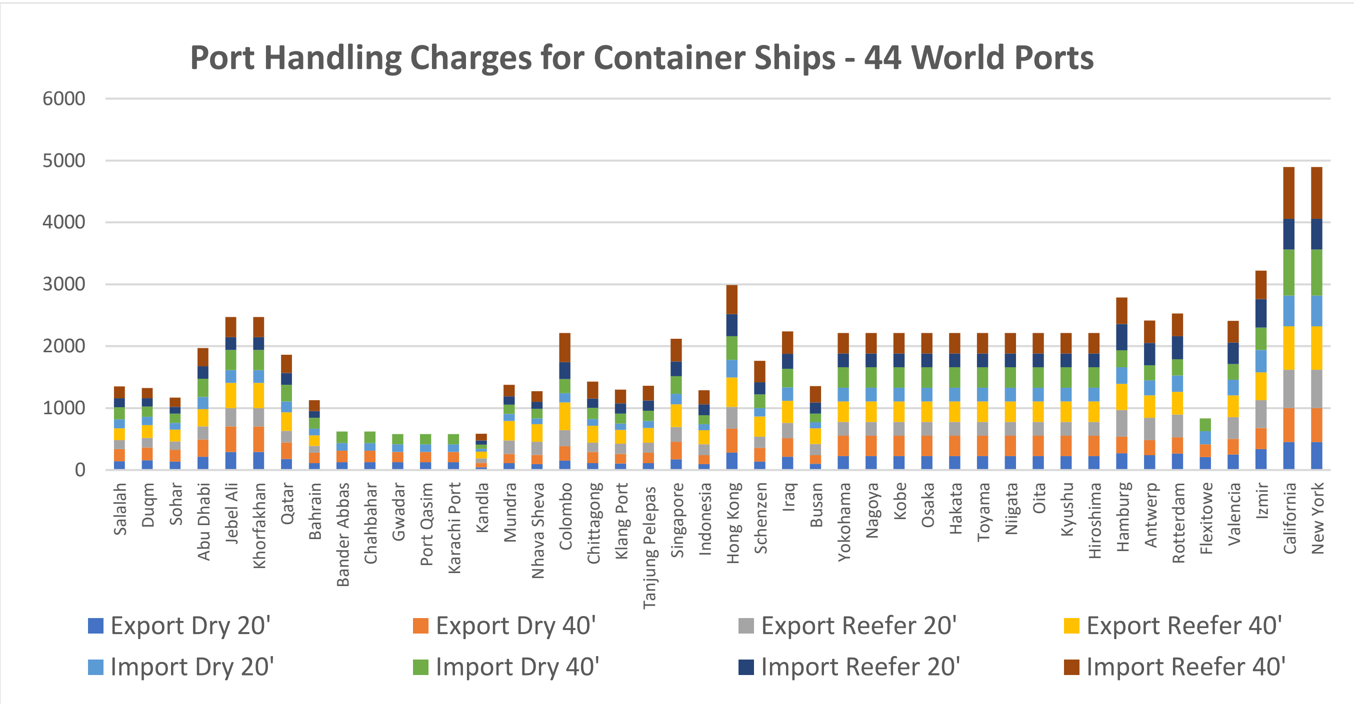
Port Handling Charges – 44 World Ports (Asia, Europe and America)

Port Name	Currency	Export				Import			
		Dry		Reefer		Dry		Reefer	
		20'	40'	20'	40'	20'	40'	20'	40'
Salalah	USD	143	195	55	75	55	75	55	75
Duqm	USD	156	208	60	80	50	65	50	65
Sohar	USD	137	190	137	190	109	150	109	150
Abu Dhabi	USD	212	279	212	279	198	296	198	296
Jebel Ali	USD	294	410	294	410	208	324	208	324
Khorfakhan	USD	294	410	294	410	208	324	208	324
Qatar	USD	176	270	189	297	176	270	189	297
Bahrain	USD	111	169	111	169	111	172	111	172
Bander Abbas	USD	124	186	-	-	124	186	-	-
Chahbahar	USD	124	186	-	-	124	186	-	-
Gwadar	USD	125	165	175	260	125	165	175	260
Port Qasim	USD	125	165	175	260	125	165	175	260
Karachi	USD	125	165	175	260	125	165	175	260
Kandla	USD	45	70	71	110	45	70	68	105
Mundra	USD	111	151	215	317	111	151	133	190
Nhava Sheva	USD	93	152	210	287	93	152	116	172
Colombo	USD	150	232	260	448	150	232	270	473
Chittagong	USD	110	180	150	275	110	180	150	275
Klang Por	USD	103	157	165	225	104	157	165	225
Tanjung Pelepas	USD	111	168	163	239	111	168	163	239
Singapore	USD	175	281	312	481	230	370	312	481
Indonesia	USD	95	145	175	230	95	145	175	230
Hongkong	USD	282	385	354	474	282	385	354	474
Shenzhen	USD	136	221	184	322	136	221	198	346
Iraq	USD	215	300	245	360	215	300	245	360
Busan	USD	100	140	180	252	100	140	180	264
Yokohama	USD	223	331	223	331	223	331	223	331
Nagoya	USD	223	331	223	331	223	331	223	331
Kobe	USD	223	331	223	331	223	331	223	331
Osaka	USD	223	331	223	331	223	331	223	331
Hakata	USD	223	331	223	331	223	331	223	331
Toyama	USD	223	331	223	331	223	331	223	331
Niigata	USD	223	331	223	331	223	331	223	331
Oita	USD	223	331	223	331	223	331	223	331
Kyushu	USD	223	331	223	331	223	331	223	331
Hiroshima	USD	223	331	223	331	223	331	223	331
Hamburg	USD	269	269	428	428	269	269	428	428
Antwerp	USD	242	242	362	362	242	242	362	362
Rotterdam	USD	264	264	368	368	264	264	368	368

Felixstowe	USD	209	209	-	-	209	209	-	-
Valencia	USD	252	252	351	351	252	252	351	351
Izmir	USD	340	340	450	450	360	360	460	460
California	USD	450	550	620	700	500	740	500	835
New York	USD	450	550	620	700	500	740	500	835

Port name	**Web link**
Salalah	https://www.cma-cgm.com/news/4191/thc-update-oman-import-export
Duqm	https://www.cma-cgm.com/news/4191/thc-update-oman-import-export
Sohar	https://www.cma-cgm.com/news/4191/thc-update-oman-import-export
Abu Dhabi	https://www.cma-cgm.com/news/3992/thc-update-abu-dhabi-u-a-e-import-export
Jebel Ali	https://www.cma-cgm.com/static/AE/attachments/Import%20Local%20Charge%20-%20Dubai%2027022019.pdf
Khorfakhan	https://www.cma-cgm.com/static/AE/attachments/Import%20Local%20Charge%20-%20Dubai%2027022019.pdf
Qatar	https://www.oocl.com/middleeast/eng/localinformation/localsurcharges/qatar/Pages/default.aspx
Bahrain	https://www.oocl.com/middleeast/eng/localinformation/localsurcharges/bahrain/Pages/default.aspx
Bander Abbas	https://www.starmarine.net/wp-content/uploads/2023/05/The-Local-Charges-that-should-be-collected-from-Cnees-1.pdf
Chahbahar	https://www.starmarine.net/wp-content/uploads/2023/05/The-Local-Charges-that-should-be-collected-from-Cnees-1.pdf
Gwadar	https://www.cma-cgm.com/news/3467/thc-update-pakistan-import-export
Port Qasim	https://www.cma-cgm.com/news/3467/thc-update-pakistan-import-export
Karachi	https://www.cma-cgm.com/news/3467/thc-update-pakistan-import-export
Kandla	https://www.cma-cgm.com/static/IN/Attachments/THC%20Tariffs%20-%20Effective%201st%20January%202023.pdf
Mundra	https://www.cma-cgm.com/static/IN/Attachments/THC%20Tariffs%20-%20Effective%201st%20January%202023.pdf
Nhava Sheva	https://www.cma-cgm.com/static/IN/Attachments/THC%20Tariffs%20-%20Effective%201st%20January%202023.pdf
Colombo	https://www.maersk.com/news/articles/2023/04/21/terminal-handling-service-ohc-dhc-sri-lanka-to-from-world
Chittagong	https://www.cma-cgm.com/news/2949/thc-update-bangladesh-import-export
Klang	https://www.cnc-line.com/static/MY/attachments/MALAYSIA%20ANCILLARY%20CHARGES%20-%20IMPORT%20(28.3.2022).pdf
Tanjung Pelepas	https://www.cnc-line.com/static/MY/attachments/MALAYSIA%20ANCILLARY%20CHARGES%20-%20IMPORT%20(28.3.2022).pdf
Singapore	https://www.oocl.com/singapore/eng/localinformation/localnews/2022/Pages/Singapore_THC.aspx
Indonesia	https://www.oocl.com/indonesia/eng/localinformation/localsurcharges/Pages/default.aspx
Hongkong	https://www.cnc-line.com/static/HK/attachments/HONG%20KONG%20-%20LOCAL%20SCES.pdf%200405.pdf
Shenzhen	https://www.oocl.com/china/eng/localinformation/localsurcharges/shenzhen/Pages/default.aspx
Iraq	https://www.oocl.com/middleeast/eng/localinformation/localsurcharges/iraq/Pages/default.aspx?site=middleeast&lang=eng
Busan	https://www.cma-cgm.com/news/2987/thc-update-south-korea-import-export
Yokohama	Mr. Shiraz, NVOCC
Nagoya	
Kobe	
Osaka	
Hakata	
Toyama	

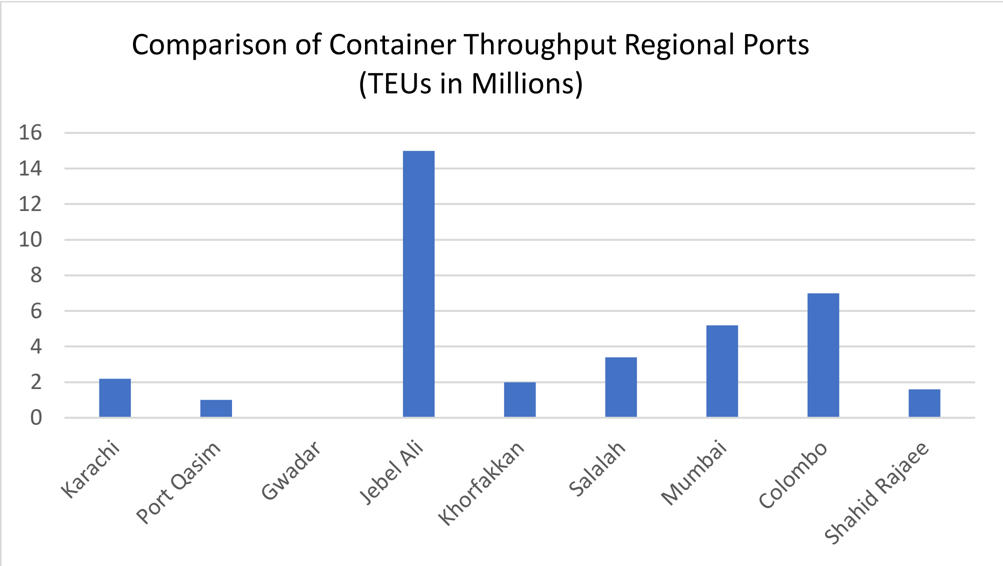
Niigata	
Oita	
Kyushu	
Hiroshima	
Hamburg	https://www.cma-cgm.com/local/slovakia/news/58/new-terminal-handling-charges-thc-and-terminal-security-fee-isps-
Antwerp	https://www.cma-cgm.com/local/belgium/news/833/update-thc-local-charges-belgium-import-export-01-01-2022
Rotterdam	https://www.oocl.com/netherlands/eng/localinformation/localsurcharges/Pages/Local%20Port%20Charges%20Netherlands.aspx
Felixstowe	https://www.cma-cgm.com/news/4014/thc-update-uk-import-export
Valencia	https://www.maersk.com/news/articles/2021/02/02/ths-ohc-dhc-odf-ddf-pae-pai-mhe-mhi-world-to-from-spain
Izmir	https://www.maersk.com/news/articles/2021/03/08/ths-ohc-dhc-turkey-to-from-world
California	https://www.hapaglloyd.com/content/dam/website/downloads/detention_demurrage/Terminal_Handling_Charges_North_America.pdf
New York	https://www.hapaglloyd.com/content/dam/website/downloads/detention_demurrage/Terminal_Handling_Charges_North_America.pdf

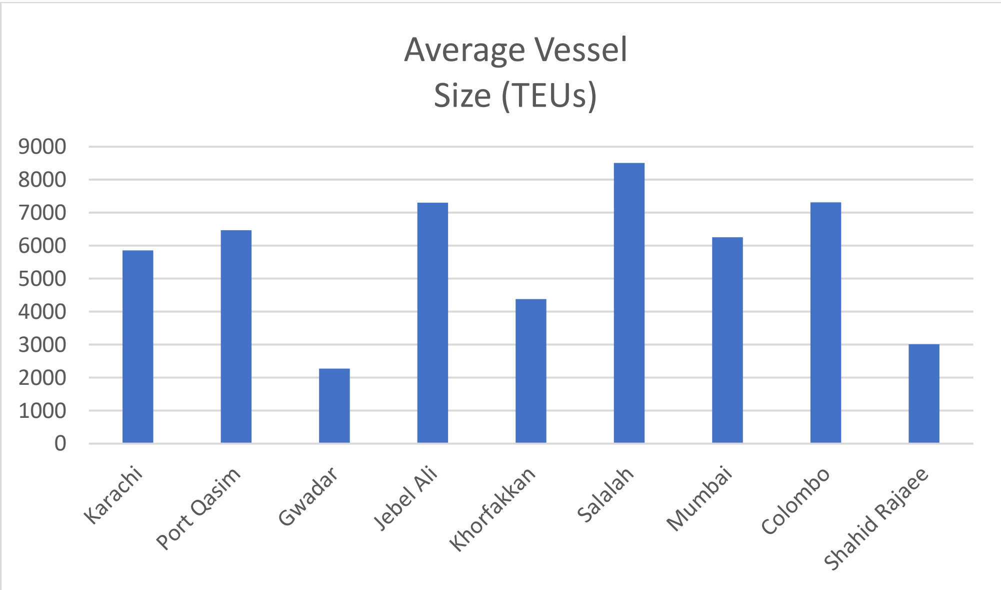


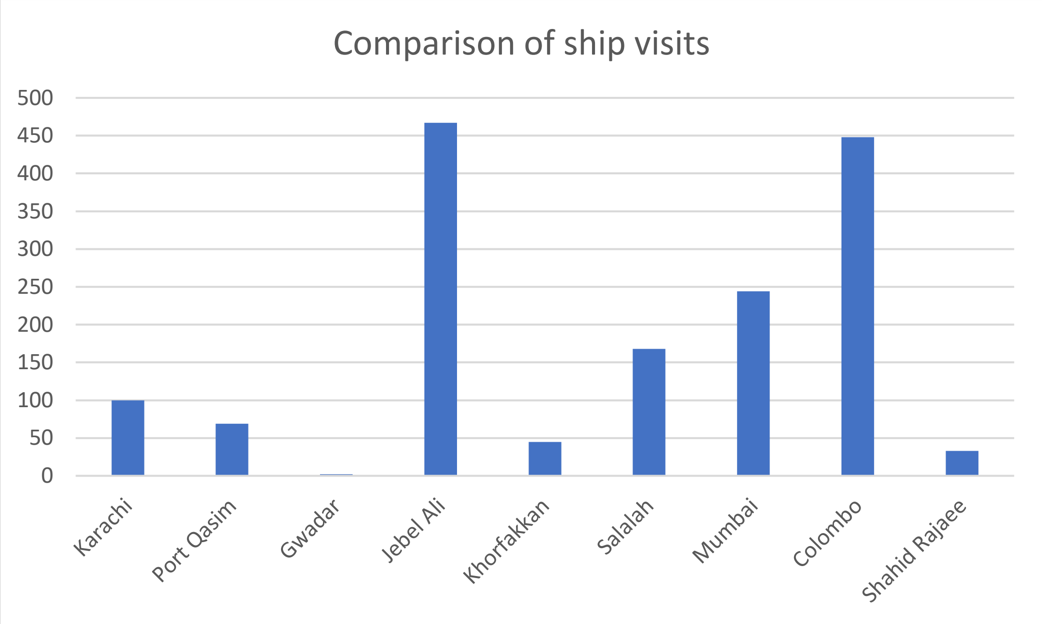
Container Throughput Comparison with Regional Ports

Seaport	Container Throughput (TEUs in M)	Number of Vessels	Fleet Capacity Deployed (TEUs)	Average Vessel Size (TEUs)	Shipping Services
Karachi	2.2	100	585,000	5,853	20
Port Qasim	1	69	446,000	6,468	11
Gwadar	0	2	4,500	2,272	1
Jebel Ali	15	467	3,410,000	7,301	105

Khorfakhan	2	45	197,000	4,381	13
Salalah	3.4	168	1,430,000	8,510	24
Mumbai	5.2	244	1,526,000	6,254	42
Colombo	7	448	3,278,000	7,316	70
Shahid Rajaee	1.6	33	99,000	3,009	12



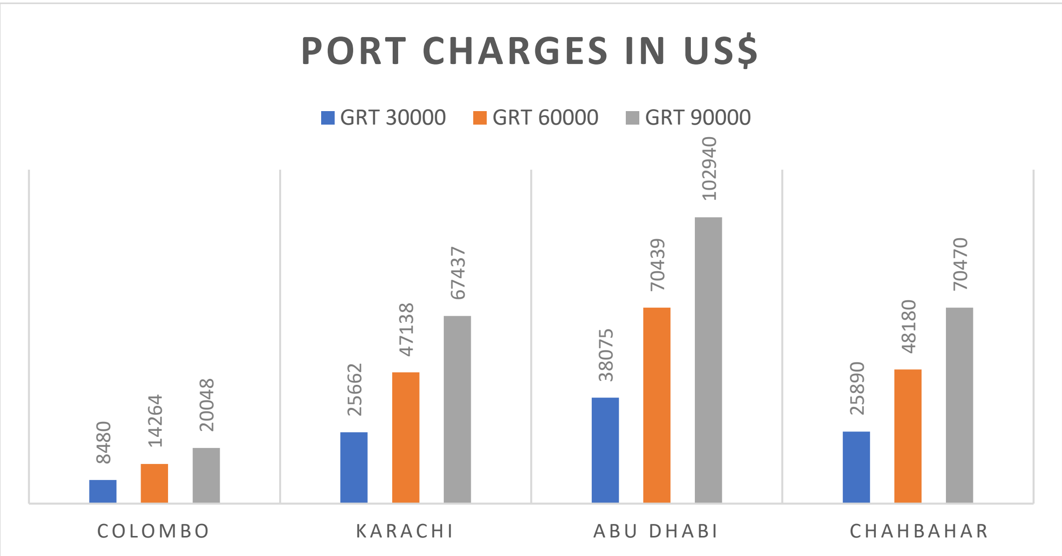




During a two-month period in 2020

Port charges in US$

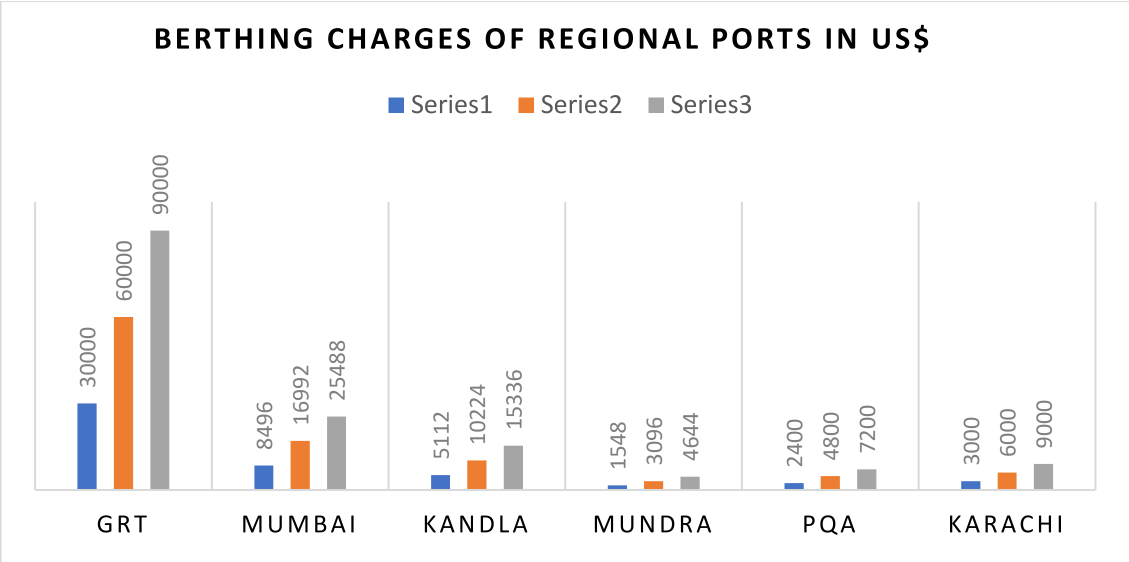
	GRT	GRT	GRT
Port	30000	60000	90000
Colombo	8480	14264	20048
Karachi	25662	47138	67437
Abu Dhabi	38075	70439	102940
Chahbahar	25890	48180	70470



Above chart shows port charges for regional ports.

BERTHING/ CHARGES OF REGIONAL PORTS

GRT	MUMBAI	KANDLA	MUNDRA	PQA	KARACHI
30000	8496	5112	1548	2400	3000
60000	16992	10224	3096	4800	6000
90000	25488	15336	4644	7200	9000



Above chart shows a comparison of berthing charges for regional ports in US$ per day

I. APPENDIX: ANALYSIS OF KARACHI PORT PRODUCTIVITY

In this section, the performance of Karachi port is compared with 25 world ports. The aim is to find the productivity of ports related to four important factors and then determine the results to compare the ranking of Karachi port with other ports. Hereafter, the ranking of Karachi port is compared with each factor of the other ports, and subsequently with all the factors cumulatively. First, the statistical data relating to key port productivity factors was collected from the published literature, such as annual throughput, quay crane, yard crane, quay length in meters, and yard storage area in hectares. Then the yearly productivity of each key factor was compiled in Table I-1. Thereafter, the productivity values were calculated by dividing the throughput of each port by the number of quay cranes, yard cranes, quay length in meters, and yard area in hectares. After obtaining the yearly productivity values of all four factors for individual ports, the relative ranking for each port was determined by comparison, as shown in the Table below.

Table I-1. Comparison of Karachi container port productivity with selected world ports

Port	Annual Throughput Million TEU 2023	QC	TEU/QC	Ranking TEU/QC	Yard Crane	TEU/YC	Ranking TEU/YC	Berth Length (m)	TEU/m	Ranking TEU/m	Yard Area in (ha)	TEU/ha	Ranking TEU/HA
Bin Qasim	0.85	11	77,272	20	37	22,973	22	1,312	648	17	24	35,417	12
Colombo Port	6.95	47	147,872	13	138	50,362	15	4,000	1,738	9	-	-	N/A
Karachi,	2.28	33	69,091	22	99	23,030	21	3,063	744	15	132	17,273	20
Singapore	39	204	191,176	8	200	95,000	1	18,276	2,134	5	740	52,703	4
Shenzhen, China	29.88	144	207,500	6	200	49,400	5	13,618	2,194	4	575	51,965	5
Hamburg, Germany	7.7	81	95,062	18	100	77,000	9	7,540	1,021	12	430	17,907	18
Mundra India	6.64	75	88,533	19	45	47,555	6	2,100	3,162	3	315	21,079	16
Busan Korea	23.15	130	178,076	9	408	56,740	12	13,073	1,771	8	387	59,819	2
Salalah	3.3	27	122,222	15	36	91,667	8	2,197	1,502	11	88	51,136	7
Jebel Ali	15.5	98	158,163	12	89	74,157	3	25,000	579	19	181	18,232	17
Jeddah	4.96	35	206,667	7	111	44,685	16	11,200	443	20	120	41,333	9
Sohar	0.818	13	62,923	23	14	58,428	11	1,140	717	16	70	11,686	23
Klang, Malaysia	13.85	97	142,783	14	324	42,747	17	8,615	1,608	10	120	115,417	1
Tanjung Pelepas, Malaysia	10.48	64	163,750	11	58	80,690	2	5,040	2,079	6	180	58,222	3
Johor, Malaysia	0.603	8	75,375	21	26	23,192	20	730	826	14	25	24,120	14
Rotterdam	13.8	55	250,909	3	116	18,965	7	1,985	6,750	1	1050	12,762	22
Izmir, Turkey	0.262	5	52,400	24	19	13,789	23	1,050	250	24	15	17,467	19
Tokyo, Japan	4.57	40	114,250	16	-		N/A	4,500	1,016	13	27.5	16,618	21

Mumbai	0.6	-		N/A	-		N/A	4,000	150	25	27.5	21,583	15
Valencia, Spain	4.8	20	240,000	4	28	71,428	4	12,000	400	22	122	39,344	11
Barcelona, Spain	3.3	13	253,846	2	54	61,111	10	23,000	143	26	80	41,250	10
Los Angles, USA	8.6	82	104,878	17	-		N/A	31,000	277	23	3035	2834	24
Kuching, Malaysia	0.274	6	45,667	25	11	24,909	19	635	433	21	-	-	N/A
Le Harve, France	2.63	11	239,091	5	68	38,676	18	4,200	626	18	107	24,579	13
Antwerp, Belgium	12.5	38	328,947	1	228	54,825	13	3,680	3397	2	242	51,653	6
Hong Kong	13.69	78	175,513	10	264	51,856	14	7,402	1849	7	279	49,068	8

Source: Author with literature support; Port websites.

Based on a comprehensive analysis of four key efficiency metrics (Quay Crane Productivity, Yard Crane Productivity, Berth Utilization, and Yard Area Utilization), the overall performance ranking of the 26 ports is ranked as per composite score (0-1 scale) across all performance metrics:

Overall Performance Ranking (Composite Score)

Rank	Port	Composite Score	Key Strengths
1	**Singapore**	0.8545	#1 in Yard Crane Efficiency, top-5 in others
2	**Shenzhen, China**	0.8290	Balanced top-5 rankings across all metrics
3	**Tanjung Pelepas, Malaysia**	0.8127	#2 in Yard Crane Efficiency, top-3 in Yard Density
4	**Antwerp, Belgium**	0.7993	#1 in Quay Crane Efficiency, #2 in Berth Utilization
5	**Busan, Korea**	0.7108	#2 in Yard Density, strong berth utilization
6	**Rotterdam, Netherlands**	0.6828	#1 in Berth Utilization, excellent QC efficiency
7	**Hong Kong**	0.6225	Consistent top-10 rankings across all categories
8	**Valencia, Spain**	0.6160	Excellent QC and YC efficiency (both rank #4)
9	**Salalah, Oman**	0.6094	Strong YC efficiency and yard density
10	**Klang, Malaysia**	0.5928	#1 in Yard Density (115,417 TEU/ha)
11	**Mundra, India**	0.5726	#3 in Berth Utilization, good YC efficiency

Rank	Port	Composite Score	Key Strengths
12	**Barcelona, Spain**	0.5395	#2 in QC efficiency but poor berth utilization
13	**Jebel Ali, UAE**	0.5088	#3 in YC efficiency but low berth utilization
14	**Jeddah, Saudi Arabia**	0.4901	Good QC efficiency, moderate in others
15	**Le Harve, France**	0.4647	Good QC efficiency, moderate overall
16	**Hamburg, Germany**	0.4373	Moderate rankings across metrics
17	**Colombo Port**	0.3859	Good berth utilization but missing yard data
18	**Johor, Malaysia**	0.3045	Moderate rankings, no standout metrics
19	**Bin Qasim, Pakistan**	0.2839	Low rankings across metrics
20	**Sohar, Oman**	0.2681	Low QC efficiency and yard density
21	**Tokyo, Japan**	0.2564	Missing YC data, moderate in others
22	**Karachi, Pakistan**	0.2072	Low rankings across all metrics
23	**Los Angeles, USA**	0.1133	Missing YC data, poor yard density
24	**Mumbai, India**	0.1078	Missing QC/YC data, poor berth utilization
25	**Kuching, Malaysia**	0.0955	Missing yard data, low QC efficiency
26	**Izmir, Turkey**	0.0848	Consistently bottom rankings across metrics

In the second step, port productivity has been compared by summarizing the inputs by only presenting the highest, lowest and average productivity values of ports in Table 5.3. In addition, the productivity values for Karachi port have also been endorsed for comparison with the average values of other ports. Moreover, the Industrial Benchmark of each important productivity factor from the literature has also been listed in Table 5.3 for comparison with Karachi port. The productivity ranking of all 25 ports is shown for each factor in Table 5.2. The ranking for Karachi port is generally on the lower side, for example, for Quay Crane it was 22, for Yard Crane it was 21, for TEU per Quay meter it was 15, and for storage yard per hectares was 20. This shows that Karachi port's average productivity ranking is 19.5 (say 20) among the 25 considered ports.

Karachi port productivity ranking $= \frac{QC + YC + Quay\ length + Yard\ area}{4}$

$= \frac{22 + 21 + 15 + 20}{4} = \frac{78}{4} = 19.5$ out of 25

Table I-2: Comparison of selected container ports with Karachi port

Source: Author with literature support; Port websites

PICT – TEU handled from 2012 to 2024

Year	Import TEU	Export TEU	Total
2012-13	396,051.00	295,496.00	691,547.00
2013-14	360,673.00	324,967.00	685,640.00
2014-15	404,074.00	343,109.00	747,183.00
2015-16	444,813.00	398,051.00	842,864.00
2016-17	429,569.00	386,038.00	815,607.00
2017-18	362,655.00	354,730.00	717,385.00
2018-19	264,807.00	309,313.00	574,120.00
2019-20	256,002.00	290,642.00	546,644.00
2020-21	333,385.00	366,968.00	700,353.00
2021-22	322,543.00	347,952.00	670,495.00
2022-23	250,740.00	254,909.00	505,649.00
2023-24	79,886.00	80,046.00	415,158.00

KICT – TEU handled 2012 to 2024

Year	Import TEU	Export TEU	Total
2012-13	453,007	447,437	900,444
2013-14	441,832	447,116	888,948
2014-15	479,665	475,403	955,068
2015-16	552,582	545,138	1,097,720
2016-17	512,356	498,061	1,010,417
2017-18	412,096	463,765	875,861
2018-19	359,834	333,876	693,710
2019-20	294,182	253,638	547,820
2020-21	367,260	317,838	685,098
2021-22	370,746	337,708	708,454
2022-23	317,703	279,159	596,862
2023-24	381,172	300,029	681,201

Productivity						
TEU/scale/year	**Highest**	**Lowest**	**Karachi/ Ranking**	**Average**	**Industry Benchmark TEU/scale/year**	**References**
TEU/QC/year	328,947	45,667	69,091 /22	151,679	Traditional 115,000 – 125,000 Automatic 160,000	Drewry 2014. (Elentably, 2015)
TEU/YC/year	195,000	13,789	23,030 /21	81,443	60,000 to 70,000	Stoilova & Martinov, 2019
TEU/m of Quay/year	6,750	143	744 /15	1,402	1,000-1072 TEU/m of Quay	Drewry 2014. (Elentably, 2015)
Yard Area Ha	3035	15	20	349	240-300 TEU/Ha	Monfort et al. 2011

SAPT – TEU handled 2012 to 2024

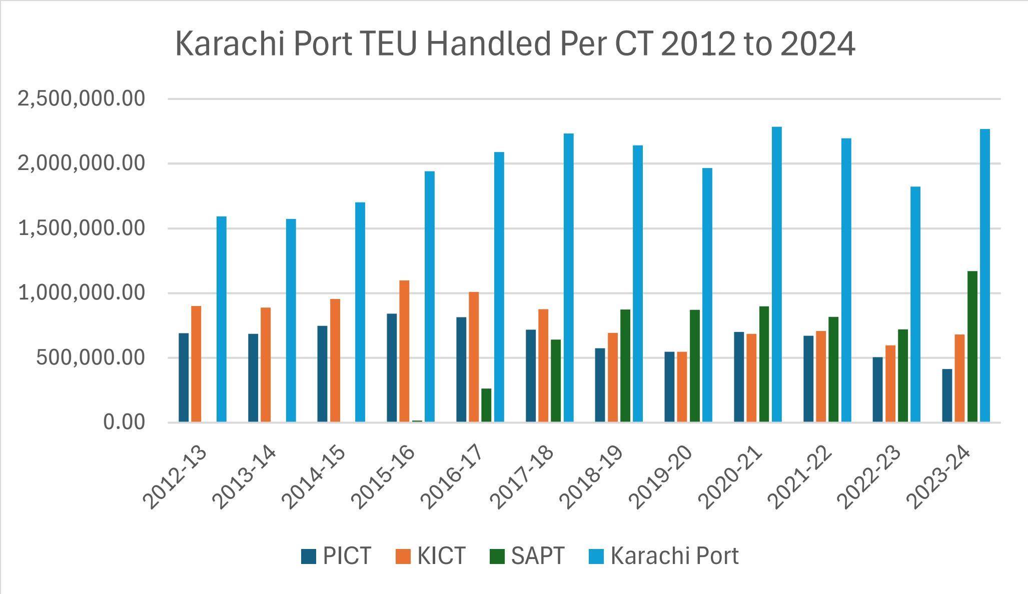
Year	Import TEU	Export TEU	Total
2015-16			6,503
2016-17	125,695	138,682	264,377
2017-18	334,633	306,222	640,855
2018-19	433,471	440,939	874,410
2019-20	436,660	434,618	871,278
2020-21	447,550	451,008	898,558
2021-22	394,298	423,605	817,903
2022-23	293,189	427,215	720,404
2023-24	608,938	562,097	1,171,035

Karachi Port – TEU handled 2012 to 2024

Year	Import TEU	Export TEU	Total
2012-13	849,058	742,933	1,591,991
2013-14	802,505	772,083	1,574,588
2014-15	883,739	818,512	1,702,251
2015-16	997,395	943,189	1,940,584
2016-17	1,067,620	1,022,781	2,090,401
2017-18	1,109,384	1,124,717	2,234,101
2018-19	1,058,112	1,084,128	2,142,240
2019-20	986,844	978,898	1,965,742
2020-21	1,148,195	1,135,814	2,284,009
2021-22	1,087,587	1,109,265	2,196,852
2022-23	861,632	961,283	1,822,915
2023-24	1,210,836	1,056,380	2,267,216

Karachi port - TEU handled 2012 to 2024

Year	PICT	KICT	SAPT	Karachi Port
2012-13	691,547.00	900,444		1,591,991
2013-14	685,640.00	888,948		1,574,588
2014-15	747,183.00	955,068		1,702,251
2015-16	842,864.00	1,097,720	16,503	1,940,584
2016-17	815,607.00	1,010,417	264,377	2,090,401
2017-18	717,385.00	875,861	640,855	2,234,101
2018-19	574,120.00	693,710	874,410	2,142,240
2019-20	546,644.00	547,820	871,278	1,965,742
2020-21	700,353.00	685,098	898,558	2,284,009
2021-22	670,495.00	708,454	817,903	2,196,852
2022-23	505,649.00	596,862	720,404	1,822,915
2023-24	415,158.00	681,201	1,171,035	2,267,216



PICT charges

Year	KPT share @$15/TEU millions of $	KDLB @$ 5 /TEU millions of $	TEU handling charges 125/TEU millions of $	TEU handling charges millions of $	Total TEU
2012-13	**10.37**	**3.46**	72.61	86.44	691,547.00
2013-14	**10.28**	**3.43**	71.99	85.71	685,640.00
2014-15	**11.21**	**3.74**	78.45	93.40	747,183.00
2015-16	**12.64**	**4.21**	88.50	105.36	842,864.00
2016-17	**12.23**	**4.08**	85.64	101.95	815,607.00
2017-18	**10.76**	**3.59**	75.33	89.67	717,385.00
2018-19	**8.61**	**2.87**	60.28	71.77	574,120.00
2019-20	**8.20**	**2.73**	57.40	68.33	546,644.00
2020-21	**10.51**	**3.50**	73.54	87.54	700,353.00
2021-22	**10.06**	**3.35**	70.40	83.81	670,495.00
2022-23	**7.58**	**2.53**	53.09	63.21	505,649.00
2023-24	**6.23**	**2.08**	43.59	51.89	415,158.00

KICT Charges

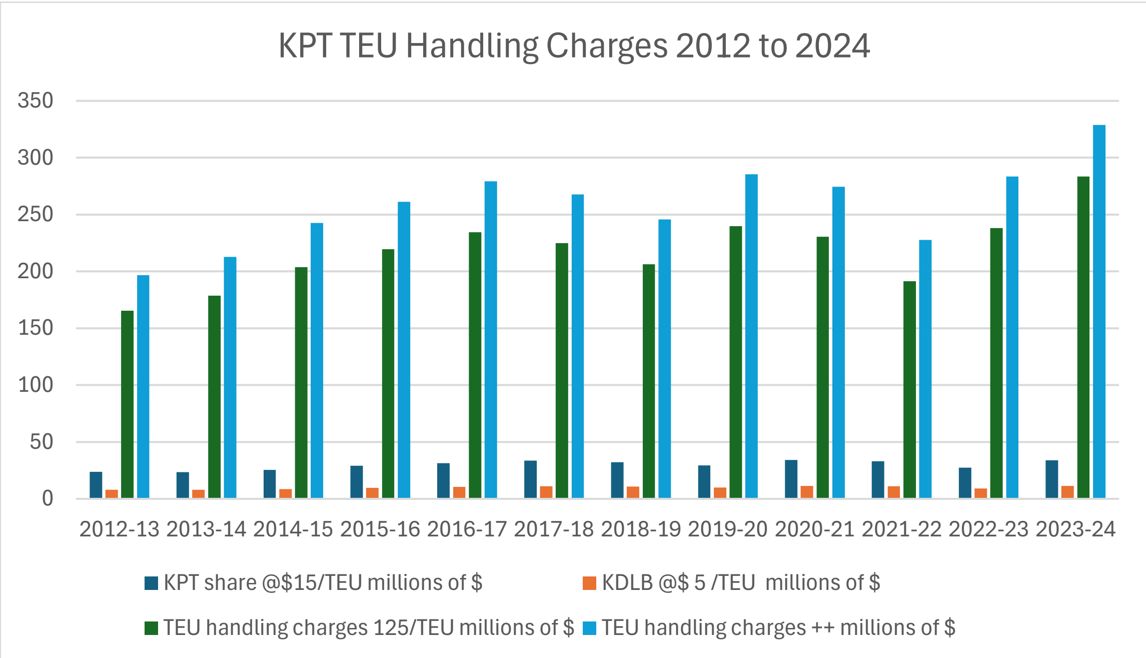
Year	KPT share @$15/TEU millions of $	KDLB $5/TEU millions of $	TEU handling charges 125/TEU millions of $	TEU handling charges millions of $	Total TEU
2012-13	**13.51**	**4.50**	94.55	112.56	900,444.00
2013-14	**13.33**	**4.44**	93.34	111.12	888,948.00
2014-15	**14.33**	**4.78**	100.28	119.38	955,068.00
2015-16	**16.47**	**5.49**	115.26	137.22	1,097,720.00
2016-17	**15.16**	**5.05**	106.09	126.30	1,010,417.00
2017-18	**13.14**	**4.38**	91.97	109.48	875,861.00
2018-19	**10.41**	**3.47**	72.84	86.71	693,710.00
2019-20	**8.22**	**2.74**	57.52	68.48	547,820.00
2020-21	**10.28**	**3.43**	71.94	85.64	685,098.00
2021-22	**10.63**	**3.54**	74.39	88.56	708,454.00
2022-23	**8.95**	**2.98**	62.67	74.61	596,862.00
2023-24	**10.22**	**3.41**	71.53	85.15	681,201.00
		48.21	1,012.37	1,205.20	

SAPT Charges – per TEU handled 2015 to 2024

Year	KPT share @$15/TEU millions of $	KDLB @$ 5 /TEU millions of $	TEU handling charges 125/TEU millions of $	TEU handling charges millions of $	Total TEU
2015-16	**0.25**	**0.08**	27.76	33.05	**16,503.00**
2016-17	**3.97**	**1.32**	67.29	80.11	264,377.00
2017-18	**9.61**	**3.20**	91.81	109.30	640,855.00
2018-19	**13.12**	**4.37**	91.48	108.91	874,410.00
2019-20	**13.07**	**4.36**	94.35	112.32	871,278.00
2020-21	**13.48**	**4.49**	85.88	102.24	898,558.00
2021-22	**12.27**	**4.09**	75.64	90.05	817,903.00
2022-23	**10.81**	**3.60**	90.05	104.46	720,404.00
2023-24	**17.57**	**5.86**	146.38	169.81	1,171,035.00

KPT Charges – per TEU handled 2012 to 2024

Year	KPT share @$15/TEU millions of $	KDLB @$ 5 /TEU millions of $	TEU handling charges 125/TEU millions of $	TEU handling charges ++ millions of $	Total TEU
2012-13	**23.88**	**7.96**	165.33	196.82	1,591,991.00
2013-14	**23.62**	**7.87**	178.74	212.78	1,574,588.00
2014-15	**25.53**	**8.51**	203.76	242.57	1,702,251.00
2015-16	**29.11**	**9.70**	219.49	261.30	1,940,584.00
2016-17	**31.36**	**10.45**	234.58	279.26	2,090,401.00
2017-18	**33.51**	**11.17**	224.94	267.78	2,234,101.00
2018-19	**32.13**	**10.71**	206.40	245.72	2,142,240.00
2019-20	**29.49**	**9.83**	239.82	285.50	1,965,742.00
2020-21	**34.26**	**11.42**	230.67	274.61	2,284,009.00
2021-22	**32.95**	**10.98**	191.41	227.86	2,196,852.00
2022-23	**27.34**	**9.11**	238.06	283.40	1,822,915.00
2023-24	**34.01**	**11.34**	283.4	328.75	2,267,216.00
12 Years	**357.19**	**119.05**	**2616.6**	**3106.35**	



KPT empty and laden containers – TEU handled 2012 to 2024

YEAR	Empty	Laden	Total
2012-13	332114	1259877	1591991
2013-14	374272	1200316	1574588
2014-15	451913	1250338	1702251
2015-16	576577	1364007	1940584
2016-17	647856	1442545	2090401
2017-18	675251	1558850	2234101
2018-19	645741	1496499	2142240
2019-20	543112	1422630	1965742
2020-21	646993	1637016	2284009
2021-22	561679	1635173	2196852
2022-23	512786	1310129	1822915
2023-24	612148	1655068	2267216

PICT Jan 2023

Date	Vessel Name	Berth	TEU capacity	Gross Tonnage	Length	Draft	Width
1/1/2023	Clemens Schulte	B-6/B-7	6000	52000	255	12	37
1/1/2023	TSS Shams	B-9/B-8	2763	34000	208	11	32
1/2/2023	Kota Megah	B-6/B-7	3566	48000	221	11	35
1/3/2023	Independent Spirit.	B-9/B-8	2500	29000	209	10	29
1/4/2023	Cape Fulmar	B-6/B-7	1440	16000	170	9	25
1/6/2023	Seaspan Chiba	B-8/B-9	4500	46000	268	11	35
1/8/2023	Pontresina	B-9/B-8	2646	33000	213	11	32
1/10/2023	Ever Utile	B-6/B-7	5652	57000	285	12	40
1/12/2023	Jolly Quarzo	B-9/B-8	3000	40000	240	12	38
1/13/2023	Cape Fulmar	B-6/B-7	1440	16000	170	9	25
1/13/2023	Wide Juliet	B-9/B-8	5380	52000	255	12	37
1/14/2023	Wan Hai 627	B-7/B-6	5527	66000	276	12	40
1/15/2023	Dalian.	B-9/B-8		48000	260	12	32
1/17/2023	TSS Shams	B-6/B-7	2763	34000	208	11	32
1/18/2023	Independent Spirit.	B-9/B-8	2500	29000	209	10	29
1/19/2023	Tarlan	B-6/B-7	532	5006	116	7	19
1/20/2023	X-Press Bardsley	B-6/B-7	4800	48330	255	13	37
1/21/2023	X-Press Anglesey	B-9/B-8	4800	48000	250	10	37
1/25/2023	Cosco Antwerp	B-6/B-7	5618	65000	280	13	40
1/26/2023	TSS Shams	B-8/B-9	2763	34000	208	11	32
1/28/2023	George Washington Bridge	B-6/B-7	5624	66000	285	12	40
1/28/2023	Cape Fulmar	B-9/B-8	1440	16000	170	9	25
1/29/2023	TS Ningbo	B-8/B-9	4250	52000	261	12	32
1/31/2023	X-Press Kilimanjaro	B-6/B-7	3853	52000	261	12.5	32
Date	**Vessel Name**	**Berth**	**TEU capacity**	**Gross Tonnage**	**Length**	**Draft**	**Width**
	24 ships		**3624**	**42197**	**231**	**10.9**	**33**

PICT Berth Occupancy rate

Date	Vessel Name	Berth	B-6	B-7	B-8	B-9	Total moves	Port hours
1/1/2023	Clemens Schulte	B-6/B-7					34	12.25
1/1/2023	TSS Shams	B-9/B-8					1293	62.92
1/2/2023	Kota Megah	B-6/B-7			ex	ex	1536	36.75
1/3/2023	Independent Spirit	B-9/B-8	ex	ex			1287	31.42
1/4/2023	Cape Fulmar	B-6/B-7			ex	ex	432	21.42
1/5/2023							1173	33.17
1/6/2023	Seaspan Chiba	B-8/B-9					1238	29.17
1/7/2023					ex	ex	2127	57.17
1/8/2023	Pontresina	B-9/B-8					289	13.08
1/9/2023					ex	ex	641	21.08
1/10/2023	Ever Utile	B-6/B-7					1434	36.75
1/11/2023			ex	ex			2175	23.50
1/12/2023	Jolly Quarzo	B-9/B-8	ex	ex			1625	42.58
1/13/2023	Cape Fulmar	B-6/B-7					1831	58.83
1/13/2023	Wide Juliet	B-9/B-8					2066	67.33
1/14/2023	Wan Hai 627	B-7/B-6			ex	ex	91	9.00
1/15/2023	Dalian.	B-9/B-8	ex	ex			1257	34.67
1/16/2023					ex	ex	2309	47.08
1/17/2023	TSS Shams	B-6/B-7					1782	80.42
1/18/2023	Independent Spirit	B-9/B-8	ex	ex			1912	58.33
1/19/2023	Tarlan	B-6/B-7			ex	ex	1776	43.08
1/20/2023	X-Press Bardsey	B-6/B-7			ex	ex	535	28.33
1/21/2023	X-Press Anglesey	B-9/B-8					1924	46.92
1/22/2023					ex	ex	733	42.83
1/23/2023								
1/24/2023								
1/25/2023	Cosco Antwerp	B-6/B-7						
1/26/2023	TSS Shams	B-8/B-9	ex	ex				
1/27/2023			ex	ex	ex	ex		
1/28/2023	George Washington Bridge	B-6/B-7						
1/28/2023	Cape Fulmar	B-9/B-8						
1/29/2023	TS Ningbo	B-8/B-9	ex	ex				
1/30/2023					ex	ex		
1/31/2023	X-Press Kilimanjaro	B-6/B-7			ex	ex		
			21/31	**21/31**	**24/31**	**24/31**		
			67.7%	**67.7%**	**77.4%**	**77.4%**		
			PICT Berth Occupancy rate 72.55%					

PICT

date	Flag		Berth	Total moves	Ship time in Port hrs	No of QC	Ship productivity mov/ship hr (mov/ship time)	QC productivity (moves hr/QCs)
1/1/2023	Singapore		B-6/B-7	34	12.25	0	3	NA
1/1/2023	Panama		B-9/B-8	1293	62.92	1	21	20.55
1/2/2023	Singapore		B-6/B-7	1536	36.75	2	42	20.90
1/3/2023	Germany		B-9/B-8	1287	31.42	2	41	20.48
1/4/2023	Marshall Island		B-6/B-7	432	21.42	1	20	20.17
1/6/2023	Hong Kong		B-8/B-9	1173	33.17	2	35	17.68
1/8/2023	Liberia		B-9/B-8	1238	29.17	2	42	21.22
1/10/2023	Panama		B-6/B-7	2127	57.17	2	37	18.60
1/12/2023	USA		B-9/B-8	289	13.08	1	22	22.09
1/13/2023	Marshall Island		B-6/B-7	641	21.08	2	30	15.20
1/13/2023	Marshall Island		B-9/B-8	1434	36.75	2	39	19.51
1/14/2023	Singapore		B-7/B-6	2175	23.50	4	93	23.14
1/15/2023	Malta		B-9/B-8	1625	42.58	2	38	19.08
1/17/2023	Panama		B-6/B-7	1831	58.83	2	31	15.56
1/18/2023	Germany		B-9/B-8	2066	67.33	2	31	15.34
1/19/2023	Comoros		B-6/B-7	91	9.00	1	10	10.11
1/20/2023	Liberia		B-6/B-7	1257	34.67	2	36	18.13
1/21/2023	Liberia		B-9/B-8	2309	47.08	2	49	24.52
1/25/2023	UK		B-6/B-7	1782	80.42	1	22	22.16
1/26/2023	Panama		B-8/B-9	1912	58.33	2	33	16.39
1/28/2023	Panama		B-6/B-7	1776	43.08	2	41	20.61
1/28/2023	Marshall Island		B-9/B-8	535	28.33	1	19	18.88
1/29/2023	Marshall Island		B-8/B-9	1924	46.92	2	41	20.50
1/31/2023	Liberia		B-6/B-7	733	42.83	1	17	17.11
	24			1312.5 31,500	39.09	1.782609	33	19.04
Date	**Flag**	**Berth**	**Total moves**	**Port hours**	No of QC	Ship productivity mov/ship hr (mov/ship time)	QC productivity (moves hr/QCs)	

KICT Jan 2023 Ships 1/2

Date	Vessel Name	Berth	TEU capacity	GRT	Length	Draft	width
Jan-23	Jan-23				m	m	m
1/1/2023	Osaka	B-26/B-27	3820	39000	228	12	37
1/2/2023	RDO Fortune	B-28/B-29	5033	52000	**251**	12	37
1/2/2023	Northern Guard	B-26/B-27	4319	43000	264	12	32
1/2/2023	Teera Bhum	B-30/B-29	1850	19000	197	11	28
1/3/2023	Wadi Bani Khalid	B-27/B-26	4250	41000	261	12	32
1/7/2023	OOCL Le Havre	B-26/B-27					
1/7/2023	Northern Dexterity	B-29/B-28	3534	37000	231	12	32
1/9/2023	Ever Uranus	B-26/B-27	5652	58000	294	13	40
1/10/2023	Ever Utile	B-26/B-27	5652	58000	285	13	40
1/9/2023	Safeen Prism	B-28/B-29	2542	26000	209	11	29
1/10/2023	Green Pole	B-29/B-30	1809	19000	172	11	27
1/14/2023	Wan Hai 627	B-28/B-29	5527	56000	276	12	40
1/15/2023	Vancouver	B-26/B-27	4000	41000	260	12	32
1/16/2023	Northern Discovery	B-28/B-29	2353	36000	231	10	32
1/16/2023	Cosco Hamburg	B-26/B-27	5250	53000	280	13	39
1/16/2023	Olympia.	B-30/B-29	1717	18000	172	8	27
1/18/2023	Safeen Prize	B-28/B-29	2542	26000	209	11	29
1/19/2023	Gulf Barakah	B-28/B-29	4300	41600	262	12	32
1/19/2023	MSC Michigan VII	B-26/B-27	6420	66000	303	12	40
1/23/2023	Osaka	B-28/B-29	3820	39000	228	12	37
1/24/2023	SSL Brahmaputra	B-26/B-27	4253	43000	260	11	32
1/24/2023	Stephanie C	B-28/B-29	5466	58000	255	12	37
1/24/2023	Green Pole	B-30/B-29	1809	19000	172	8	27
1/25/2023	Cosco Antwerp	B-28/B-29	5250	55000	280	13	39
1/26/2023	YM Express	B-26/B-27	5600	47952	259	12	37
1/29/2023	OOCL Australia	B-26/B-27	4253	42500	263	12	32
1/30/2023	Navios Jasmine	B-26/B-27	4300	43500	267	12	32
1/31/2023	Olympia.	B-28/B-29	1717	18000	172	8	27
1/30/2023	MSC Diya F	B-29/B-30	1118	9957	148	7	24
1/31/2023	Northern Dexterity	B-26/B-27	3534	36000	231	12	32
1/31/2023	Safeen Prism	B-28/B-29	2542	26000	209	11	29
	31 Ships		**3808**	**38917**	237.6	11.3	33
Date	**Vessel Name**	**Berth**	**TEU capacity**	**GRT**	**Length**	**Draft**	**width**

KICT Jan 2023 Ships 2/2

Date	Berth	total moves	Port hours	No of QC	Ship productivity mov/ship hour	crane productivity mov pr hour/qc
1/1/2023	B-26/B-27	647.00	10.6	3	61	20.38
1/2/2023	B-28/B-29	1348.00	14.7	3	92	30.64
1/2/2023	B-26/B-27	1138.00	22.3	2	51	25.57
1/2/2023	B-30/B-29	439.00	25.8	1	17	16.99
1/3/2023	B-27/B-26	1005.00	22.3	2	45	22.50
1/7/2023	B-26/B-27	2687.00	36.4	3	74	24.59
1/7/2023	B-29/B-28	659.00	23.4	2	28	14.07
1/9/2023	B-26/B-27	1807.00	29.8	3	61	20.19
1/10/2023	B-26/B-27	1121.00	23.2	2	48	24.19
1/9/2023	B-28/B-29	341.00	21.7	1	16	15.74
1/10/2023	B-29/B-30	699.00	28.3	2	25	12.37
1/14/2023	B-28/B-29	1056.00	23.5	2	45	22.47
1/15/2023	B-26/B-27	2740.00	42	3	65	21.75
1/16/2023	B-28/B-29	933.00	28.9	2	32	16.13
1/16/2023	B-26/B-27	1187.00	31.2	2	38	19.04
1/16/2023	B-30/B-29	541.00	29.9	1	18	18.08
1/18/2023	B-28/B-29	140.00	11.7	1	12	12.00
1/19/2023	B-28/B-29	604.00	23.9	2	25	12.63
1/19/2023	B-26/B-27	1744.00	25.5	3	68	22.80
1/23/2023	B-28/B-29	585.00	22.7	2	26	12.90
1/24/2023	B-26/B-27	1168.00	36.5	2	32	16.00
1/24/2023	B-28/B-29	421.00	17.7	1	24	23.83
1/24/2023	B-30/B-29	692.00	22.1	2	31	15.67
1/25/2023	B-28/B-29	1275.00	22.3	3	57	19.10
1/26/2023	B-26/B-27	3670.00	56.5	3	65	21.65
1/29/2023	B-26/B-27	2593.00	35.4	3	73	24.40
1/30/2023	B-26/B-27	1045.00	23.4	2	45	22.31
1/31/2023	B-28/B-29	656.00	28.3	1	23	23.15
1/30/2023	B-29/B-30	445.00	18.7	2	24	11.92
1/31/2023	B-26/B-27	1242.00	33.8	2	37	18.40
1/31/2023	B-28/B-29	99.00	9	1	11	11.00
		1120.23	25.8	2.06452	41	19.11
Date	Berth	Avg total moves	Port hours	No of QC	Ship productivity mov/ship hr	crane productivity mov pr hr/qc

KICT Berth occupancy

	Date	Vessel Name	Berth	B-26	B-27	B-28	B-29	B-30	Total moves	Port hours
1	1/1/2023	Osaka	B-26/B-27						647	10.6
2	1/2/2023	RDO Fortune	B-28/B-29						1348	14.7
	1/2/2023	Northern Guard	B-26/B-27						1138	22.3
	1/2/2023	Teera Bhum	B-30/B-29						439	25.8
3	1/3/2023	Wadi Bani Khalid	B-27/B-26						1005	22.3
4	1/4/2023			ex	ex					
5	1/5/2023									
6	1/6/2023									
7	1/7/2023	OOCL Le Havre	B-26/B-27						2687	36.4
	1/7/2023	Northern Dexterity	B-29/B-28	ex	ex				659	23.4
8	1/8/2023									
9	1/9/2023	Ever Uranus	B-26/B-27						1807	29.8
	1/9/2023	Safeen Prism	B-28/B-29						341	21.7
10	1/10/2023	Ever Utile	B-26/B-27						1121	23.2
	1/10/2023	Green Pole	B-29/B-30	ex	ex				699	28.3
11	1/11/2023						ex	ex		
12	1/12/2023									
13	1/13/2023									
14	1/14/2023	Wan Hai 627	B-28/B-29						1056	23.5
15	1/15/2023	Vancouver	B-26/B-27						2740	42
16	1/16/2023	Cosco Hamburg	B-26/B-27						1187	31.2
	1/16/2023	Northern Discovery	B-28/B-29						933	28.9
	1/16/2023	Olympia.	B-30/B-29						541	29.9
17	1/17/2023			ex	ex	ex	ex	ex		
18	1/18/2023	Safeen Prize	B-28/B-29						140	11.7
19	1/19/2023	MSC Michigan VII	B-26/B-27						1744	25.5
	1/19/2023	Gulf Barakah	B-28/B-29						604	23.9
20	1/20/2023			ex	ex	ex	ex			
21	1/21/2023									
22	1/22/2023									
23	1/23/2023	Osaka	B-28/B-29						585	22.7
24	1/24/2023	SSL Brahmaputra	B-26/B-27						1168	36.5
	1/24/2023	Stephanie C	B-28/B-29						421	17.7
	1/24/2023	Green Pole	B-30/B-29						692	22.1
25	1/25/2023	Cosco Antwerp	B-28/B-29	ex	ex				1275	22.3
26	1/26/2023	YM Express	B-26/B-27						3670	56.5
27	1/27/2023			ex	ex					
28	1/28/2023			ex	ex					
29	1/29/2023	OOCL Australia	B-26/B-27						2593	35.4
30	1/30/2023	Navios Jasmine	B-26/B-27						1045	23.4
	1/30/2023	MSC Diya F	B-29/B-30						445	18.7
31	1/31/2023	Olympia.	B-28/B-29						656	28.3
	1/31/2023	Northern Dexterity	B-26/B-27						1242	33.8
	1/31/2023	Safeen Prism	B-28/B-29						99	9
		31 Ships		22/31	22/31	12/31	15/31	7/31	**1120**	**25.8**
				71%	71%	39%	48%	23%	Total moves	Port hours
				KICT average berth occupancy = 50.4%						

SAPT Jan 2023, 1/2

Date	Vessel Name	Berth	TEU Capacity	tonnage	Length	Draft	Width
1/1/2023	Ningbo Express	Sapt-4	7506	88500	320	12	42
1/2/2023	CMA CGM Melisande	Sapt-3/Sapt-2	8721	95000	335	12.5	43
1/3/2023	TS Singapore.	Sapt-4	4395	46000	260	11.5	32
1/4/2023	KMTC Colombo	Sapt-3/Sapt-2	6500	75488	304	13.5	40
1/5/2023	Tsingtao Express	Sapt-4	8500	93750	335	14	42
1/5/2023	COSCO Thailand	Sapt-3/Sapt-2	8500	91000	334	14	43
1/6/2023	MSC Rita	Sapt-3	8034	90000	325	14	43
1/8/2023	Hyundai Oakland	Sapt-4	6266	72600	293	13	40
1/9/2023	KMTC Delhi	Sapt-3/Sapt-2	6572	77000	300	13	40
1/10/2023	Dalian Express	Sapt-4	7506	88495	321	14.5	40
1/12/2023	Sofia Express	Sapt-3/Sapt-2	8604	93750	335	14	43
1/13/2023	MSC Mumbai VIII	Sapt-4	8500	98000	332	14	43
1/13/2023	Xin Hong Kong	Sapt-2/Sapt-3	9580	108000	336	14	45
1/15/2023	Uranus.	Sapt-4	510	10000	117	7	18
1/16/2023	Gfs Pride	Sapt-3	2824	28300	222	12	30
1/17/2023	Express Berlin	Sapt-2/Sapt-3	10100	114000	366	14	48
1/18/2023	Delos Wave	Sapt-2	2824	28600	222	12	30
1/18/2023	Henrika	Sapt-4	5605	59300	275	13	40
1/20/2023	OOCL Atlanta	Sapt-4					
1/19/2023	Kyoto Express	Sapt-3/Sapt-2	8750	93750	335	14	48
1/21/2023	Northern Jamboree	Sapt-4	8400	9440	333	14	43
1/21/2023	Hyundai Bangkok	Sapt-3/Sapt-2	6800	75300	304	13	40
1/22/2023	GFS Prestige	Sapt-4	2824	28600	222	11	30
1/23/2023	Koi.	Sapt-3/Sapt-2	8586	91585	335	14	43
1/24/2023	Hyundai Singapore	Sapt-4	6800	75300	304	13	40
1/26/2023	TS Dubai.	Sapt-3/Sapt-2	6200	73000	272	13	43
1/27/2023	Budapest Express	Sapt-4					
1/28/2023	Chennai Voyager	Sapt-3	2546	26500	207	11	30
1/28/2023	MSC Houston	Sapt-4	4500	47000	255	12	32
1/29/2023	Seamax Westport	Sapt-3/Sapt-2					
1/30/2023	Apl Antwerp.	Sapt-2/Sapt-3	8102	88000	320	14	46
1/30/2023	CMA CGM Tosca	Sapt-3/Sapt-4	8488	93000	334	13	43
1/31/2023	Uranus.	Sapt-3	510	10000	117	7	18
1/31/2023	Hyundai Hong Kong	Sapt-4/Sapt-3	6800	75300	304	13	40
Date	**Vessel Name**	**Berth**	**TEU Capacity**	**tonnage**	**Length**	**Draft**	**Width**
	33 ships		**6463**	**69179**	**289.5**	**12.7**	**38.6**

SAPT Jan 2023 2/2

Date	Berth	Total moves	port hours	No of QC	Ship productivity mov/ship hour	Single crane productivity mov per hour/QC
1/1/2023	Sapt-4	1117	17.67	3	63	21.08
1/2/2023	Sapt-3/ Sapt-2	2044	24.08	4	85	21.22
1/3/2023	Sapt-4	510	29.92	1	17	17.05
1/4/2023	Sapt-3/ Sapt-2	2115	24.17	3	88	29.17
1/5/2023	Sapt-4	1156	18.75	3	62	20.55
1/5/2023	Sapt-3/ Sapt-2	2003	25.25	3	79	26.44
1/6/2023	Sapt-3	524	12.33	2	42	21.24
1/8/2023	Sapt-4	1826	21.42	3	85	28.42
1/9/2023	Sapt-3/ Sapt-2	2476	25.42	4	97	24.35
1/10/2023	Sapt-4	1411	21.42	3	66	21.96
1/12/2023	Sapt-3/ Sapt-2	1107	19.58	2	57	28.26
1/13/2023	Sapt-4	490	13.42	2	37	18.26
1/13/2023	Sapt-2/ Sapt-3	2989	30.58	4	98	24.43
1/15/2023	Sapt-4	102	7.75	1	13	13.16
1/16/2023	Sapt-3	1340	17.67	3	76	25.28
1/17/2023	Sapt-2/ Sapt-3	1382	24.33	2	57	28.40
1/18/2023	Sapt-2	776	15.00	2	52	25.87
1/18/2023	Sapt-4	1879	26.50	3	71	23.64
1/20/2023	Sapt-4	1731	21.50	3	81	26.84
1/19/2023	Sapt-3/ Sapt-2	1062	24.08	2	44	22.05
1/21/2023	Sapt-4	602	12.08	2	50	24.91
1/21/2023	Sapt-3/ Sapt-2	1473	29.25	2	50	25.18
1/22/2023	Sapt-4	625	27.17	1	23	23.01
1/23/2023	Sapt-3/ Sapt-2	975	18.92	2	52	25.77
1/24/2023	Sapt-4	1516	18.42	3	82	27.44
1/26/2023	Sapt-3/ Sapt-2	2306	28.92	3	80	26.58
1/27/2023	Sapt-4	1341	23.42	2	57	28.63
1/28/2023	Sapt-3	1341	13.25	2	101	50.60
1/28/2023	Sapt-4	548	10.58	1	52	51.78
1/29/2023	Sapt-3/ Sapt-2	140	29.00	4	5	1.21
1/30/2023	Sapt-2/ Sapt-3	1300	20.33	3	64	21.31
1/30/2023	Sapt-3/ Sapt-4	1792	23.00	3	78	25.97
1/31/2023	Sapt-3	127	10.17	1	12	12.49
1/31/2023	Sapt-4/ Sapt-3	1561	18.75	3	83	27.75
31	33	1284.9	20.7	2.5	61	24.7
days	ships	Total moves	port hours	No of QC	Ship productivity mov/ship hr	crane productivity mov per hr/qc

SAPT Berth Occupancy Rate

	Date	Vessel Name	Berth	SAPT-2	SAPT-3	SAPT-4	Total moves	Port hours
1	1/1/2023	Ningbo Express	Sapt-4				1117	17.67
2	1/2/2023	CMA CGM Melisande	Sapt-3/Sapt-2				2044	24.08
3	1/3/2023	TS Singapore.	Sapt-4	ex	ex		510	29.92
4	1/4/2023	KMTC Colombo	Sapt-3/Sapt-2				2115	24.17
5	1/5/2023	Tsingtao Express	Sapt-4				1156	18.75
	1/5/2023	Cosco Thailand	Sapt-3/Sapt-2				2003	25.25
6	1/6/2023	MSC Rita	Sapt-3	ex			524	12.33
7	1/7/2023							
8	1/8/2023	Hyundai Oakland	Sapt-4				1826	21.42
9	1/9/2023	KMTC Delhi	Sapt-3/Sapt-2			ex	2476	25.42
10	1/10/2023	Dalian Express	Sapt-4				1411	21.42
11	1/11/2023							
12	1/12/2023	Sofia Express	Sapt-3/Sapt-2				1107	19.58
13	1/13/2023	MSC Mumbai VIII	Sapt-4				490	13.42
	1/13/2023	Xin Hong Kong	Sapt-2/Sapt-3				2989	30.58
14	1/14/2023			ex	ex			
15	1/15/2023	Uranus.	Sapt-4				102	7.75
16	1/16/2023	GFS Pride	Sapt-3				1340	17.67
17	1/17/2023	Express Berlin	Sapt-2/Sapt-3				1382	24.33
18	1/18/2023	Delos Wave	Sapt-2				776	15.00
	1/18/2023	Henrika	Sapt-4				1879	26.50
19	1/19/2023	Kyoto Express	Sapt-3/Sapt-2			ex	1062	24.08
20	1/20/2023	OOCL Atlanta	Sapt-4				1731	21.50
21	1/21/2023	Northern Jamboree	Sapt-4				602	12.08
	1/21/2023	Hyundai Bangkok	Sapt-3/Sapt-2				1473	29.25
22	1/22/2023	GFS Prestige	Sapt-4	ex	ex		625	27.17
23	1/23/2023	Koi.	Sapt-3/Sapt-2			ex	975	18.92
24	1/24/2023	Hyundai Singapore	Sapt-4				1516	18.42
25	1/25/2023							
26	1/26/2023	Ts Dubai.	Sapt-3/Sapt-2				2306	28.92
27	1/27/2023	Budapest Express	Sapt-4	ex	ex		1341	23.42
28	1/28/2023	Chennai Voyager	Sapt-3				1341	13.25
	1/28/2023	MSC Houston	Sapt-4				548	10.58
29	1/29/2023	Seamax Westport	Sapt-3/Sapt-2				140	29.00
30	1/30/2023	Apl Antwerp.	Sapt-2/Sapt-3				1300	20.33
	1/30/2023	CMA CGM Tosca	Sapt-3/Sapt-4				1792	23.00
31	1/31/2023	Uranus.	Sapt-3	ex		ex	127	10.17
	1/31/2023	Hyundai Hong Kong	Sapt-4/Sapt-3				1561	18.75
	31 days	33 ships		20/31=64.5%	22/31=71%	21/31=68%	**1285**	**20.7**
				SAPT Avg Berth occupancy=**67.8%**				

Date	Vessel Name	Berth	TEU Capacity	tonnage	Length	Draft	Width
			6463	69179	289.5	12.7	38.6

1285	**20.7**	
Total moves	**Port hours**	

		1285	**20.7**	**2.5**	**61**	**24.7**
Date	**Berth**	Total moves	port hours	No of QC	Ship productivity mov/ship hour	crane productivity mov per hour/QC

Comparative Analysis Table PICT, KICT, SAPT

Metric	PICT	KICT	**SAPT**	Analysis & Winner
Ships Visited (Monthly)	24	31	**33**	**SAPT** handles the highest vessel call volume.
Avg Moves per Ship	1,313	1,120	**~1,285**	PICT has the highest moves/ship, but this doesn't equate to efficiency.
Avg Port Hours (Turnaround Time)	39.1	25.8	**20.7**	**SAPT** is the clear winner. Fastest turnaround indicates superior operational fluidity.
Avg QCs Used per Ship	1.8	2.1	**2.5**	**SAPT** employs more cranes simultaneously, enabling faster work.
Ship Productivity (Moves/Ship/Hr)	33	41	**61**	**SAPT** is overwhelmingly more productive at the berth.
Crane Productivity (Moves/Hr/QC)	19.0	19.1	**24.7**	**SAPT's** crane operations are significantly more efficient.

Container Yard Storage Capacity

The container yard (CY) storage capacity is an important factor for CT. While yard capacity is a design matter, it has a critical relationship with CY ground slots, stacking elevation, handling equipment capability, effective container management, dwell time, throughput, and the port manager's expertise. The cumulative design capacity of all CTs at Karachi port is 4.5 million TEU.

As per Monfort et al. (2011), learned that the area thickness (ground slots per hectare) for RTG (6; 4+1) (nominal stacking elevation), the area thickness (ground slots per hectare) is between 260 to 300. The working average stacking elevation is 2.40.

For SAPT, the average stacking elevation is clearly related to storage capacity. Area density x Operating standard stacking height = Static capacity (SC) or 260 x 2.4 = 624 TEU per ha; 300 x 2.4 = 720 TEU per ha. That is 624 to 720 TEU per ha. Thus, for 85 ha terminal, it is 85 x 624 = 53,040 or 85 x 720 = 61,200, like the entire storage capacity of SAPT is between 53,040 and 61,200, **average capacity being 57,120 TEU**, while the **ground slots are 14,280 TEU**. The terminal capacity is calculated at 7 days average dwell time.

Likewise, for PICT 23 ha terminal, it is 23 x 624 = 14,352 or 23 x 720 = 16,560, like the entire storage capacity of PICT is between 14,352 and 16,560, **average capacity being 15,456 TEU**, while the **ground slots are 3300 TEU**. The terminal capacity is calculated at 7 7-day average dwell time.

Similarly, for the KICT 26 ha terminal, it is 26 x 624 = 16,224 or 26 x 720 = 18,720, like the entire storage capacity of KICT is between 16,224 and 18,720, **average capacity being 17,472 TEU**, while the **ground slots are 4,000 TEU**. The terminal capacity is calculated at 7-day average dwell time.

Comparative analysis of container terminals at Karachi port

The data regarding Karachi port and its container terminals was compiled by the author with the help of literature and observation/discussion during visits. Among the three CTs, PICT was established in 2002 on a build-operate-and-transfer basis and operated by ICTSI. PICT operated from the berths B6-B9, measuring 600 meters. However, upon completion of the lease period in June 2024, the ICTSI was asked to vacate and hand over PICT to KPT. Thereafter, the terminal was leased to Abu Dhabi ports for 50 years and renamed as Karachi Gateway Terminal Limited (KGTL). Due to depth and length constraints, both KGTL (ex-PICT) and KICT can dock ships with below capacity of below 8000 TEU. The second terminal, KICT, operates from B26-B30, having an overall length of 973 meters. It has been operated by Hutchison Port Holdings since 1998. The third terminal SAPT was commissioned in 2016. It has a depth of 16.5 meters and can dock large and modern container ships, having the capacity to carry up to 19,000 TEU. The data regarding port resources at the three CTs are shown in Table 5.3.

Table I-3. Comparison of Container Terminals (CTs) at Karachi Port 1 to 31 January 2023

Port Productivity Factors	PICT	KICT	SAPT	Total	Ranking		
					PICT	KICT	SAPT
Quay length in (m)	600	973	1500	3073	3	2	1
Number of berths	4	5	4 (2 ops)	13	2	2	1
Berth depth	13.5	13.5	16.5		2	2	1
Quay crane (QC)	6	9	14	29	3	2	1
Yard Crane (YC) (RTG)	10	29	31	64	3	2	1
Container yard area in Hectare	23	26	85	134	3	2	1
Gates	2 in, 2 out	5 in, 3 out	9 in, 6 out		3	2	1
Ground slots	3300	4000	12800		3	2	1
Dwell time (days)	7-8	7-8	7-8		1	1	1
CTs Handling capacity million TEU	0.75	0.75	3.0		2	2	1
Rail handling – TEU per week	Nil	200	200		-	1	1
Ships visited Jan 2023	24	31	33	88	3	2	1
Avg ship length meter (m)	230	238	290	253 averages	3	2	1

Avg ship draft meter (m)	10.9	11.3	12.7	11.6 average	3	2	1
Avg ship width meter (m)	33	33	38.6	34.9 average	2	2	1
Avg QCs used per ship	1.8	2.1	2.5	2.1 average	3	2	1
QC moves per hour	19	19.1	24.7	20.9 average	3	2	1
YC moves per hour	0.6	1.7	2.4		3	2	1
TEU storage per Ha (1/23)	901	1149	649		2	1	3
TEU handled per Quay meter	34.5	30.7	69		3	2	1
Avg Ship moves per hour	33	41	61		3	2	1
Avg berth occupancy rate	72.6%	50.4%	67.8%		1	3	2
Throughput Jan 2023	20,719	29,862	55,176		3	2	1
Throughput annual mil TEU	.415	.681	1.171		3	2	1
Avg ship time in port (hour)	39.1	25.8	20.71		3	2	1
Avg TEU per ground slot	2.4	3.4	1.8		2	1	3
Avg moves per ship	1313	1120	1285		1	3	2
Avg ship size (GRT)	42,197	38,917	69,179		2	3	1
Avg ship TEU capacity	3624	3808	6463		3	2	1

Note: QC=Quay crane, YC Yard crane, CY=Container yard, Ha=Hectare, TEU=Twenty-foot equivalent unit, GRT=Gross registered ton, m=meter, Avg=Average.

Source: pict.com.pk, kict.com.pk, sapt.com.pk. and various port websites

The port statistics and operational data were obtained from the KPT Head Office and the CTs during the port visit. The productivity of various containers handling equipment and facilities in each CT was calculated and compared to one another, as shown in the above Table. Each CT facility/resource was marked from 1 to 3. It was found that SAPT possessed the highest score, KICT was in second place, while PICT (now KGTL) was the third. The key difference was due to resources and facilities. SAPT, being newer, had deeper and longer berths with deeper depth alongside and hence had the edge.

Although the berth occupancy rate is higher at PICT, the reason is that the ship's stay is longer in port due to slower cargo handling, as compared to SAPT.

Summary of Relative Strengths for CTs at Karachi Port

Factor	PICT	KICT	SAPT	Analysis
Scale & Capacity	Smallest	Medium	**Largest by far**	SAPT is a mega-terminal.
Absolute Throughput	Lowest	Medium	**Highest by far**	Direct result of scale.
Ship Turnaround Time	Slowest (39.1h)	**Fastest (25.8h)**	Very Good (20.7h)	**KICT is most efficient.**
Quay Productivity (TEU/m)	34.5	30.7	**69.0**	**SAPT uses its quay best.**
Crane Productivity (QC Moves/hr)	19.0	19.1	**24.7**	**SAPT's equipment is the fastest.**
Yard Productivity (YC Moves/hr)	0.6 (Very Low)	1.7	**2.4**	PICT's yard is a weak point.
Asset Utilization (TEU/Slot)	2.4	**3.4**	1.8	**KICT squeezes most from its assets.**
Berth Occupancy	High (72.6%)	**Low (50.4%)**	Moderate (67.8%)	**KICT has room to grow without congestion**

J APPENDIX: MISCELLANEOUS

Port Performance Indicators

Sr.#	Author(s)	Port Logistic Efficiency PLE			Port Container Management (PCM)							Port Technology (PT)						Port Infrastructure (PI)					
		Annual Container Throughput (TEU) (PLE1)	Throughput growth (PLE2)	Container ships visited port per year (PLE3)	Truck turnaround (hours) (PCM1)	Vessel turnaround (days) (PCM2)	QC productivity (TEU/year) (PCM3)	Berth occupancy (vessels/year) (PCM4)	Berth Productivity (TEU/year) (PCM5)	Yard utilization (TEUs/year) (PCM6)	Container dwell time (days) (PCM7)	IT systems (PT1)	Database (PT2)	IoT (Internet of Things) (PT3)	RFID (Radio Frequency Identification) (PT4)	5G Network (PT5)	Laser (PT6)	Container berths total (m) (PI1)	Berth Length/LOA (m) (PI2)	Draft maximum at berth (m) (PI3)	Terminal land area (Ha) (PI4)	Terminal Storage capacity (TEU) (PI5)	Navigation Channel dimensions (PI6)
1	tongzon200	•					•											•					
2	wang2004	•																	•		•		
3	yang2019	•																	•		•		
4	nyema2014		•								•												
5	mr2018				•						•							•					
6	merk2012	•			•														•				
7	cullinane20	•																	•		•		
8	bichou2013	•																	•	•	•		
9	cullinane20	•																	•		•		
10	yang2019	•																	•				
11	munisamy2	•																	•				
12	pinto2016	•						•															
13	notteboom	•																	•		•		
14	kammoun20	•																					
15	sharma200	•																	•		•		
16	gamassa20	•																•	•		•		
17	ambrosy 2015																•						
18	wanke2011	•																•			•		
19	zahran2017																	•					
20	rubem2015	•																	•	•			
21	shetty2018					•																	
22	parolaetal2016																						

Sr.#	Author(s)	Port Equipment (PE)						Port Service (PS)						Port HR (PHR)						Port Charges (PC)					
		Quay crane (QC) (PE1)	Yard Gantry (Rubber tired/Rail) (PE2)	Straddle Carriers (STC) (PE3)	Reach Stacker (PE4)	Empty container handlers (PE5)	Stevedoring equip (yard truck, forklift, mob crane) (PE6)	Overall service reliability (PS1)	Responsiveness to customer requests (PS2)	Incidence of cargo damage (PS3)	Incidence of service delay (PS4)	Degree of customer satisfaction (PS5)	Ship waiting time (congestion period) (PS6)	No of employees (PHR1)	Average age of employees (PHR2)	Commitment and loyalty (PHR3)	Employee Productivity (TEU handled) (PHR4)	Training and education (PHR5)	Knowledge, skills and abilities (PHR6)	Overall service cost (PC1)	Cargo handling charges (PC2)	Cost of terminal ancillary services (PC3)	Port revenue/EBITDA (operating profit) (PC4)	Net profit margin (PC5)	Revenue growth (PC6)
1	tongzon200						•				•			•											
2	wang2004	•		•			•																		
3	yang2019	•																							
4	nyema2014	•	•																						
5	mr2018																								
6	merk2012	•			•		•																		
7	cullinane20	•		•																					
8	bichou2013																								
9	cullinane20	•		•																					
10	yang2019																								
11	munisamy2	•					•																		
12	pinto2016																								
13	notteboom	•																							
14	kammoun20						•							•											
15	sharma200	•		•																					
16	gamassa20	•																							
17	ambrosy 2015																								
18	wanke2011																								
19	zahran2017						•																		
20	rubem2015																								
21	shetty2018																								
22	parolaetal2016																					•			

Transportation Congestion at Karachi Port: Challenges and Proposed Solution

The Issue. Vehicle congestion at the entrance and departure points of Karachi Port is an important operational choke point affecting port logistics efficiency. Container Terminals at Karachi port handle a substantial volume of containerized cargo, but depend heavily on road carriage, with very little rail integration. Peak-time bottleneck at port gates, particularly at the roads connecting the access corridors, results in long truck lines, undue waiting period, and return to the city highways. This congestion is further worsened by manual gate processes, poor appointment planning, and the concurrent arrival of import and export container trucks.

Main Reasons for Congestion. Numerous structural and operational factors cause this problem. Firstly, ineffective gate management systems and inadequate use of automatic gate technologies enhance the processing period for each truck. Secondly, the delay in the customs clearance process compels the trucks to remain in the port for a longer period due to the slow documentation process, increasing yard and gate congestion. Thirdly, the absence of devoted freight corridors forces port traffic to contest with urban traffic, intensifying congestion in working hours. Also, the restricted use of rail service and inland container depots concentrates container traffic around the port, deteriorating road congestion.

Influence on Port Logistics Efficiency. Transport congestion particularly enhances the truck turnaround period, dwell time, and logistics expenditures, directly weakening port logistics efficiency. From the perspective of the Economic Theory of the Port (ETP), congestion raises transaction and handling charges, lowering throughput productivity. Under Resource Dependence Theory (RDT), Karachi Port becomes greatly reliant on external transport providers (trucking companies, customs, city traffic police), deteriorating operational control and coordination. This congestion, thus, nullifies the advantages of investments in port infrastructure, equipment, and container handling systems.

The point did come under discussion with KPT officials and CT managers during port visits. The problem was there, but was toned down due to less cargo handling at Karachi port, compared to its capacity. However, to analyze this issue, items were included in the survey to obtain input.

Proposed Solutions

Gate Automation and Computerized programming. Applying automatic gate setup, including RFID and truck appointment systems, can substantially decrease the gate processing period. Pre-reserved time slots can help traffic flow and avoid high congestion periods.

Growth of Rail Network and Dry Ports. The consolidated rail carriage system connecting Karachi Port and inland dry ports efficiently (like, Pipri, Lahore, Sialkot) will reduce the cargo load from the roads, reducing gate congestion.

Devoted Port Access Roads. Developing devoted cargo corridors or elevated highways solely for port-related traffic will split commercial cargo from city traffic, decreasing delays at entry and exit points.

Customs Procedure Changes. Reform of customs via paperless clearance, risk-based inspections, and longer working hours would reduce truck turnaround time in the port and avoid congestion at gates.

Enhanced Container Management (PCM). Augmenting container management practices, such as better yard planning, real-time container tracking, and faster container release, would ensure smoother truck movement and quicker gate clearance—reinforcing the mediating role of PCM identified in this study.

Strategy and Stakeholder Management. Efficient congestion management needs coordination between KPT, CT operators, customs officials, traffic police, and transport unions. An integrated port and city transport management framework is vital to align operating choices and decrease dependency-related inefficiencies.

Conclusion. Addressing transport congestion at Karachi Port's entry and exit points is important. It is essential to realize the full benefits of port resource capabilities and container management improvements. Without resolving this bottleneck, gains from technology, infrastructure, and human resources will remain unrealized. The findings of this study support the view that efficient container management and coordinated resource utilization are critical mechanisms for mitigating congestion and enhancing overall port logistics efficiency.

Interview process/discussion

Details regarding the interview process, including the target population, sample size, and interview protocol, have been included in the document. As the main study is quantitative in nature, the interviews/discussions have been analyzed to the required level. Nevertheless, more precise steps have also been conducted during the process of this research. The interviews and discussions were undertaken with several managers at Karachi port container terminals, KPT, shipping firms, and subject matter specialists to learn in detail about the problems being faced at Karachi port. However, the process for qualitative research was not done, as this research is mainly quantitative in nature. The discussions took place during several visits to Karachi port. The salient officials with whom discussion took place in person included the Minister for Maritime Affairs, Chairman KPT, DG operations KPT, Traffic manager KPT, technical and other KPT managers, DG National Institute of Maritime Affairs (NIMA), and other Directors at NIMA, Senior, middle, and lower managers at SAPT, KICT, and PICT /KGTL, and Managers at shipping and clearing firms. Besides, the discussion on Karachi port also took place with several other serving and retired container terminal and maritime port industry and logistics-related officials. For example, former chairman KPT, managers of container terminals (CTs), container ship captains, Manager/owner Private container storage company, Director Maritime Affairs at Pak secretariat, Islamabad, etc. Moreover, the present study is quantitative research. The sample size and target population are included in Chapter 3 of the main document. Another reason for the interviews and discussion was the topic identification and validation. To build a relationship with port functionaries, where possible, to be able to discuss the port operations matters again.

Interview Protocol and Procedures

1. Target Population

The target population for this qualitative component of the study primarily comprised operations and logistics managerial professionals directly involved in CT operations, Karachi Port Trust (KPT) head office, shipping and clearing firms, and affiliated experts, as mentioned above. However, the shortlisted category of individuals with whom interviews/discussions were intended:

- Port managers and operational supervisors at KPT
- Managers at container terminals
- Shipping and clearing firms managers
- Customs clearing officials and agents

- Logistics service providers

This population was chosen as they were knowledgeable about operational interruptions, resource constraints, container movement issues, documentation procedures, logistics blockages, port charges, technology adoption, human resource issues, training, infrastructure, services, organizational matters, equipment, shipping procedures, etc. The target population was estimated to be about 500 people.

2. Sample Size and Sampling Process

A purposive expert sampling approach was utilized to recognize officials with a requisite understanding and experience. Overall, interviews and discussions were conducted with 12 experts, as follows:

2 from Karachi Port Trust (KPT)

5 from container terminals (CT), (PICT, KICT, SAPT)

2 from shipping and clearing/logistics firms

1 from the shipping and clearing firms

This sample size is appropriate for qualitative triangulation, where thematic saturation is achieved. The perspective of this study was to learn about the operating functions, the processes, the problems being faced by the terminal operators, and the port performance. The interest was in those maritime logistic resources, factors, and organizations that contribute towards higher efficiency and productivity of the port and container terminals. The list of various maritime logistics employees at CTs was not readily available in the selected organizations due to their secrecy and confidentiality. COVID-19 (Cheng et al., 2023) had also emerged during this process, making port visits and meeting people more difficult. The interaction through interviews was also useful for making acquaintances with a few managers who could be helpful in referring to motivating others to meet, or to fill out the survey.

In this study, it was essential to ensure that the respondents were maritime logistics employees who met the following conditions: first, they must be from a particular section primarily responsible for promoting operational efficiency of port logistics. Second, the age group of the respondents ought to be between 20 to 60 years, as the average qualifying age for undergraduate studies in Pakistan is 20 years, and the superannuation age is 60 years in many of the maritime logistics organizations, except where a more skilled resource is required. Third, respondents must preferably hold at least an undergraduate degree to comprehend and complete the survey. All three levels of respondents, including the top, middle, and lower management, were selected in the process. Initially, the operation and logistics managers in the selected maritime organizations were contacted. These individuals helped to facilitate meetings with eligible candidates or agreed to discuss themselves.

3. Number of Field Visits. To ensure contextual validity and observational accuracy, the researcher conducted six separate field visits to Karachi Port. Each visit lasted 3 to 4 hours and included:

- Observing container yards working
- Monitoring gate operations.
- Container handling between the ship and berth.
- Reviewing documentation flow
- Discussing operational matters
- Verifying real-time port operations

These visits ensured a credible, firsthand understanding of port operations and the problems being encountered.

4. Interview Design and Protocol

4.1 Interview Format

- Semi-structured face-to-face interviews
- Conducted in English and Urdu, depending on respondent preference
- Duration: 20 to 30 minutes per interview
- Notes were taken with consent

4.2 Interview Instrument. The interview guide consisted of three key thematic areas:

Section A: Port Resource Capabilities (RDT Focus)

- What are the major operational resources and capabilities affecting performance?
- Which capability shortages create external dependencies (shipping lines, customs, truck carriers, etc.)?
- How do IT, infrastructure, HR, and equipment etc., influence daily port operations?

Section B: Container Management Processes (ETP Focus)

- How are container flows coordinated from vessel arrival to gate-out?
- What challenges occur in yard space planning, documentation, or inter-terminal transfers?
- How do bottlenecks in container processing affect logistics performance?

Section C: Logistics Efficiency Challenges

- What major sources of delay or inefficiency exist?
- How do operational decisions affect turnaround time and reliability?
- What transformations would improve efficiency?

5. Ethical Considerations

- Participation was voluntary.
- Interviewees were informed of the academic purpose.
- No personal identifiers were disclosed.
- Findings are presented in aggregate form.

6. Data Analysis Procedure

- Interview notes were transcribed after each session.
- A thematic analysis approach was used.
- Themes were aligned with RDT (dependency reduction) and ETP (operational transformation).
- Findings were to be triangulated with quantitative results.

7. Incorporation with the Main Study. These expert interviews served three primary functions:

- Triangulating the quantitative model by validating whether the key constructs (e.g., technology, infrastructure, equipment, human resources, services, charges, container management, logistics efficiency) reflect real-world problems.
- Contextualizing the results by understanding operational bottlenecks specific to Karachi Port.
- Informing discussion and recommendations based on direct practitioner insights.

1

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