

EXPLORING THE IMPACT OF LOGISTICS NETWORK DYNAMICS ON PORT EFFICIENCY: A CASE OF THE KARACHI PORT TRUST

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Abstract

Due to the complexity of Supply Chain Management (SCM) concepts on a global scale, ports are concentrating more on the logistics network model to identify the elements influencing it. The ability of port infrastructure to facilitate economic growth is well accepted. For countries that heavily rely on international trade, adequate infrastructure is necessary to reduce traffic, promote trade expansion, and support sustainable operations that improve port efficiency. The research aims to investigate the impact of hinterland logistics on port efficiency and their collective impact on the overall performance of Karachi Port Trust (KPT). The efficiency and productivity of many ports still experience congestion due to the unreliable flow of hinterland transit, which compromises their performance and the supply chain. The problem of the hinterland is a challenge for ports because logistics service providers, shippers, and shipping lines actively consider the conveyance of the hinterland when selecting a port. The port authority was approached, and port officials were interviewed regarding the flow of cargo, traffic situation, and problems faced during the operations on and off the port. The study concludes that the problems faced by ports such as road congestion, unplanned positioning of infrastructure, etc. The study looks forward to taking appropriate action therefore KPT's difficulties can be resolved, and production can be increased

Keywords: Port Operating Efficiency, Port Infrastructure, Karachi Port Trust (KPT), Logistical Network, Port Infrastructure, Hinterland Logistics

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1 Introduction

1.1 Background

Ports play a pivotal role in a nation's economic development, serving as vital hubs for freight transportation¹. The efficiency and performance of these ports are of paramount importance, given that the global economy heavily relies on maritime trade. Approximately 90% of global trade², accounting for nearly 70% of its total value, is facilitated by sea transport. Ports have historically served as strategic interfaces for both maritime and inland transportation, connecting ships and ground-based logistics networks through various modes like road, rail, and inland canals, thereby functioning as essential nodes in the global supply chain³.

In response to the surge in globalization and the resultant expansion of international trade, the adoption of containerized freight has soared as a means of streamlining transportation and enhancing logistics efficiency⁴. To meet the growing demand, logistics enterprises have transitioned from bulk carriers to container ships, which employ ports as their ultimate gateways. This shift is driven by the sheer volume and value of global maritime trade. Seaports have long played a pivotal role in facilitating the transfer of goods as part of the multimodal distribution process, bridging the gap between maritime and overland transport securely⁵.

The rapid expansion of the container shipping industry has led to increased competition among cargo businesses⁶, prompting them to invest in larger vessels to reduce operational costs, such as fuel, labor, and maintenance, while achieving economies of scale through the simultaneous transport of vast cargo quantities⁷. Additionally, they have developed supply chain management tools to oversee the entire product journey, from manufacturers to end customers. Further strategies include mergers, acquisitions, and maritime partnerships to expand operations and enhance traffic performance through collaborative transportation alliances⁸.

¹ Munim, Z. H., & Schramm, H. J. (2018). The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. *Journal of Shipping and Trade*, 3(1), 1-19.

² Zohaib, H. S., & Zaidi, S. S. Z. (2022). Antecedents of Maritime Supply Chain Resilience Affecting Supply Chain Performance—An Empirical Study Based on Pharmaceutical Industry. *GMJACS*, 12(2), 82-103.

³ Beresford, A., Pettit, S., Xu, Q., & Williams, S. (2012). A study of dry port development in China. *Maritime Economics & Logistics*, 14, 73-98.

⁴ Ding, J. F., Chou, M. T., Yeh, I., Yang, Y. L., Chou, C. C., & Shyu, W. H. (2016). An evaluation of key service effectiveness of Keelung port. *Journal of Marine Science and Technology*, 24(2), 11.

⁵ Jeevan, J., Othman, M. R., Salleh, N. H. M., Ghani, N. M. A., Noralam, N. A., & Divine Caesar, L. (2021). An analysis on the triadic connection between seaports, inland terminals and hinterland market. *Australian Journal of Maritime & Ocean Affairs*, 13(1), 23-42.

⁶ Wan, M., Kuang, H., Yu, Y., & Zhang, R. (2022). Evaluation of the competitiveness of the container multimodal port hub. *Scientific Reports*, 12(1), 19334.

⁷ Jia-qi, Y. A. N. G. (2002). Gravity model for partitioning port hinterlands based on fuzzy comprehensive evaluation. *交通运输工程学报*, 2(2), 123-126.

⁸ Amir, F. (2016). CPEC and regional integration. *The Pakistan Development Review*, 579-596.

The onset of the COVID-19 pandemic disrupted global trade, causing temporary stagnation. However, as demand and supply of shipments rebounded post-pandemic, port activity surged, underscoring the urgency for ports to enhance their efficiency while incorporating COVID-19 safety protocols into their operational procedures.

1.1.1 Port Terminals

The hub-and-spoke model, introduced to enhance transport efficiency and security, relies on specialized ports along major routes while reducing ports of call, fostering competition among ports to serve as hubs⁹. Ports upgraded infrastructure like quay lengths and cranes to stay competitive, while Global Terminal Operators (GTOs) emerged with extensive networks to secure freight traffic¹⁰.

Though GTOs improved terminal efficiency and stability, they also increased infrastructure costs and faced challenges from larger ships, shifting alliances, and global uncertainties. GTOs focus on economies of scale, requiring innovative evaluation methods for sustained efficiency and competitiveness¹¹.

Overland transportation plays a vital role in enhancing port performance by reducing container wait times, congestion, and turnaround times. Better coordination of hinterland logistics via trucking, rail, and inland waterways strengthens distribution networks and improves operational capacity.¹²

1.1.2 Port of Karachi

By 1852, Karachi had grown into a thriving metropolis with a population of around 14,000 and thriving overseas market commerce. The operations to dredge the major navigable channel and build a mole or causeway connecting the main harbor with the rest of the city were begun in 1854, which is when the current Port began to take shape. Five years later, work on the Manora Breakwater, Keamari Groyne, Napier Mole Bridge, Native Jetty, and China Creek began, giving the port its first shape.

The port's capacity was around 1.5 million tonnes of dry cargo and 1.0 million tonnes of P.O.L. products per year at the time of independence in 1947. At present, Karachi Port processes around 11.74 million tonnes of liquid cargo and 25.45 million tonnes of dry cargo, including 1,213,744 TEUs, representing almost 60% of the nation's imports and exports.

⁹ Antão, P., Soares, C., & Gerretsen, A. (2005). Benchmarking analysis of European sea ports and terminals. *Maritime Transportation and Exploitation of Ocean and Coastal Resources (IMAM 2005)*, 2, 1301-1310.

¹⁰ Bai, Y. C. (2008). Research of Hinterland Segmentation Method Based on Attractive Force Model [D]. *Beijing Jiaotong University, Beijing*.

¹¹ Khan, A., Ahmad, N., & Sharif, N. (2019). Highlighting the Dynamics of the Game-Changer: Empirical Evidence from Stock Markets of the Key Players. *International Journal of Experiential Learning & Case Studies*, 4(2).

¹² Mckinnon, A., (2013). Efficient Hinterland Transport Infrastructure and Services for Large Container Ports. *International Transport Forum Discussion*.

The Port has two container terminals: the Pakistan International Container Terminal (PICT), which is operated by International Container Terminal Services (ICTS), and the Karachi International Container Terminal (KICT), which is operated by Hutchison. Both terminals were built on a build-operate-transfer (BOT) basis by the private sector. The new Deep Water Container Port at Keamari Groyne, located to the south at the approach to Karachi Port, began development in 2006 under the direction of KPT with initial activities including dredging, land reclamation, and construction planning as detailed in KPT's annual development reports from 2006 onwards.

1.1.3 Hutchison Port Holdings: South Asia Pakistan Terminal (SAPT)

South Asia Pakistan Terminal (SAPT) by Hutchison Port Holdings for the delivery of the first 4 berths and 1.5 km of quay wall to support a throughput of 2.5–3 million TEU. South Asia Pakistan Terminal is the name of the first phase's concessionaires, Hutchison Port Holdings (HPH) (SAPT). The superstructure and apparatus are managed by Hutchison Port.

The central focus of this study is the issue of port inefficiency, a multifaceted problem with far-reaching consequences. This research aims to comprehensively investigate the various factors contributing to port inefficiency, with a particular emphasis on the challenges that impede port performance. Within this overarching problem, the research paper delves into the critical relationship between hinterland logistics and port performance, recognizing their interdependence and their combined impact on the overall efficiency of ports, specifically in the context of Karachi. To guide this investigation, the following research questions have been formulated:

- a. Is there an established link between the performance of hinterland logistics and the performance of Karachi Port?
- b. What are the factors that affect the performance of the hinterland and logistics?
- c. What determinants affect the port performance efficiency at Karachi Port?

2. Literature Review

2.1 Hinterland Transportation in Pakistan

In Pakistan, roadways and railways are the two only hinterland transportation methods that are being utilized to transport goods from and to the seaports of Karachi for shipment and trade. While Pakistan is blessed with many rivers and canals, inland water transportation is zero. In-country trade includes a wide range of agrarian commodities from farms to marketplaces, as well as manufacturing goods from diverse regions throughout the nation. As a result, a 9,574-kilometer state motorway and expressway

infrastructure support this weight of internal and overseas commerce, accounting for only 3.65% of the total roadway infrastructure yet transporting 91 percent of local human flow and 96 percent of the cargo. Furthermore, owing to the Belt and Road Initiative (BRI) and the China-Pakistan Economic Corridor (CPEC) transit, cargo congestion is expected to increase dramatically. To sustain the existing volume in the near and intermediate future, a 350 percent expansion in roadway width could be necessary. To retain the existing commerce quantity volume, spending roughly 35 billion dollars is necessary, with a mean expense of approximately one million dollars per kilometer for an expressway. One hundred seventy billion tonnes per kilometer indicates an overburdened roadway transit system and spending 35 billion dollars on the construction of roads in the next eight to ten years for Pakistan is nearly impossible due to the deteriorating economic conditions of the country¹³.

2.2 Empirical Literature Review

Young et al (2016) found that in maritime the relationship between supply chain collaboration (SCC), collaborative advantage, and port performance. Data were gathered via a web-based questionnaire poll that drew 178 responses from South Korean maritime logistics companies. Using hierarchical analysis and structural equation modeling, hypotheses were evaluated. The findings support the hypothesis that supply chain collaboration (SCC) enhances collaborative advantage, which enhances port efficiency. The results show that the relationship between SCC- port performances is fully mediated by collaborative advantage. The goal of this effort is to encourage managers to recapture the benefits of inter- organizational SCC practices in boosting port performance and collaborative advantage inside the port supply chain. Ports are putting a lot of money, time, and effort into new initiatives or the renovation of existing facilities to improve port performance and customer satisfaction. Due to how difficult and expensive it is to get rid of finished construction, ports are likely to have significant sunk costs.

The findings support the notion that ports can produce business synergy, quality, innovation, and flexibility through SCC such as information sharing, knowledge creation, collaborative communication, goal similarity, decision harmonization, and joint supply chain performance measurement between ports and port users along the port supply chain. Therefore, it is clear that where ports or port users are reluctant to invest their efforts in developing collaborative activities, it is difficult to gain a competitive advantage through collaboration. Additionally, this study's findings confirm the hypothesis that there is a favorable correlation between collaborative advantage and port performance.

For each supply chain partner, the collaborative advantage often increases company performance. Notably, the purpose of this study was to analyze the role of collaborative advantage in the maritime context by investigating port performance. According to the results, a port and its customers are more likely to experience improved port performance in terms of connection, value-added services, safety and security, efficient operation, cost efficiency, and user ease. This outcome is in line with other

¹³ Tehsin, M., & Nasir, S. I. (2019). Inland Water Transport in Pakistan: Limits and Prospects. *Global Social Sciences Review*, 4(1), 441.

research showing how innovation, quality, and flexibility can increase efficiency and effectiveness.

3. Methodology

3.1 Research Approach

This study employs a qualitative analysis approach, given its exploratory nature. Exploratory research methodology involves interpreting data to connect various aspects of research inquiries when no distinct vantage point is available. To investigate the impact of the logistics network on port performance, the study engaged with key professionals at Karachi Port Trust (KPT) through interviews.

3.2 Research Strategy

The primary objective of the study is to explore the complex relationship between logistics and hinterland systems, and how they influence port performance and efficiency. Additionally, this research seeks to identify the underlying factors influencing hinterland logistics and port performance, ultimately affecting port efficiency. The research strategy for this qualitative study comprised several key steps. Secondary research was conducted to identify the primary factors influencing hinterland logistics and port performance, providing a foundational understanding. Qualitative research methods, including interviews with professionals at Karachi Port, were employed to uncover emerging factors, themes, and latent issues that impact hinterland logistics and port performance. Data collected during interviews were analyzed thematically to identify patterns, challenges, and opportunities in improving hinterland logistics and port performance. Based on the findings, recommendations and implications for enhancing port efficiency and hinterland logistics were formulated. A graphical overview of the research strategy is provided below to illustrate the process.

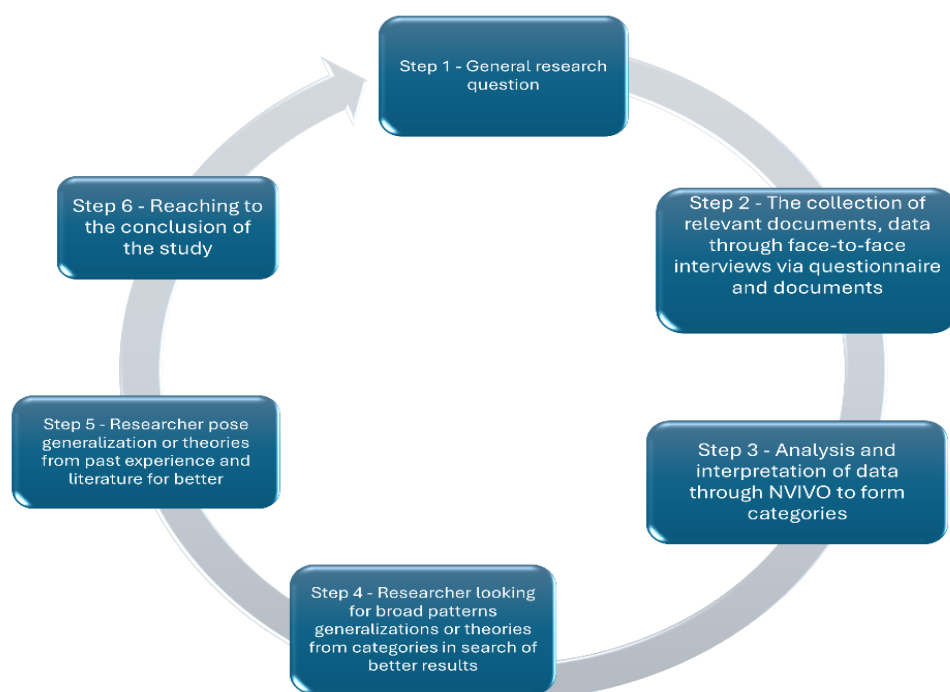


Figure 1 Research Strategy Population Sampling

Ethics start to develop with intent and end with the interview-neatly annotated as the primary means of data collection. Informal consent suffices to eliminate copyright and plagiarism concerns. Principles of the following kinds of research guided the study:

- a. Open discussions on serious issues.
- b. Aware of different responsibilities.
- c. Adherence to standards of prior informed consent where appropriate.
- d. Respect of confidentiality and privacy.

4. Reporting of Results and Findings

The outcomes of interviews conducted with operational management personnel at Karachi Port Trust (KPT) who possess significant experience in port operations are presented (fig 1).

4.1 Analysis and Findings

Data analysis was conducted using the transcriptions of the interviews and completed questionnaires. To visualize recurring key phrases related to port performance and hinterland-logistics linkages, a word cloud was generated using specialized software. Additionally, NVIVO, a dedicated qualitative data analysis program, was employed to code the data, with these codes subsequently organized into thematic categories. The project map generated by NVIVO served as a visual representation of the study's overarching concepts and structure.

The program allowed for a fair comparison of the interviews because identical codes could be compared, and it was discovered that 70% of the conversations had the same issues. As a result, no additional interviews were conducted.

4.2 Measurement of Hinterland- Related Performance

Measuring hinterland connectivity performance is challenging due to inconsistent and limited data, complicating comparisons and evaluations. Connectivity operates on two levels: macro (national transportation networks) and micro (ports, dry terminals, and

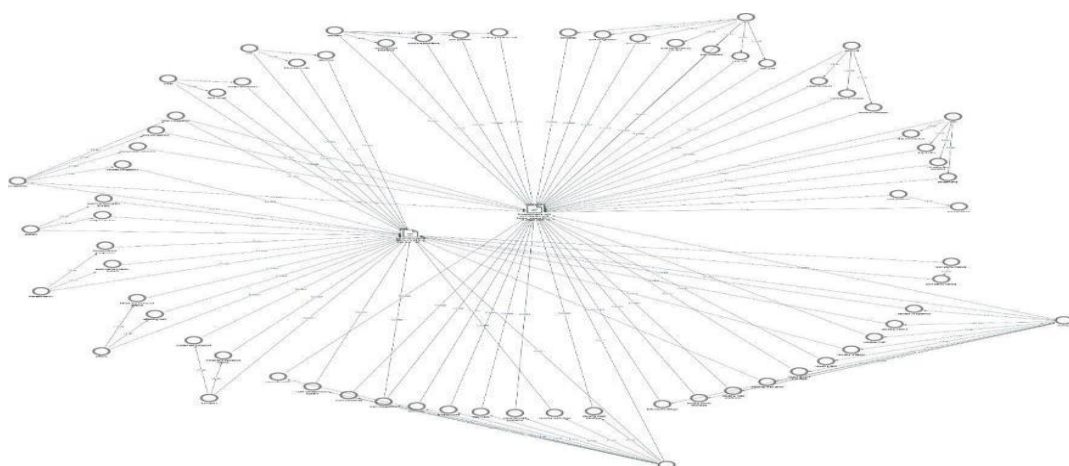


Figure 2 Project Map of Thematic analysis using NVIVO

corridors). While ports can use metrics like service frequency, travel duration, and processing times to assess performance, no uniform evaluation exists, especially in Pakistan, where data collection is significantly constrained¹⁴. Ecological performance metrics are also gaining relevance.

The World Bank's Logistic Performance Index (LPI), comprising six key components such as customs efficiency, transportation quality, and logistics costs, evaluates countries' logistical systems. Pakistan has consistently ranked at the lowest end of the LPI, with a score of 2.2 in 2019, and is ranked 122nd out of 136 on the Enabling Trading Index. On the Trading Across Borders Index, Pakistan remains outside the top 100, reflecting challenges in cross-border trade. Recent improvements, such as integrating the Web-Based One Customs (WEBOC) platform and streamlining documentation, have had limited impact (Web Desk, 2021).

Despite some progress, Pakistan faces numerous challenges in improving hinterland and logistical networks. This section identifies key issues in Karachi's hinterland logistics based on secondary research and primary insights from interviews and observations.

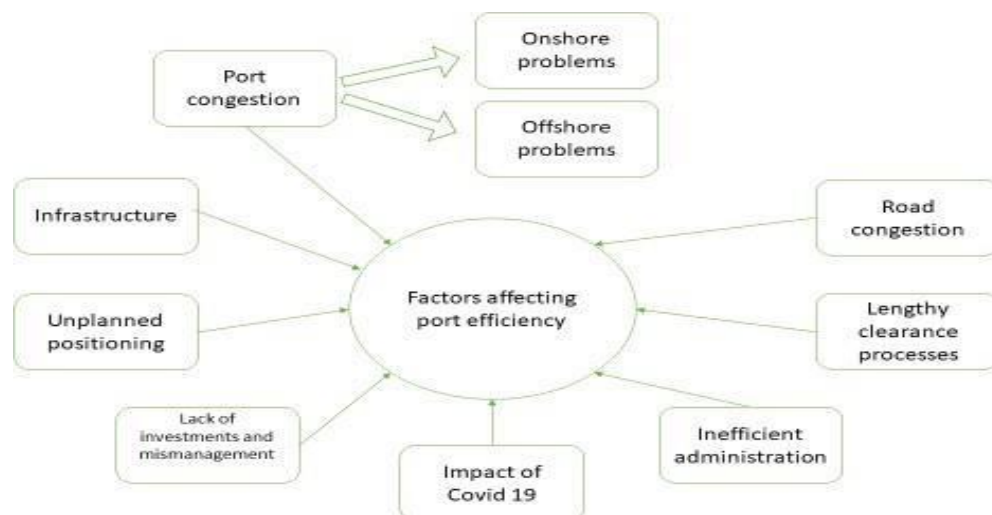


Figure 3 Factors affecting Port Efficiency

The transport infrastructure that connects the hinterland to highways and intercity transport routes for cargo is underdeveloped.

As mentioned previously, the process of getting clearance for cargo transport trucks and vehicles from the port is an unnecessarily long and drawn-out process that spans over the time of many days sometimes. During this time, the vehicles remain parked within the hinterland area as they cannot leave the area without being officially cleared by agents.

Mismanagement is the primary reason why delays occur in many operations of logistics in the hinterland. Most of the data is stored manually on pieces of paper,

¹⁴ Bank, W., (2009). Transport Costs and Specialization. World Development Report. Reshaping Economic Geography, pp. 170-196.

clearance slips are printed, filled in, and signed by the department. Truck and cargo labeling and recordkeeping are mostly on paper creating delays in many subsequent and dependent operations of the logistics and delaying decision-making. Elements of corruption can also be seen at the administration level, making operations of logistics in the hinterland inefficient. Railways systems for transport have become inefficient over the years due to political agendas, lack of administrative efficiency, and mishandling of investment.

Vehicles often remain parked in the hinterland for extended periods due to a variety of reasons. Traffic congestion happens in the hinterland as public transport and cargo transport vehicles end up taking the same routes. Many public transport vehicles remain parked in the hinterland area which is mainly supposed to be for cargo vehicles. Within inter-city transport, roads have converged and narrowed due to encroachments along the road taking up transport space.

4.3 Problems faced at KPT

Based on insights gathered from interviews with KPT personnel, several key challenges hinder the efficient operation of Karachi's ports, particularly related to port congestion and offshore issues. Karachi ports experience significant congestion as specific terminals are required for different cargo types, such as containers and bulk ships. The lack of enough terminals results in ships waiting at anchorage, leading to delays in offloading and loading cargo. Additionally, there is a limited capacity for ships to be berthed until clearance is obtained, causing delays and congestion. Ships may also miss optimal tide timings, further hindering smooth port operations.

As gathered from the interview with the KPT personnel, there are a few major problems that can be said to exist at the port which serves to hinder the efficient performance of ports in Karachi. Specific terminals are usually needed for each type of cargo such as container ships, bulk ships, etc. There are not enough terminals for each trade of cargo leading to port congestion as ships have to wait out at anchorage. Delays in getting clearance for incoming or outgoing cargo to be offloaded or loaded into containers for shipments leave ships having to stay on the sea near the port, crowding the area. The KPT have a limited number and size of ships that can be anchored and berthed till clearance has been received. With many ships already at the port, new ships must often delay coming into the port to drop off shipments or standby at nearby distances of the port. Delays in the processing of shipments often lead to ships missing the high tides that come into the port which enable ships to steer into and out of the KPT. Due to the flow of high and low tides, siltation builds up at the bed of the sea and areas near the port further decreasing the depth of the ports to less than 12 meters in KPT which cause problems for much heavier and deep ships to steer into the ports. Inadequate insufficient road construction, planning, and the narrowing of roads in the vicinity of the port have collectively contributed to severe road congestion. The road infrastructure struggles to accommodate the growing volume of traffic, including cargo trucks, transport vehicles, and commuter traffic, leading to frequent traffic jams and delays. The problem of road convergence compounds the issue of road congestion. Encroachments onto roadways

and thoroughfares near the port have further narrowed the available road space. These unauthorized constructions not only reduce the width of roads but also disrupt the smooth flow of traffic, creating bottlenecks and exacerbating congestion. The ongoing construction projects near the port area have significantly reduced the availability of parking spaces. This shortage of parking facilities places additional stress on the already congested road network. Vehicles, including those of port workers and visitors, often struggle to find suitable parking spots, leading to further chaos and delays. Unregulated parking practices by various forms of public transport, such as rickshaws and qing-qi vehicles, contribute significantly to congestion outside the port. These indiscriminately vehicles along often park roadsides, obstructing the flow of traffic and causing further gridlock. The lack of organized parking zones for these and other vehicles, combined with broader infrastructural and regulatory shortcomings, further exacerbates the already critical congestion around the port.

Furthermore, supply and demand imbalances, coupled with Ukraine's civil unrest affecting grain imports, have led to decreased ship traffic. Government policies imposing higher import taxes and duties have increased the cost of raw material imports, discouraging companies from importing goods. Moreover, nearly all trade with China is routed through Gwadar Port rather than Karachi Port, primarily due to the strategic alignment of the China-Pakistan Economic Corridor (CPEC), which designates Gwadar as the central hub for trade and connectivity under the agreement—leaving Karachi Port underutilized for this purpose. This also means nearly all investments in the development of the port and hinterland at Gwadar are for that region specifically and developed of particular highways that aid in transporting these shipments up to the landlocked countries. Budgets allocated for the port are often poorly managed and end up being applied in inefficient ways in less important projects. The port's transport infrastructure, including its road network, has reached a state of advanced deterioration. Years of heavy usage, exposure to the elements, and inadequate maintenance have taken their toll. As a result, roads within the port area are riddled with potholes, cracks, and uneven surfaces. This deterioration poses a significant risk to vehicles, especially cargo trucks, which are often laden with heavy shipments. These road conditions frequently lead to vehicle breakdowns and unexpected delays in the movement of goods to and from the port. Moreover, the rough and uneven roads can cause damage to cargo and result in increased maintenance costs for transport companies. The port's infrastructure suffers from inadequacies and deficiencies that impede the efficient operation of essential heavy equipment, such as cranes used for the loading and unloading of containers. These faults may manifest as electrical issues, mechanical breakdowns, or structural weaknesses in the equipment. When cranes and other crucial machinery experience malfunctions due to faulty infrastructure, it disrupts the cargo-handling process and causes delays in vessel operations. The reliability of equipment is paramount in maintaining port efficiency, and any disruptions resulting from faulty infrastructure can have cascading effects on overall port productivity and timeliness.

Additionally, Karachi's historical development has been characterized by a lack of structured urban planning. Over the years, the city experienced rapid growth without the

implementation of a coordinated and well-thought-out urban development plan. Consequently, the expansion of Karachi took place in an unplanned and ad-hoc manner, resulting in a cityscape with inconsistent construction patterns and road layouts. The absence of a comprehensive urban plan has led to challenges in infrastructure management, services, and urban mobility. Karachi's ports suffer from significant urban planning issues related to their remote location from major highways. Unlike well-designed port systems in some other cities, the exits of Karachi's ports are situated at a considerable distance from the main highways. This lack of a planned and direct connection to major transportation arteries means that cargo transport vehicles must navigate through city roads to reach highways, leading to traffic congestion, increased travel time, and a higher risk of accidents. The absence of efficient and direct access routes between ports and highways hinders the smooth flow of goods in and out of Karachi's ports.

5. Discussion and Conclusion

In summary, the efficient functioning of inland transportation is pivotal to alleviating congestion at port entrances, reducing truck turnaround times, and minimizing queue wait periods. The management and enhancement of truck achievement encompasses three crucial facets; infrastructure development, administrative efficiency, and attention to political and legal considerations. Notably, congestion emerged as a predominant challenge affecting both hinterland areas and the ports themselves.

The origins of this congestion are multifaceted and can be attributed to several interconnected factors. Escalating transportation costs, driven by rising inflation and fuel prices, have placed a substantial burden on the logistics industry. Additionally, the reluctance of businesses to meet payment obligations, coupled with labour strikes within the transportation sector, further exacerbates the issue. These strikes lead to cargo-laden vehicles idling in hinterland areas and outside port premises, even after obtaining clearance. Furthermore, the ad-hoc road inspections conducted by traffic police on cargo vehicles, especially those carrying liquid or dry cargo, contribute to road congestion. The lack of proximity between Karachi's ports and major highways necessitates cargo-loaded trucks to navigate intercity routes, compounding traffic congestion risks and increasing the potential for accidents, endangering human lives and cargo integrity. Addressing these multi-faceted challenges requires a comprehensive approach, including infrastructural improvements, effective administration, and policy interventions. Additionally, fostering open dialogue and collaboration between stakeholders in the logistics and transportation sectors is crucial for identifying sustainable factors that impact hinterland logistics and port performance are essential for optimizing the efficiency and sustainability of Karachi's seaborne trade.

Private corporations, commercial shipping, transportation companies, logistics providers, emptying representatives, hinterland travel suppliers, commuter trains, and bulk carriers' businesses, as well as government bodies such as customs, container terminals, quality inspection, and management companies, are all involved in hinterland transportation. This research looked at the cooperation in hinterland transportation and

proposed several strategies to increase cooperation in areas where there are more obstacles inside the quality and supply chain. They noted that a lack of ambition and motivation for continued collaboration, such as free-riding issues, informational inconsistency, and the demand for contractual duties, which originate from a cost-benefit mismatch and a lack of readiness to spend, might stymie progress. It was summarized that coordination issues arise for a variety of reasons, including poor information return, investor difficulties, online platforms requiring basic quantities that may be turned down if not encountered, inadequate planning for empty container management, traditions and safety checks delays, and incomplete knowledge about vessel customs clearance. In addition, four major control system structures were established to improve coordination: including the introduction of incentive schemes (such as rewards or variable pricing), the establishment of penalty systems to discourage non-compliance, the formation of inter-firm alliances, and the redesign of collaborative efforts between port operators and transportation firms. Much like the globally renowned ports that successfully catered their turned around time and their ineffective operations and moved towards better performance, Pakistan, especially KPT can try and implement some ways, if not all, in Karachi's ports and make sure that the administration of the hinterland logistics leads towards the efficient performance of its operations.

For improvement in the performance of ports in Karachi relating to administrative issues, the port should implement more automated practices for performing administrative activities.

A substantial body of research has been dedicated to exploring ways to enhance the efficiency of hinterland transportation. Among these, optimizing the flow of trucks and cargo vehicles responsible for transporting goods to and from the port emerges as a pivotal solution in alleviating congestion both at the port and in the hinterland. Removing bottlenecks created by trailers is a practical step to decongest terminal gates. Notably, only half of the drivers of imported box trailers had the requisite administrative documentation, a significant factor contributing to port gate bottlenecks.

The Transportation Research Board has shed light on another crucial aspect improper documentation carried by trailer drivers, which has been a contributing factor to congestion at port entrances. Ports worldwide have implemented various strategies to streamline truck flow, reduce congestion, and mitigate the adverse effects of excessive reliance on destination system¹⁵. These strategies include:

The Truck Appointment System involves scheduling truck arrivals at ports, distributing truck traffic evenly throughout the day. Drivers are incentivized to adhere to their scheduled appointments, as exceeding a 30-minute idle time can result in substantial fines. Utilizing digital platforms and social media applications has facilitated this scheduling process, enhancing truck flow, terminal capacity, and overall productivity for trucking businesses and terminals.

¹⁵ Giuliano, G., & O'Brien, T. (2008). Extended gate operations at the ports of Los Angeles and Long Beach: a preliminary assessment. *Maritime Policy & Management*, 35(2), 215-235.

Additionally, extended gate hours encourage trucking companies to shift their operations to off-peak hours, thereby reducing traffic at ports and on city roads¹⁶. Programs like the Pier PASS initiative, utilized in Pakistani and Kashgar, Chinese ports, have implemented a Traffic Mitigation Fee (TMF) during peak hours, which cargo owners must pay. Conversely, trucks arriving during off-peak hours are exempt from the TMF. However, challenges such as long lines just before off-peak hours begin need to be managed.

The extended gates strategy also involves relocating a portion of port operations and cargo processing, as well as immigration procedures, to inland ports. This approach effectively reduces congestion at the primary port terminals and gates. Many ports worldwide have adopted this strategy, established an inland expanded gate network and integrated inland ports with distribution centers to create dry ports, thus simplifying hinterland transportation networks. Several nations have invested in dedicated freight routes, roads, and corridors, facilitating uninterrupted freight movement while segregating it from urban passenger transportation.

Although in its nascent stages, automated transportation technology shows promise. Benefits include reduced labor costs, 24-hour operations, and enhanced reliability. Autonomous transportation methods include automated trucks and multi-trailer systems, automated trains, automated barge handling systems, and automatic compartment rail systems. While the initial investment in automation equipment is significant, the potential for labor cost savings and round-the-clock functionality makes it a viable consideration.

Finally, truck flow optimization is just one of the critical aspects that need to be improved when dealing with port and hinterland logistics. Efficiency in moving goods is entirely dependent on good strategies and technologies. It is well known that truck turnaround times and vehicle throughput significantly impact the overall quality of service that ports offer. Therefore, these strategies must be considered by authorities and stakeholders as top priorities in their actions to enhance efficiency, reduce congestion, and promote transportation.

¹⁶ Epstein, C., (2003). State taxation of imported goods in Customs. *Journal of Eastern Asia Society for Transportation Studies*, 5(3), pp. 726-741.