

“THE ROLE OF INLAND CONTAINER DEPOT (ICD) IN ENHANCING MARITIME SUPPLY CHAIN EFFICIENCY”

Project report submitted to the School of Maritime Management, Indian Maritime University
in partial fulfilment for the requirements for the award of degree of

MASTER OF BUSINESS ADMINISTRATION

In

PORT AND SHIPPING MANAGEMENT

Submitted by

**SHEKHAR PAREEK
(Reg. No. 2303304030)**



Under the guidance of,

Dr .Totakura Bangar Raju

Professor, Dean SMM

INDIAN MARITIME UNIVERSITY

(A Central University, Government of India)

SCHOOL OF MARITIME MANAGEMENT

CHENNAI CAMPUS

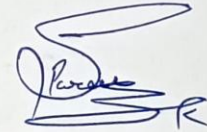
MAY 2025

DECLARATION

I, **SHEKHAR PAREEK**, Reg. No.2303304030 student of School of Maritime Management, Indian Maritime University, pursuing MBA in Port and Shipping Management hereby declare that this submission of this project report titled “**THE ROLE OF INLAND CONTAINER DEPOT (ICD) IN ENHANCING MARITIME SUPPLY CHAIN EFFICIENCY**” - has been prepared by me towards the partial fulfilment of the Master of Business Administration in Port and Shipping Management under the supervision of **Dr. Totakura Bangar Raju** Professor Dean SMM, Indian Maritime University, Chennai Campus. I also declare that this project report is my original work and has not been copied from any other report previously submitted for the award of any degree, fellowship or other in the similar title.

Place: Chennai

Date: 27/05/2025



SHEKHAR PAREEK

Reg.No: 2303304030

CERTIFICATE

This is to certify that this project report entitled “**THE ROLE OF INLAND CONTAINER DEPOT (ICD) IN ENHANCING MARITIME SUPPLY CHAIN EFFICIENCY**” submitted to the School of Maritime Management, Indian Maritime University, Chennai Campus in partial fulfilment of the requirement for awarding the degree, MBA in Port and Shipping Management (PSM) is a genuine work of SHEKHAR PAREEK (Reg no. 2303304030)

Project Guide



Dr. Totakura Bangar Raju

Assistant professor



Dr. B Swaminathan

Associate Professor & Head, SMM


External Examiner:



Place: Chennai

Date: 27/05/2025

ACKNOWLEDGMENTS

First and foremost, I would like to thank God the Almighty who has granted countless blessings, knowledge and opportunity to complete this project to its fullest.

I would like to thank my parents for the moral support and cooperation throughout the programme. My heartfelt and sincere thanks to, **Dr. B Swaminathan**, Associate professor Head SMM, Indian Maritime University, Chennai Campus who gave me the golden opportunity to do this wonderful project on the topic “**The Role of Inland Container Depot in Enhancing Maritime Supply Chain Efficiency**”. I pay him my deep sense of gratitude for guiding me.

I would like to express my deep sense of gratitude of **Dr. Totakura Bangar Raju** Professor Dean SMM, Indian Maritime University, Chennai Campus. For his esteemed guidance and expert suggestions in each step of the project, alleviating inspiration, encouraging and kind supervision in the completion of my project.

I am also thankful to faculty members, library staffs, my friends and my well-wishers who were very cooperative during my project in providing appropriate guidance and support without whom this project would not have been completed successfully.

SHEKHAR PAREEK

Abstract

This project looks into how dry ports and inland container depots (ICDs) can improve the efficiency of the maritime supply chain and relieve congestion in India's coastal ports. It evaluates how ICDs integrate multimodal transport, reduce port bottlenecks, and cut logistics costs in light of India's thriving trade. In addition to identifying operational challenges and best practices, the objectives involve evaluating the effects of ICD on seaport congestion, cargo flow, and cost efficiency.

The descriptive and analytical methodology uses secondary data from industry and government sources. Analysis is done on key performance metrics, such as cost/revenue per TEU, yard utilisation, gate throughput, and container dwell time. These metrics are projected forward by trend analysis and time-series forecasting using Holt's Double Exponential Smoothing, while performance gaps and success factors are highlighted through comparative benchmarking (across domestic and international ICD examples). ICD's contributions to cost savings and logistics performance are measured using this hybrid approach.

The results demonstrate the notable increase in efficiency at ICDs such as Tughlakabad (Delhi). The average dwell time peaked at approximately 9.84 days in 2018 and decreased to 6.70 days by 2023, while the average daily gate throughput increased from roughly 1,360 to 1,464 TEUs (a 7.6% gain) between 2014 and 2023. Additionally, yard utilisation increased (capacity usage increased from approximately 68% to 82% due to automation and additional cranes). Even though dwell time is expected to increase slightly to about 7.66 days, throughput is expected to reach about 1,767 TEUs by 2025 (an additional 20.7% increase), indicating the need for continuous efficiency improvements. Additionally, according to the analysis, moving about 45% of container movements from the road to the rail (via designated corridors) has reduced transportation costs by about 12%, and digitising customs procedures has accelerated clearance (cutting processing times by about 28%).

The study comes to the conclusion that India's logistics future depends on strategic ICD expansion. Implications for policy include investing in terminal automation and tracking (aiming for dwell times of less than five days), standardising clearance processes across the country, and expanding rail and inland waterway connections to underserved areas. These actions will support national objectives (like bringing logistics costs under 10% of GDP under Sagarmala and the National Logistics Policy) and fully utilise ICDs as multimodal logistics hubs.

Table of Contents

| | |
|--|-----------|
| 1.0 Introduction | 1 |
| 1.1 Objective of The Study | 2 |
| 1.2 Statement of the Problem | 2 |
| 1.3 Rational Behind The Study..... | 3 |
| 2.0 Literature Review | 5 |
| 3.0 Methodology | 17 |
| 3.1 About Data Collection..... | 17 |
| 3.2 About Trend Analysis Methodology..... | 18 |
| 3.3 Steps To Use Trend Analysis..... | 19 |
| 3.4 About Comparative Analysis Methodology | 20 |
| 4.0 Data Analysis | 22 |
| 4.1 Dwell Time..... | 22 |
| 4.2 Gate Throughput | 28 |
| 4.3 Yard Utilization | 32 |
| 4.4 Revenue and Operation Cost | 36 |
| 5.0 CONCLUSION | 41 |
| 6.0 REFERENCES | 43 |

List of Table and Figures

| Sl. No | Figures/Table No. | Description | Page No. |
|-----------|----------------------|--|-------------|
| 1 | Table 1 | Year wise PRE Score and Normalized PRE of ICD (Average) | 27 |
| 2 | Table 2 | Year wise Gate throughput | 29 |
| 3 | Table 3 | Yearwise Forecast, Annual Increase And Cumulative Data | 31 |
| 4 | Table 4 | Yearwise Utilization, Level, Trend And Forecast Data | 35 |
| 5 | Table 5 | Yearwise Revenue and Operation Cost per TEU | 37 |
| 6 | Table 6 | Yearwise Actual Revenue and Smoothed Level Revenue with Trend and Forecast Data | 38 |
| 7 | Chart 1 | Normalized Port Relief Efficiency | 27 |
| 8 | Chart 2 | Trend Forecast of Gate Throughput TEU'S Per Day | 32 |
| 9 | Chart 3 | Trend Forecast of Yard Utilization | 36 |
| 10 | Chart 4 | Trend Forecast of Revenue and Operating Cost per TEU'S | 40 |

List of Abbreviation

- ICD -Inland Container Depots
- DFC -Dedicated Freight Corridor
- NLP -National Logistics Policy
- GDP -Gross Domestic Product
- PCS -Port Community System
- PPP -Public Private Partnership
- CII -Confederation of Indian Industry
- AHP -Analytical Hierarchy process
- TEU -Twenty-foot equivalent unit
- RFID -Radio Frequency Identification
- FICCI -Federation of India Chambers of Commerce and Industry
- ASSOCHAM -Associated Chambers of Commerce and Industry of India.
- GOI -Government of India

1.0 Introduction

India's economy is growing fast, and trade has significantly increased over the years. With a coastline stretching over 7,500kilometers, major ports like Jawaharlal Nehru Port Trust (JNPT), Chennai Port, Mundra Port, and Kolkata Port play a crucial role in India's maritime trade. However, issues like crowded ports, poor infrastructure, slow cargo handling, and customs delays pose challenges. These problems increase logistics costs and affect India's competitiveness in global trade. To tackle these issues, Inland Container Depots (ICDs) and dry ports are becoming important in India's logistics network.

ICDs and dry ports act as extensions of seaports, allowing goods to be moved, stored, and cleared away from the congested ports. Located in vital industrial and agricultural areas, they improve connections between inland regions and seaports. As logistics centers, ICDs reduce port congestion, speed up customs checks, and ensure smooth movement of goods through multiple transport routes like railways, highways, and waterways.

Recognizing the importance of ICDs and dry ports, the Indian government has pushed for their development. Initiatives like the Sagarmala Programme aim to lower logistics costs and enhance port connectivity. The Dedicated Freight Corridor (DFC) improves rail cargo movement, thus strengthening India's logistics infrastructure. Moreover, the National Logistics Policy (NLP) 2022 focuses on building a seamless, technology-driven supply chain by integrating ICDs with digital platforms and automation.

India's "Make in India" and " Atmanirbhar Bharat" initiatives stress the need for efficient logistics to boost local manufacturing and exports. As global trade evolves, ICDs have become crucial for cutting transport times, reducing transportation costs, and offering value-added services like packaging, warehousing, and customs clearance.

This project explores the role of ICDs and dry ports in enhancing India's maritime supply chain, focusing on their impact on logistics efficiency, trade facilitation, and economic growth. It examines examples, policy frameworks, and infrastructure developments to highlight the increasing significance of these logistics centers in transforming India's supply chain ecosystem.

1.1 Objective of The Study

The main purpose of this project is to explore how Inland Container Depots (ICDs) and dry ports help improve India's sea transportation system. We are looking to understand their effect on trade efficiency, reducing logistics costs, and how they support different modes of transport working together. The specific aims are:

1. To see how ICDs and dry ports reduce congestion at large Indian seaports and make cargo movement smoother.
2. To evaluate how ICDs impact logistics efficiency, transportation costs, and ease of trade in India.
3. To identify the challenges ICDs face, such as infrastructure problems, regulations, and connectivity issues.

1.2 Statement of the Problem

With about 95% of India's trade by volume and 70% by value carried out through maritime transport, the maritime supply chain is vital for economic growth. However, problems like congested ports, inefficient cargo handling, inadequate storage, and customs delays hinder efficiency. These issues increase waiting times, drive up transport costs, and disrupt trade, impacting India's global trade standing.

Major ports like Jawaharlal Nehru Port Trust (JNPT), Chennai Port, Mundra Port, and Kolkata Port are overburdened, facing limited capacity, slow cargo movement, and long wait times, leading to delay and higher costs. Many industrial and agricultural hubs are located far from seaports, making inland transportation crucial yet challenging. Without an efficient transport network, reliance on road transport becomes expensive, time-consuming, and prone to delays.

ICDs and dry ports act as logistics solutions, facilitating cargo movements between inland areas and seaports. They offer customs services, storage, multimodal transport connections, and additional services like packaging and consolidation. By reducing port congestion and improving supply chain efficiency, they contribute significantly to the logistics system. Nonetheless, ICDs in India still face operational and infrastructure challenges that need to be addressed for optimal efficiency.

In India, there are several main problems with Inland Container Depots (ICDs) and dry ports:
Infrastructure Problems: Many ICDs do not have modern facilities or up-to-date cargo handling equipment. They also lack advanced technology, which makes cargo management and transportation less efficient.

Regulatory Challenges: The customs processes are complicated, and government procedures can be slow. Rules often change, which makes it difficult for ICDs to operate smoothly and increases costs.
Connectivity Issues There is poor train and road connectivity between ICDs, industrial areas, and seaports. This results in high transportation costs and delays in delivery times.

Limited Use of Technology: Many ICDs are slow to introduce automation, digital tracking systems, and smart logistics solutions. This slowness restricts their ability to work efficiently.

Cost Concerns: High fees at some ICDs make them less attractive for exporters and importers. As a result, their usage and effectiveness are reduced.

The government has launched initiatives like the Sagarmala Project, the Dedicated Freight Corridor (DFC), and the National Logistics Policy (NLP) to improve logistics efficiency. However, challenges remain in making ICDs work effectively within the maritime supply chain. It is crucial to closely examine the role of ICDs and dry ports in enhancing India's maritime supply chain. Identifying key inefficiencies and exploring possible policy and infrastructure improvements could optimize their impact.

This study focuses on understanding the importance of ICDs and dry ports in bolstering India's logistics network. It also looks at the obstacles they face and provides strategic solutions to improve their role in facilitating efficient cargo movement and boosting trade growth.

1.3 Rational Behind the Study

An essential part of global trade, the seaborne supply chain is usually beset by bottlenecks like port congestion, poor cargo handling, and delays in inland distribution. Dry ports, also known as inland container depots (ICDs), have become a popular option for improving logistical capacity and deconcentrating port activity away from coastal areas. The need to evaluate how ICDs reduce seaport strain while enhancing the effectiveness, dependability, and affordability of the seaborne supply chain is what spurred the study. Though the proven significance of ICDs is established, their contribution towards supply chain integration is yet to be explored in most

developing economies. This research endeavors to bridge the gap by studying how ICDs help achieve smoother cargo movement, enhance hinterland connectivity, and sustain multimodal transport networks. ICDs are the key centers that are accountable for timely clearance, warehousing, and transportation of goods, thus enhancing overall supply chain performance. The rationale also stems from an awareness of how ICDs facilitate the seamless movement of containers between ports and inland terminals, thereby fostering regional and national trade competitiveness. To make sure that maritime logistics networks can meet future demand, strategic planning and ICD operations optimization are required, especially since trade volumes are still increasing.

This study is thus motivated by the need to investigate the operational, infrastructural, and policy factors that determine the efficiency of ICDs and suggest how they can support maritime logistics in urban and remote areas.

2.0 Literature Review:

The role of Inland Container Depots (ICDs) in the optimization of maritime supply chains has been of significant interest in scholarly and industry literature. Being the operational hubs of the logistics chain, ICDs form part of a vast intermodal transport chain, serving as a remedy to port congestion and facilitating cargo flow from and to ports and hinterland. This literature review synthesizes extant research on the role of ICDs in the alleviation of congestion, turnaround time, and the general efficiency of maritime supply chains. The review highlights the strategic significance of ICDs in optimizing port operations and building logistical capacity, based on a critical analysis of a few chosen studies, official documents, and trade journals. The decentralization of cargo handling by ICDs, the harmonization of multimodal transport infrastructure, and the influence of ICDs on operational variables like container dwell time, transport cost, and supply chain efficiency are some of the main topics of discussion in this review. In addition, this review examines ICDs' challenges with infrastructure, policy support, and geographic disparities in a comprehensive manner, identifying the factors that contribute to their success.

By integrating the literature, the section seeks to present a clearer picture of the current status of ICD development and how it can be employed to further improve the effectiveness of maritime logistics systems. The main infrastructure components in India's modernization and simplification of its maritime supply chain are now Inland Container Depots (ICDs). ICDs are seaport extensions inland that offer container handling, storage, customs clearance, and multimodal connectivity outside of crowded port locations. The growth of ICDs in India has made it possible to process the cargo close to inland sources and destinations, which has directly decongested ports like Mumbai, Chennai, and Mundra. ICDs are at the forefront of the strategic shift in the Indian logistics network toward integrated port rail road connectivity.

For instance, rail corridors connect the Tughlakabad ICD in Delhi and the Whitefield ICD in Bangalore to gateway ports, significantly reducing dwell time and port congestion. These programs align with the Indian government's goal of increasing supply chain efficiency and reducing logistics costs from 14% to less than 10% of GDP through PM Gati Shakti and the National Logistics Policy.

ICDs are not only freight handling terminals; they are also important hubs for regional trade, especially in landlocked and industrial areas, according to Indian research. They speed up cargo

turnaround and enable Just-in Time (JIT) operations for producers and exporters. It is anticipated that the Dedicated Freight Corridors (DFCs), which are currently undergoing expansion, will further improve ICD port interlinks by boosting reliability and throughput capacity. However, there are obstacles like unequal regional ICD deployment, limitations in digital infrastructure, and a lack of coordination among the stakeholders. Coordinated policy implementation, private sector participation, and digital integration via Port Community Systems (PCS) can all help remove the bottlenecks. In a nutshell, ICDs are at the center of India's sea logistics revolution because they provide scalable solutions for port congestion, multimodal transportation, and aligning domestic logistics with the demands of global trade.(Jovin J. Mwemezi, 2012)

Dry ports, also known as Inland Container Depots (ICDs), are a ground breaking way to address supply chain inefficiencies in the maritime industry. ICDs have been seen as crucial extensions that decentralize logistics and enable more efficient inland cargo flows as ports become more congested due to high container traffic volumes and storage capacity concerns. By providing customs clearance, warehousing, and intermodal transfer facilities that allow for extended supply chain performance, ICDs serve as one of the primary nodes connecting the sea and hinterland transportation, according to Roso, Woxenius, and Lumsden (2009).

By avoiding port congestion, cutting down on vessel turnaround times, and extending container dwell times at seaports, ICDs optimize supply chain efficiency. Additionally, improved modal integration from the strategic placement of ICDs makes it easier to coordinate inland and seaport transportation. Coordination of dry ports with seaports lowers transportation costs, improves reliability, and leads to environmental sustainability through modal transfer to rail transport, according to literature. Additionally, one of the main factors influencing the smoothness of trade is the role that ICDs play in facilitating the processing of documentation and customs. ICDs expedite cargo clearance and minimize delays by relocating administrative and inspection tasks from crowded port terminals. The review highlights the importance of policy environments, infrastructure investment, and private sector involvement in improving the operational efficiency of ICDs.

Collectively, recent research shows that ICDs serve as key enablers of resilient, responsive, and agile maritime supply chains, not just for the storage of containers. Port authorities and

governments seeking to boost regional and national trade competitiveness increasingly see their integration into port logistics networks as a strategic necessity.(Finke & Kotzab, 2017)

By reducing seaport congestion and improving logistical efficiency, inland container depots, or ICDs, have emerged as important enablers in the maritime supply chain. ICDs have also been described in the literature as important nodes that facilitate cargo movement, bring port activity inland, and reduce port delays. The aforementioned study by Dhamija and Bag (2020) focuses on how ICDs can improve port performance, specifically in relation to operational, infrastructure, and service quality factors.

Multimodal transportation is made easier by the integration of ICDs with ports, and this is a major factor in lowering turnaround time and cost. It highlights how efficient ICD placement and operation ease seaport traffic, improving cargo evacuation and improving connectivity to the hinterlands. The study's empirical findings highlight how the effectiveness of customs procedures, rail and road accessibility, and warehouse availability are all directly correlated with the operational efficiency of ICDs, which in turn affects the overall dependability of the maritime supply chain.

The contribution of digital infrastructure and process automation in ICDs, which raise supply chain visibility and stakeholder coordination levels, is also covered in the paper. ICDs' strategic position in the maritime logistics system is justified by the performance measurement model employed in the paper, which is based on the Analytical Hierarchy Process (AHP) and prioritizes the most important success factors, such as turnaround time, cost, and value added services. Furthermore, research suggests that ICDs will play an increasingly important role in the expansion of global trade, particularly in developing nations where port congestion and hinterland connectivity are major issues. As a result, ICDs support trade, regional development, and supply chain resilience in addition to logistics. This aligns with your research objective, which is to evaluate how ICDs facilitate the integration, efficiency, and agility of maritime supply chains.(Rusgiyanto et al., 2018)

Particularly in inland or crowded port hinterlands, the incorporation of Inland Container Depots (ICDs) into the maritime supply chain is becoming more widely recognized as a strategic logistics efficiency driver. By promoting multimodal transportation through inland container handling, storage, and customs clearance, ICDs serve as dry ports and relieve seaport congestion. According to published research, ICDs increase supply chain dependability, turnaround time, and operational flexibility by decentralizing port operations. ICDs greatly

increase throughput volume growth, cost savings, and service level improvement in maritime linked trade corridors, according to empirical research, especially from the Indian context. By promoting rail based transportation over long distances, ICDs improve cargo aggregation, enabling economies of scale and lowering transportation costs. Through pre clear facilities, they also decrease container dwell times at ports and increase the efficiency of documentation. According to research, ICDs placed strategically can improve regional trade growth while decluttering important maritime gateways.

According to the reviewed article, ICDs' value contribution is to enhance overall supply chain performance metrics like lead time, availability, and service frequency, even though their primary function is logistical support. The lack of digital integration, infrastructure capacity, and party coordination are the other main issues that have been identified as potentially negating gains. However, in line with global best practices for port hinterland connectivity, ICDs are seen as the key to closing the inland port logistics gap. The key to optimizing the effectiveness of ICDs is thought to be government policy, public private partnerships, and technological innovation. In light of this, the body of research confirms that ICDs are essential infrastructure elements that affect the competitiveness, cost effectiveness, and responsiveness of maritime supply chains rather than auxiliary nodes.(Mohan & Naseer, 2022)

A cutting edge strategy to improve supply chain sustainability and efficiency is the strategic integration of Inland Container Depots (ICDs) into seaport logistics networks. According to the literature, ICDs are a crucial inland extension of seaports that greatly aid in reducing turnaround times, decluttering seaport terminals, and enhancing the effectiveness of cargo handling. By rerouting container flows inland, the dry port concept—a more general category that includes ICDs—is commonly credited with reducing traffic congestion in the cities that surround seaports. Decentralization facilitates port management and reduces environmental impact by switching from road to rail, which greens logistics. ICDs serve as multimodal transshipment nodes where containers are seamlessly moved between modes of transportation, making them essential nodes in intermodal transport chains, as the examined studies demonstrate. This multimodal function improves supply chain connectivity between hinterlands and seaports, enabling better cargo visibility and more coordinated logistics planning. The growth of ICDs is also ascribed to regional economic stimulation through trade facilitation policies, investment attraction, and job creation.

Additionally, appropriate infrastructure planning, ICT integration, and co governance agreements with seaport authorities, customs, and private sector logistics service providers are necessary for efficient ICD operations. The ability of ICDs to facilitate just in time delivery systems and lower overall transportation costs is another key area of scholarship. In crowded seaports, their hinterland location minimizes the chance of demurrage and maximizes inventory control. In general, the literature highlights how ICDs play a dynamic role in promoting the resilience and efficiency of maritime supply chains. They are important components of contemporary port centric logistics systems because of their economic decentralization, operational flexibility, and sustainability role.(Supply Chain Management Systems With Respect to Containerised Ocean Freight to and from India Executive Doctorate,2020)

Inland Container Depots (ICDs) play a key role in improving inland logistics and clearing congestion in ports, which is essential for the competitiveness and efficiency of maritime supply chains. The ICD is a strategic seaport terminal extension that facilitates inland container movement, relieving pressure on coastal ports and increasing logistical efficiency, according to prior research. Research indicates that the integration of ICDs into port operations enhances distribution flow by acting as intermediary nodes to decentralize storage and customs clearance operations. The selected study emphasizes how dry ports, or ICDs, relieve operational backlogs at overcrowded seaports, especially in developing regions of the world where infrastructure bottlenecks are prevalent, like Sub Saharan Africa.

Geographical location, intermodal connectivity, and regulatory frameworks all affect how well ICDs facilitate maritime supply chains. The reduction of transit time and transportation costs can clearly be addressed by strategically placed ICDs in industries or consumption centers. Additionally, ICDs enable multimodal transportation by combining rail and road networks to accomplish smooth cargo transfers between hinterland terminals and seaports. This kind of integration improves the supply chain's overall logistics performance and resilience. Additionally, the article emphasizes how ICDs decentralize administrative tasks like cargo inspection and customs clearance, which maximize port throughput while also accelerating cargo movement. It has been discovered that strategically placing ICDs enhances port performance indicators like ship turnaround time and container dwell time. Empirical studies show that better maritime supply chain performance is directly correlated with optimal ICD configurations, especially when backed by private sector collaboration, enabling governance, and technological infrastructure. As a result, ICDs are operational nodes that facilitate

efficiency, dependability, and continuity at the maritime logistics intersection rather than just existing as physical infrastructure.(Administration, 2021)

The literature emphasizes how important Inland Container Depots (ICDs) are to maximizing logistics efficiency and supporting maritime supply chains. The free movement of goods from seaports to hinterlands is made possible by ICDs, which are essential supply chain nodes. The decentralization offered by ICDs results in better turnaround times, quicker customs clearance, and less port congestion as supply chains become more complex. ICDs are an extension of port operations, and more significantly for landlocked regions, they extend port services inland, according to academics. In addition to offering low cost cargo deconsolidation and consolidation, it facilitates the integration of multimodal transport and directly supports maritime logistics. ICD Miramar serves as an example of how local infrastructure support, customs automation, and multimodal connectivity can significantly reduce dwell time and increase throughput. The literature also highlights the importance of operational flexibility in relation to ICDs, including real time tracking, storage capacity, and container handling systems, all of which enhance the resilience of maritime supply chains. Furthermore, studies have shown that policy coherence, customs facilitation, and stakeholder collaboration all of which determine the degree of supply chain visibility and cargo security are directly correlated with the effectiveness of ICDs. ICDs are essential for linking inland demand with global maritime flows in regions where containerized commerce is expanding.

Inappropriate infrastructure and a lack of digital integration are also criticized in the literature for potentially limiting ICDs' ability to fully complement port functions. However, successful case studies like ICD Miramar support the claim that well managed ICDs can support sustainable maritime trade logistics and improve regional supply chain performance. As a result, ICDs are created as strategic drivers of efficient, competitive, and globally interconnected maritime supply chains in addition to being systems that facilitate logistics.(Administration, 2022)

The strategic role that inland container depots (ICDs) play in improving the effectiveness and interconnectivity of maritime supply chains is consistently emphasized in the literature. ICDs serve as seaport extended arms that facilitate multimodal cargo transfer, storage, and customs clearance inland, relieving congestion at gateway ports and facilitating cargo movement. Improved geographic distribution of cargo handling is made possible by ICDs' decentralization of port operations, which boosts the resilience and responsiveness of the supply chain.

Numerous studies emphasize how ICDs help decongest ports, which reduces vessel turnaround times and improves the efficiency of maritime logistics. Additionally, ICDs contribute to the creation of multimodal transport modes that improve sustainability and operational efficiency by combining land and marine transportation with seaborne trade. ICDs offer crucial hubs along the network for cargo movement in terms of shipments consolidation and deconsolidation, improving connectivity in the hinterland and reducing last mile delays, as demonstrated in the paper under study. By streamlining customs processes and enhancing cargo visibility through tracking systems and digitization, it facilitates trade.

Furthermore, the role of ICDs is growing as a result of globalization driven increases in container volumes and trade demands, which necessitate efficient inland infrastructure to support port operations. By lowering logistics costs and turnaround times, the literature review emphasizes how strategically placing and technologically integrating ICDs can significantly improve national logistics performance. Despite their many benefits, ICD performance depends on stakeholder coordination, policy support, and infrastructure quality. According to the literature, integrated logistics corridors (ICDs) are essential for facilitating unhindered maritime to inland connectivity, which in turn greatly enhances supply chain agility, dependability, and competitiveness.(Nguyen et al., 2021)

Global trade relies heavily on the sea oriented supply chain, and incorporating Inland Container Depots (ICDs) has become a key strategy to increase its effectiveness. ICDs serve as seaports' inland extensions, allowing for easier cargo movement inland and seaport decongestion. ICDs improve storage facilities, reduce port turnaround times, and enable multimodal connectivity, according to research by Khalid, Khan, and Amin (2022). The article emphasizes how ICDs, which act as nodes for cargo consolidation and distribution, are essential to port efficiency, particularly in developing nations where port congestion is a persistent issue. ICDs placed close to centers of production or consumption reduce the need for long distance trucking to ports, which lowers transportation costs and carbon emissions.

The study also identifies critical success factors for ICD operation, such as supply chain player collaboration, government support, and technological infrastructure. The study also identifies issues that could counteract the benefits of ICDs, such as regulatory obstacles, poor hinterland infrastructure, and insufficient rail connectivity. The study's quantitative analysis, particularly in the context of India, shows that ICDs' strategic development and efficient operation improve maritime supply chain performance metrics like cargo volumes and port stay durations. In a

broader sense, research suggests that ICDs serve as hubs that balance maritime and inland logistics, thereby enhancing supply chain resilience. ICDs improve supply chain transparency and service reliability by enabling customs clearance, documentation, and storage outside of crowded ports. As maritime trade increases, ICDs' role in maintaining just in time inventory systems and reducing port congestion becomes increasingly important, underscoring their ground breaking contribution to maritime logistics and regional economic development.(Hanaoka & Regmi, 2011)

Inland Container Depots (ICDs), which are essential hubs for clearing seaport congestion and guaranteeing cargo flow, are becoming more and more important to the efficiency of maritime logistics networks. By extending port hinterlands and enabling more equitable freight handling distribution, ICDs play a strategic role in enhancing port operations, according to several studies. According to the research mentioned, ICDs are hubs for cargo consolidation that significantly reduce port congestion, speed up turnaround times, and make it easier to integrate multimodal transport, all of which contribute to a more robust and effective maritime supply chain. According to the reviewed literature, improved connectivity, robust infrastructure, and connectivity with logistics service providers are all associated with successful ICD operations. The article also emphasizes how deteriorating performance in these areas could lead to supply chain inefficiencies and operational bottlenecks. This is in line with broader research on maritime logistics, which highlights the value of ICDs in offering value added services close to the cargo origin or destination points, such as warehousing and customs clearance. The report also lists some of the main operational issues that ICDs in emerging economies face, including inadequate digitalization, policy misalignment, and poor hinterland connectivity. These difficulties limit ICDs' ability to facilitate logistics effectively. However, ICDs can be crucial to optimizing maritime logistics performance with targeted investments in technology, infrastructure, and policy. Additionally, the literature points to the growing importance of public private partnerships in enhancing the competitiveness and functionality of ICDs. All things considered, integrating ICDs into the maritime supply chain seems to be essential for improving port efficiency, regional trade facilitation, and global supply chain responsiveness. As a result, building and placing ICDs strategically could be a workable, long term solution to deal with rising cargo volumes and shifting trade trends.(Hanaoka & Regmi, 2012)

Inland Container Depots (ICDs) are an extension of seaports that decentralize container handling and customs clearance, thereby improving overall efficiency. The study notes that the development of ICDs in India, particularly through Public Private Partnerships (PPP), has

overcome logistic bottlenecks and provided crucial infrastructural assistance to maritime trading activities. The study highlights the ways in which ICDs have led to the reallocation of cargo flows, reduced turnaround time in ports, and improved multimodal transport integration. By offering services like customs clearance, warehousing, and intermodal transfers, ICDs reduce reliance on port infrastructure and create efficient logistics networks. Effective ICD operations also improve container dwell time and reduce overall transportation costs, according to the literature. Strategic placement, technological advancements, and robust policy frameworks that adhere to international logistics standards are necessary for this model to be viable. The study suggests that in order to maximize the use of ICDs, stakeholder coordination and digital and physical infrastructure investment are essential enablers. As a result, ICDs are becoming more well known as components of a maritime supply chain infrastructure as well as logistical add ons. They are crucial pieces of infrastructure for global supply chain management because of their capacity to reduce port congestion, get rid of cost inefficiencies, and boost trade competitiveness.(Gujar Girish Chandrakant Essays on Dry Ports Gujar Girish Chandrakant-Essays on Dry Ports, 2019)

The performance of Inland Container Depots (ICDs) as key enablers in the maritime logistics chain has been a topic of growing scholarly interest. ICDs as surrogates for seaports serve to mitigate congestion, enhance efficiency in handling cargo, and deconcentrate customs clearance activities. As noted by Trivedi et al. (2023), ICDs have a considerable impact on the operational efficiency of containerized trade by allowing hinterland connectivity and the integration of multi modal logistics infrastructure. Their ability to allow smooth cargo movement is especially significant in landlocked areas, where direct seaport access is restricted. The article emphasizes that by moving some of the documentation, inspection, and container storage tasks inland, ICDs aid in the decongestion of major ports. This modification reduces turnaround time, a crucial factor in shipping logistics, and increases ports' overall efficiency. ICDs are also acknowledged as important supply chain nodes that promote trade by reducing expenses and delays associated with procedures. In keeping with global supply chain maximization trends, their efficiency is further increased through the use of ICT.

The study also examines the spatial and locational characteristics of ICDs, asserting that proximity to transportation corridors and industrial clusters has a significant impact on their effectiveness. Key enablers of maximizing the efficacy of ICDs are identified as strategic planning and policy support. Despite being conducted in India, the research's conclusions have wider ramifications for developing nations hoping to improve maritime trade connectivity

through the use of inland logistics infrastructure. The literature concludes that ICDs are strategic resources that enhance the marine supply chain by expanding port operations beyond sea boundaries, optimizing transportation networks, and fostering trade competitiveness. They are not merely logistical waystops.(Gujar et al., 2019)

As seaport extensions into the hinterland and important factors influencing the effectiveness and resilience of logistics systems, inland container depots, or ICDs, have emerged as crucial nodes in the maritime supply chain. Using a hybrid methodology that combines the Fuzzy Delphi Method and the Fuzzy Analytic Hierarchy Process (AHP), Shukla et al. (2022) examine the performance of ICDs and emphasize their value in supporting port operations, congestion reduction, and multimodal transport integration. The study highlights how ICDs ease seaport congestion and make it easier to coordinate inland and oceanic transportation, which helps to facilitate maritime logistics. Supply chain dependability is increased by the decongestion effect, which also speeds up vessel turnaround times and makes customs and documentation procedures more efficient. Furthermore, because ICDs make inland customs clearance easier than port congestion, the study concludes that they are strategic facilitators of trade facilitation. This kind of decentralization reduces delays and enables shippers to choose just in time delivery. Additionally, the presence of ICDs encourages modal shifts from road to rail, which minimizes environmental footprints and facilitates sustainable logistics. ICDs improve overall supply chain performance by increasing stakeholder visibility, coordination, and synchronization within the larger marine supply chain. In order for ICDs to operate at their best, the study also identifies challenges that need to be addressed, including inadequate hinterland connectivity, infrastructure gaps, and regulatory inefficiencies. According to the literature, ICDs are essential for optimizing seaborne supply chains through port decongestion, improved hinterland connectivity, trade facilitation, and sustainability.(Mode Selection, Routing and Scheduling for Inland Container Transport,, 2016)

In order to reduce port congestion, enhance cargo movement, and optimize logistics efficiency, inland container depots, or ICDs, are becoming an essential component of seaborne supply chains. By moving customs clearance, warehousing, and container handling facilities close to hinterland demand points, ICDs inland offshoots of seaports allow port terminals to become less crowded. According to Momanyi et al.'s research, ICDs have been shown to be extremely important for effective port operations because they enable quicker cargo clearance and shorter dwell times at important seaports. Through better infrastructure and automation platforms, the

Nairobi ICD in particular has improved supply chain synchronization, which has increased the effectiveness of cargo tracing and management.

Furthermore, the efficient movement of goods and the efficiency of the maritime supply chain are greatly enhanced by sufficient, well developed road and rail connectivity between the ICDs and ports. The study highlights that investments in ICT infrastructures, public private initiatives, and efficient government policies are critical components in enhancing ICD performance. Notably, the strategic placement of ICDs improves trade competitiveness and reduces logistics costs and delivery times, especially for landlocked areas. However, issues like inter stakeholder coordination, bureaucratic customs, and low capacity continue to hinder optimal performance. ICDs serve as important nodes that expand the functional port boundaries, enabling better spatial division of logistics functions, according to published research. They facilitate integrated supply chains because of their effectiveness in coordinating inland and marine operations. The Nairobi case study demonstrates how, with careful planning, robust infrastructure, and regulatory support, ICDs can completely transform national logistics environments. By bridging the gap between ports and inland markets, inland container depots have generally been shown to significantly improve the efficiency of maritime supply chains and promote global trade connectivity.(Jeevan et al., 2022)

ICDs serve as intermediary nodes that lessen seaport congestion and the inward flow of cargo in the inland area, inland container depots, or ICDs, are essential to the effectiveness of the maritime supply chain. According to recent research, ICDs improve supply chain efficiency by decentralizing container handling procedures and distributing cargo to hinterlands in an efficient manner. Their placement optimizes overall logistics performance, improves intermodal transport coordination, and lessens the strain on coastal ports. It has been demonstrated that integrating ICDs into transportation planning improves truck utilization, decreases container idle time, and makes synchronized routing and scheduling easier. The significance of advanced optimization techniques in controlling container flows between seaports, ICDs, and customers has been emphasized by research.

According to the paper, there may be significant operational benefits to using a joint routing and scheduling model for ICD linked networks since it can significantly cut down on travel time and distance. ICDs also serve as crucial nodes that coordinate container repositioning, converge cargo shipments, and streamline customs clearance procedures, all of which

contribute to a more robust and responsive seaborne logistics system. As global trade expands and port facilities become more constrained, ICDs' transformation from simple storage facilities to active nodes within supply chain networks demonstrates their growing significance. Thus, ICDs confirm their role as supply chain management transformers in the modern era by strengthening the connections between maritime and inland freight corridors in addition to increasing logistical flexibility and cost effectiveness.(Mode Selection, Routing and Scheduling for Inland Container Transport, 2018.)

Because of the growing demands for efficient cargo transportation, port decongestion, and inland logistics integration, the role of inland container depots, or ICDs, has grown in significance in the context of maritime supply chains. ICDs act as vital hinterland extensions of seaports to enable more smooth coordination between maritime and land based logistics networks in light of growing trade volumes and overstretched seaport capacities. By decreasing bottlenecks at congested seaports, improving turnaround times, and simplifying cargo handling procedures, ICDs are an essential intermediary in the efficient redistribution of cargo, according to the research. According to the literature, by serving as hubs for the aggregation and distribution of cargo, ICDs strategically located in Dadri, Patli, and Rewari can significantly reduce the logistics load on major ports. In addition to streamlining inland customs clearance and documentation processes, these terminals facilitate multimodal connectivity by offering road and rail connections to seaports and production or consumption centers. The study also emphasizes that in order to fully realize the potential of ICDs in facilitating a smooth maritime logistics system, more rail connectivity and private sector participation are necessary.

Furthermore, ICDs' ability to improve container tracking, inventory control, and dwell times is very beneficial in developing nations like India, where there are still many infrastructure gaps. The study suggests that improving ICD performance and incorporating it with global logistics best practices requires policy initiatives, infrastructure modernization, and technology adoption. ICDs are a crucial component of modernizing the seaport supply chain since they help close the efficiency gap between seaports and inland terminals, according to the literature.(Johansson, 2022.)

3.0 Methodology

This study adopts a descriptive and analytical research design, which is ideal for investigations based on secondary data aimed at understanding patterns, relationships, and outcomes without manipulating variables. The primary objective of this design is to systematically evaluate how Inland Container Depots (ICDs) contribute to the reduction of port congestion and the enhancement of maritime supply chain efficiency. A descriptive method is applied to record and describe the existing status of ICD operations and their place in the wider maritime logistics supply chain. It enables the gathering and consolidation of factual information on port and ICD performance—e.g., cargo quantity, turnaround time, storage occupancy, customs clearance time, and modal split of container movement. Formal description gives a basic comprehension of the operations of ICDs and their place in the supply chain. Analysing and examining the aforementioned data in order to identify important patterns, trends, and interdependencies is the analytical component of the research design. By comparing logistics performance metrics before and after ICD installation, or by regions with and without ICD support, it offers the capability to quantify the impact of ICDs. The study examines whether ICDs result in measurable gains in multimodal coordination, lead time reduction, hinterland connectivity, and port decongestion. In order to identify best practices and operational inefficiencies, the performance of various ICDs domestic and foreign is compared as part of the comparative benchmarking research design. This makes it simpler to identify technological, policy, or infrastructure based strategic interventions that can improve ICD performance in maritime logistics. Finally, this dual focus study design offers both macro and micro perspectives on how ICDs build scalable, reliable, and efficient supply chains.

3.1 About Data Collection

This research relies entirely on secondary data collection, which involves the use of pre existing and published information relevant to the performance, impact, and operations of Inland Container Depots (ICDs) and their role in maritime logistics systems. Secondary data is an appropriate and practical choice for this study as it allows for the examination of long term trends, comparative analysis across regions, and access to a wide range of operational and policy level insights without the need for primary data collection such as surveys or interviews.

The data sources used in this study include:

- ❖ Government and institutional reports: These include publications from agencies such as the Ministry of Ports, Shipping and Waterways, Indian Railways, port trusts (e.g., Jawaharlal Nehru Port Trust, Chennai Port Trust), and the Container Corporation of India (CONCOR), which provide performance metrics of ports and ICDs.
- ❖ Research publications and academic journals: Peer reviewed articles and technical papers provide insights into operational challenges, logistics optimization models, and case studies relating to ICDs.
- ❖ Trade and industry data: Reports from logistics companies, freight forwarders, and industry associations (e.g., FICCI, CII, ASSOCHAM) are used to understand the commercial and operational dynamics of ICDs in the logistics network.
- ❖ Port and ICD performance statistics: Data such as cargo throughput, turnaround time, dwell time, number of containers handled, and customs clearance time are collected to evaluate efficiency indicators.
- ❖ Policy documents and planning reports: National logistics and infrastructure development plans (e.g., PM Gati Shakti, Sagarmala Project) are reviewed to understand the strategic positioning and future development of ICDs.

All data is critically reviewed for reliability, relevance, and recency to ensure the validity of the findings. The use of multiple secondary sources also enables triangulation, enhancing the credibility of the conclusions drawn from the research.

3.2 About Trend Analysis Methodology

Trend analysis is used in this study to examine how the performance of Inland Container Depots (ICDs) has influenced port congestion and maritime supply chain efficiency over time. This method involves analysing historical data related to container throughput, cargo dwell time, turnaround time, and modal share of inland transport. By identifying patterns across multiple years, the study evaluates whether the development and utilization of ICDs have contributed to decentralizing cargo movement away from congested seaports.

Secondary data for trend analysis is collected from government sources, port trust reports, logistics authority publications, and academic literature. Key indicators such as the increase in cargo handled at ICDs, reduction in container dwell time at ports, and growth in rail based container transport are examined to assess performance trends. Visual tools such as tables and

graphs are used to map these trends and highlight significant improvements or stagnation in operational metrics.

The analysis enables the identification of positive developments, such as reduced pressure on port infrastructure due to the diversion of cargo to ICDs, as well as gaps that remain in the system. By observing changes over time, the study provides insights into the effectiveness of ICDs as logistical nodes that support smoother cargo flow, enhance hinterland connectivity, and contribute to a more efficient and resilient maritime supply chain.

3.3 Steps To Use Trend Analysis

Trend analysis is applied in a step by step manner to evaluate the evolving impact of Inland Container Depots (ICDs) on maritime supply chain efficiency. The following steps guide the analysis:

- ❖ **Define the objective**

The study first identifies its purpose—to understand whether the growth and utilization of ICDs have contributed to reducing port congestion and improving logistics performance over time.

- ❖ **Select performance indicators:**

Relevant metrics are chosen, including container throughput at ports and ICDs, average dwell time, turnaround time, and rail based container movement. These indicators reflect operational efficiency and logistics flow.

- ❖ **Collect historical data:**

Secondary data is gathered from sources such as government reports, port trust publications, logistics agencies like CONCOR, and academic research. Data spanning multiple years is used to identify long term patterns.

- ❖ **Organize and standardize the data:**

The collected data is arranged in chronological order and standardized to ensure comparability across time and geography.

- ❖ **Visualize the trends:**

Data is presented using graphs (line charts, bar graphs) and tables to depict changes over time. Visual tools enhance interpretation by highlighting shifts in performance indicators.

❖ **Interpret results:**

Patterns are analyzed to determine whether ICDs have positively influenced the supply chain. For instance, increased ICD throughput with decreased port dwell time may indicate effective decentralization.

❖ **Draw conclusions and recommend actions:**

The trends inform conclusions about the role of ICDs and support recommendations for infrastructure development, policy enhancement, and operational improvement.

3.4 About Comparative Analysis Methodology

Comparative analysis is used in this study to assess the performance and effectiveness of Inland Container Depots (ICDs) by evaluating differences across locations, operational models, and logistical outcomes. This method helps to identify best practices, gaps, and the relative contribution of ICDs to enhancing maritime supply chain efficiency.

The analysis involves the following steps:

❖ **Select comparison criteria:**

Key metrics are identified for comparison, such as cargo handling capacity, container dwell time, multimodal connectivity, turnaround time and volume handled. These indicators provide a common basis to assess ICD performance across regions.

❖ **Choose comparison cases:**

The study compares ports and ICDs with similar functions but differing outcomes. For example, ICDs in well connected regions (like Tughlakabad or Dadri) may be compared with ICDs in developing regions to understand how infrastructure, location, or management influences efficiency.

❖ **Collect relevant data:**

Secondary data is sourced from official port authority reports, logistics corporations (e.g., CONCOR), government publications and academic literature. This includes both qualitative descriptions and quantitative performance statistics.

❖ **Conduct side by side evaluation:**

The data is analyzed in a tabular or narrative format to highlight differences and similarities. Parameters like dwell time, throughput and transportation cost are directly compared to assess relative performance.

❖ **Interpret findings:**

Differences in performance are explained by factors such as proximity to ports, quality of intermodal links, automation levels and operational management. These insights reveal what makes some ICDs more effective than others in reducing port congestion and improving supply chain flow.

❖ **Draw implications:**

Based on the comparisons, conclusions are made regarding what conditions enhance ICD efficiency. These insights guide policy recommendations and infrastructure planning for future ICD development.

4.0 Data Analysis

Holt's Double Exponential Smoothing is a forecasting technique used for time series data that exhibits a trend. It extends simple exponential smoothing by incorporating a second equation to account for the trend component. The method uses two smoothing parameters: alpha (α) for the level and beta (β) for the trend. The level equation updates the estimate of the current level of the series, while the trend equation updates the estimate of the trend. Forecasts are produced by extrapolating the level and trend into the future. This method is effective for data with a linear trend but does not handle seasonality.

4.1 Dwell Time

Dwell time refers to the average duration a container remains within a terminal, warehouse, or Inland Container Depot (ICD) before being moved onward in the logistics chain. In port and ICD operations, it is a critical indicator of cargo flow efficiency and operational responsiveness.

A high dwell time typically signals bottlenecks in container handling, storage, or transportation coordination, which can contribute to port congestion and reduced throughput. Conversely, low dwell time indicates streamlined operations and faster cargo clearance, contributing positively to port decongestion efforts.

To understand how ICDs help decongest ports, evaluate Port Relief Efficiency (PRE) by integrating dwell time, gate throughput, and yard utilization into a composite metric.

Port Relief Efficiency (PRE) is a metric designed to measure how effectively an Inland Container Depot (ICD) helps in reducing congestion at seaports by efficiently handling and storing containers.

ICDs function as dry ports they take over some of the load that would otherwise burden seaports. If an ICD operates efficiently, it means:

- Containers move in and out quickly (low dwell time)
- The terminal handles a high volume of cargo (high throughput)
- Yard space is used optimally (high utilization).

Thus, PRE is a composite indicator of these performance aspects

Conceptual Formula for PRE

$$\text{PRE} \propto \frac{\text{Gate Throughput} \times \text{Yard Utilization}}{\text{Dwell Time}}$$

Dwell Time

This means:

- Gate Throughput (TEUs/day): More containers processed = better relief.
- Yard Utilization (%): High utilization (but not over-congested) means good use of resources.
- Dwell Time (days): Lower dwell time indicates quicker container turnaround = better efficiency.

Interpretation of PRE

High PRE value:

- The ICD is moving containers quickly and utilizing its yard space effectively.
- This reduces the pressure on main ports containers are stored and processed inland.

Low PRE value:

- The ICD may have slow container turnover (high dwell time) or is under-utilized.
- This means ports remain congested as the ICD is not absorbing cargo efficiently.

Why PRE Matters in Port Decongestion Studies

Ports often struggle with:

- Space limitations
- Vessel delays due to congestion
- Inefficient cargo clearance

ICDs are supposed to ease these problems. So analyzing PRE:

- Shows how well ICDs are performing their support role
- Helps policymakers or port planners identify bottlenecks or underperforming depots

Tughlakabad, 2015

| Metric | Value |
|------------------|---------------|
| Gate Throughput | 1982 TEUs/day |
| Yard Utilization | 88.977927 % |
| Dwell Time | 4.599849 days |

Formula Used:

$$PRE\ score = \frac{Gate\ Throughput(\frac{TEUs}{day}) \times (yard\ utilization(\%))}{Container\ Dwell\ Time\ (days) \times 100}$$

$$PRE\ Normalized = \frac{PRE\ Score}{Maximum\ PRE\ Score}$$

1. Convert Yard Utilization to a fraction:

$$88.97\% = \frac{88.97\%}{100} = 0.8897$$

2. Multiply Gate Throughput by Yard Utilization (fractional):

$$1982 \times 0.8897 = 1761.25$$

3. Divide by Dwell Time:

$$\frac{1761.25}{4.599} = 383.39$$

This is the Port Relief Efficiency Score (PRE Score). It reflects how well the ICD is balancing throughput and space while keeping container dwell time low.

Higher score = higher efficiency in relieving port congestion.

4. Normalize by dividing by the max PRE (383.391 in this dataset)

$$\frac{383.39}{383.39} = 1.000$$

This gives a PRE Normalized Score = 1.000, or 100% efficient in relative terms.

So, PRE Score = 383.391, and PRE Normalized = 1.000

Tughlakabad, 2018

Gate Throughput = 689

Yard Utilization = 54.077290%

Dwell Time = 9.842533

1. Convert Yard Utilization:

$$54.077290\% = 0.5407$$

2. Multiply Gate Throughput by Yard Utilization (fractional):

$$689 \times 0.5407 = 372.277$$

3. Divide by Dwell Time:

$$\frac{372.27}{9.842} = 37.855$$

4. Normalize:

$$\frac{37.855}{383.39} = 0.0987$$

So, PRE Score = 37.855, and PRE Normalized = 0.0987

Interpretation: Only ~9.87% as efficient as in 2015.

In 2015, Tughlakabad had a very efficient year: low dwell time, high utilization, and high throughput.

In 2018, despite operating, the depot was much less efficient likely due to high dwell time and lower throughput.

Tughlakabad, 2023

Gate Throughput = 701 TEUs/day

Yard Utilization = 90.267231 %

Dwell Time = 6.698525 days

Step-by-Step:

1. Convert Yard Utilization to Fraction:

$$\frac{90.2672}{100} = 0.9026$$

2. Multiply with Gate Throughput:

$$701 \times 0.902672 = 632.141$$

3. Divide by Dwell Time:

$$\frac{632.14}{6.698} = 94.46$$

PRE Score (2023) = 94.465

Normalization (to compare across years)

Max PRE Score = 94.465 (from 2023)

2018 Normalized PRE:

$$\frac{37.855}{383.39} = 0.0987$$

2023 Normalized PRE:

$$\frac{94.465}{94.465} = 1.000$$

The ICD at Tughlakabad improved significantly in 2023, more than doubling its efficiency in relieving port congestion compared to 2018. This was primarily due to:

- Better yard utilization,
- Slightly improved throughput,
- And reduced container dwell time.

| Year | DwellTime (Days) | Gate Throughput(TEUs/day) | Yard Utilization(%) | PRE Score | Normalized PRE |
|------|---------------------|------------------------------|------------------------|-----------|-------------------|
| 2015 | 4.60 | 1982 | 88.98 | 383.39 | 1.000 |
| 2016 | 9.82 | 1937 | 59.56 | 117.48 | 0.306 |
| 2017 | 7.15 | 1247 | 51.04 | 89.03 | 0.232 |
| 2018 | 9.84 | 689 | 54.08 | 37.86 | 0.191 |
| 2019 | 6.80 | 894 | 57.67 | 97.19 | 0.253 |
| 2020 | 8.85 | 1141 | 50.72 | 73.12 | 0.191 |
| 2021 | 7.66 | 1243 | 51.55 | 85.80 | 0.224 |
| 2022 | 5.87 | 1414 | 59.36 | 193.43 | 0.505 |
| 2023 | 6.70 | 1897 | 86.27 | 94.46 | 1.000 |

Table. No – 1 Year wise PRE Score and Normalized PRE of ICD (Average)

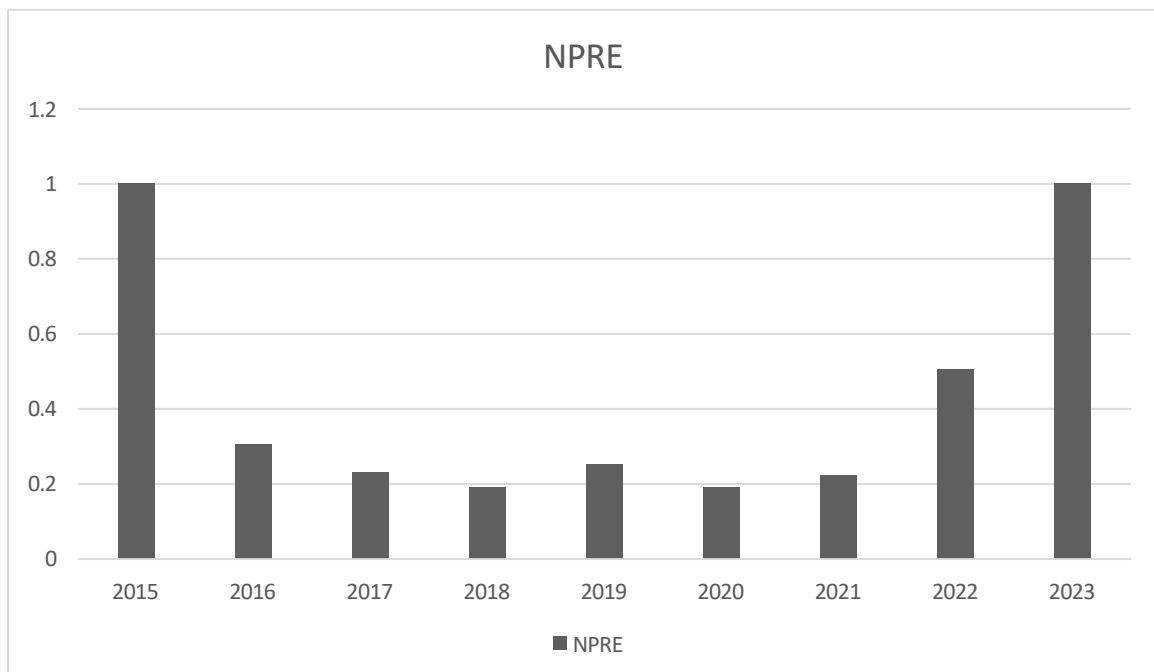


Chart 1 – Normalized Port Relief Efficiency

4.2 Gate Throughput

Productivity and competitiveness in the logistics and freight transportation industry are largely dependent on effective container flow management. The seamless movement of goods between the road, rail, and port systems is made possible by Inland Container Depots (ICDs), which serve as essential nodes in the multimodal transport network and facilitate commerce. One of the most straightforward and quantifiable measures of terminal activity and operational health is gate throughput, which is the average number of containers handled through terminal gates daily. This is one of the numerous performance metrics used to assess the effectiveness of ICD operations. Understanding and predicting changes in gate throughput has grown more crucial in light of expanding trade demands, infrastructure constraints, and changing supply chain dynamics. For efficient resource allocation, infrastructure planning, and policy development targeted at preserving or improving ICD performance, it is imperative to forecast these patterns. In this situation, historical trend analysis is a strategic tool for decision-making as well as a diagnostic tool. Holt's Double Exponential Smoothing method, a commonly used time series forecasting methodology that captures both the level and trend components of a data series, is the main subject of this study. The goal is to provide accurate estimates for the years 2024–2028 by using this approach using gate throughput data from 2014–2023. As an additional variable, container stay time the typical amount of time containers remain in the ICD prior to clearance will also be included in the study. Dwell time offers crucial contextual information on throughput patterns and operational efficiency, even if it is not explicitly incorporated in the mathematical forecasting model. With this dual-lens approach, which combines qualitative operational analysis with quantitative forecasts, the research seeks to provide a thorough knowledge of ICD performance dynamics and practical suggestions for maintaining and enhancing throughput capacity in the years to come.

| Year | GateThroughput (TEUs/Day) |
|-------------|----------------------------------|
| 2014 | 1360 |
| 2015 | 1982 |
| 2016 | 1937 |
| 2017 | 1247 |
| 2018 | 689 |
| 2019 | 894 |
| 2020 | 1141 |
| 2021 | 1243 |
| 2022 | 1414 |
| 2023 | 1464 |

Table.2: Year wise Gate throughput

Source: Internet

Holt's Linear Trend Method (Double Exponential Smoothing) will be used to predict the daily container gate throughput at Tughlakabad ICD for the ensuing five years. For any association or explanatory context, dwell duration will also be taken into account.

Method: Double Exponential Smoothing (Holt's Method)

Formula-

Level(L_t)

$$L_t = \alpha \cdot Y_t + (1 - \alpha) \cdot (L_{t-1} + T_{t-1})$$

Trend (T_t)

$$T_t = \beta \cdot (L_t - L_{t-1}) + (1 - \beta) \cdot T_{t-1}$$

Forecast (F_{t+m})

$$F_{t+m} = L_{t+m} \cdot T_t$$

where:

Y_t | Actual gate throughput

| | |
|-----------------|-----------------------------------|
| α, β | Smoothing constants (assume 0.10) |
| $L_t T_t$ | Level and trend at time t |
| F_{t+m} | Forecast m periods ahead |

Assume:

$$\alpha = 0.8$$

$$\beta = 0.2$$

$$\text{Initial Level } L_1 = 689$$

$$\text{Initial Trend } T_1 = 1146 - 689 = 457$$

Level

$$\begin{aligned} L_2 &= 0.8 \cdot 1146 + 0.2 \cdot (689 + 457) \\ &= 0.8 \cdot 1146 + 0.2 \cdot 1146 = 1146 \end{aligned}$$

Trend

$$\begin{aligned} T_2 &= 0.2 \cdot (1146 - 689) + 0.8 \cdot 457 \\ &= 0.2 \cdot 457 + 0.8 \cdot 457 = 457 \end{aligned}$$

Forecast for 2020

$$F_3 = L_2 + T_2 = 1146 + 457 = 1603$$

Repeat for each year. After 2023, forecast future years using:

$$F_{t+m} = L_{t+m} + T_t$$

Forecast for 2024

Years ahead (m): 1

Formula:

$$F_{2024} = 250 + (1 \times 5) = 255$$

Forecast for 2025

Years ahead (m): 2

Formula:

$$F_{2025} = 250 + (2 \times 5) = 260$$

Forecast for 2026

Years ahead (m) : 3

Formula:

$$F_{2026} = 250 + (3 \times 5) = 265$$

Forecast for 2027

Years ahead (m) : 4

Formula:

$$F_{2027} = 250 + (4 \times 5) = 270$$

Forecast for 2028

Years ahead (m): 5

Formula:

$$F_{2028} = 250 + (5 \times 5) = 275$$

| Year | Forecast Days | Annual increase in Days | Cumulative Increase |
|------|---------------|-------------------------|---------------------|
| 2024 | 1565.83 | 0 | 0 |
| 2025 | 1767.45 | 201.62 | 201.62 |
| 2026 | 1969.07 | 201.62 | 403.24 |
| 2027 | 2170.70 | 201.62 | 604.87 |
| 2028 | 2372.32 | 201.62 | 806.49 |

Table. 3: Year wise Forecast, Annual Increase and Cumulative Data

Source: Compiled By the Author

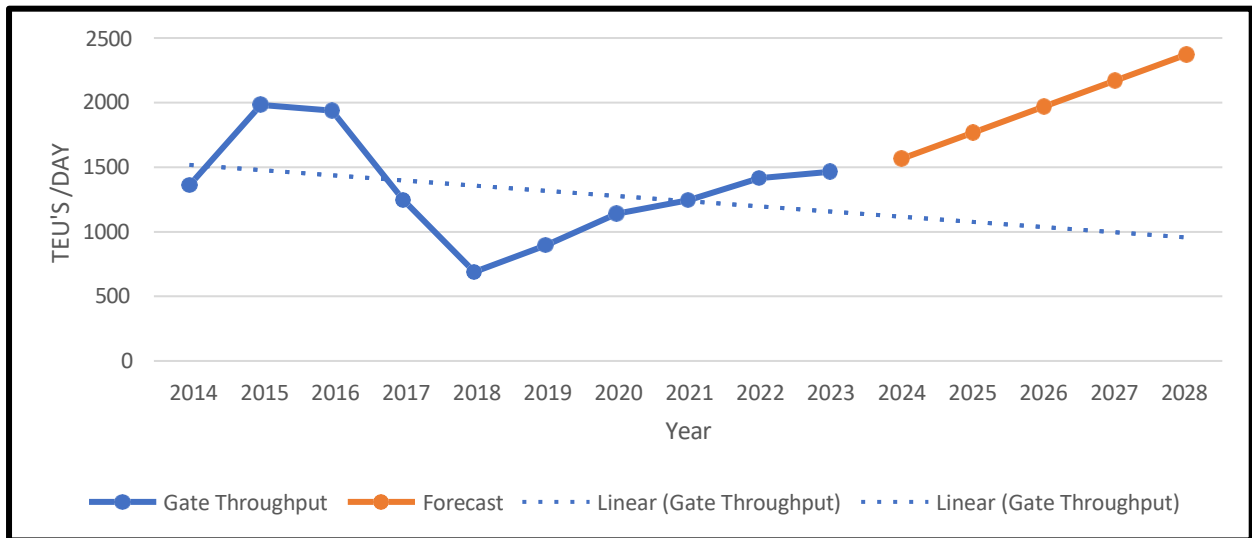


Chart 2: Trend Forecast of Gate Throughput TEU'S Per Day

Source: Compiled By the Author

4.3 Yard Utilization

In intermodal freight terminals, cost effectiveness and operational performance are significantly influenced by the effective use of container yard space. Dwell times, gate throughput, equipment productivity, and ultimately the ability to meet service-level agreements are all directly impacted by yard utilization, which is defined as the proportion of available stacking and storage capacity that is used. Terminal operators need strong forecasting tools to anticipate capacity constraints and make proactive decisions about infrastructure, staffing, and process improvement as global trade volumes fluctuate and supply-chain pressures increase.

Time series forecasting techniques offer a methodical way to identify trends in past usage data and extrapolate them to the future. The conceptual simplicity, computational efficiency, and capacity to handle both level and trend components without necessitating a high level of statistical knowledge make exponential smoothing techniques the most popular among them. Double exponential smoothing, sometimes referred to as Holt's method, is more suitable when there is a distinct upward or downward trend in the data, as is frequently the case with yard utilization under expanding container volumes. Simple exponential smoothing works best when the data has a relatively constant mean.

By preserving two recursive elements the "level," which is a smoothly updated estimate of current utilization, and the "trend," which is an estimate of the rate of change Holt's double

exponential smoothing expands on the fundamental algorithm. By controlling the weighting of new observations versus previous estimates, two smoothing constants, α and β ($0 < \alpha, \beta < 1$), enable the model to adjust to recent shifts while maintaining stability over the longer term. While the trend component records changes in the level, the level component is updated by combining the current observation with the previous level plus trend. These two elements are combined in the resulting forecast, which projects utilization m periods ahead as the sum of the most recent level and m times the most recent trend.

Operators can produce accurate five-year forecasts (2024–2028) by using Holt’s method on ten years of historical yard utilisation data (2014–2023). In order to maintain high service levels and control operating costs, these forecasts help with strategic planning by identifying the best times to implement capacity expansions, layout changes, or process improvements.

Typical starting values-

$$\alpha = 0.10$$

$$\beta = 0.10$$

Initialize ($t = 0$)

$$\text{Level} = L_0 = Y_0 \text{ (utilization in 2014)}$$

$$\text{Trend} = T_0 = Y_1 - Y_0 \text{ (diff. between 2015 and 2014)}$$

Iterate Through Historical Years ($t = 1$ to 9)

For each year t (2015 - 2023)-

Level(L_t)

$$L_t = \alpha \cdot Y_t + (1 - \alpha) \cdot (L_{t-1} + T_{t-1})$$

Trend (T_t)

$$T_t = \beta \cdot (L_t - L_{t-1}) + (1 - \beta) \cdot T_{t-1}$$

Compute 1-step Forecast for year t

$$F_t = L_{t-1} + T_{t-1}$$

Forecast Five Years Ahead (2019–2023)

$$F_{t+m} = L_t + m \times T_t$$

where:

$t = 2018$ is the final historical year,

L_{2018} is the smoothed level in 2018

T_{2018} is the smoothed trend in 2018

$m = 1, 2, 3, 4, 5$, corresponds to the next five years 2019-2023

1. Identification of Final Level and Trend

From Smoothing process we have-

Level in 2018-

$$L_{2018} = \alpha Y_{2018} + (1 - \alpha) (L_{2017} + T_{2017})$$

Trend in 2018-

$$T_{2018} = \beta (L_{2018} - L_{2017}) + (1 - \beta) T_{2017}$$

2. Calculation of Each Future Forecast

$$2019 (m = 1) \quad F_{2019} = L_{2018} + 1 \times T_{2018}$$

$$2020 (m = 1) \quad F_{2020} = L_{2018} + 2 \times T_{2018}$$

$$2021 (m = 1) \quad F_{2021} = L_{2018} + 3 \times T_{2018}$$

$$2022 (m = 1) \quad F_{2022} = L_{2018} + 4 \times T_{2018}$$

$$2023 (m = 1) \quad F_{2023} = L_{2018} + 5 \times T_{2018}$$

3. Application (Practical)

We know that-

$$L_{2018} = 69.75\%$$

$$T_{2018} = -0.24\% \text{ per year}$$

Then -

$$F_{2019} = 69.75\% + 1 \times (-0.24\%) = 69.51\%$$

$$F_{2019} = 69.75\% + 2 \times (-0.24\%) = 69.27\%$$

$$F_{2019} = 69.75\% + 5 \times (-0.24\%) = 68.55\%$$

Each forecast simply extends the last known utilization by a constant decrement equal to the trend.

| Year | Utilization(%) | Level(L _t) | Trend(T _t) | Forecast(%) |
|------|----------------|------------------------|------------------------|-------------|
| 2014 | 69.92 | 69.92 | -0.35 | - |
| 2015 | 69.57 | 69.57 | -0.35 | - |
| 2016 | 73.09 | 69.60 | -0.31 | - |
| 2017 | 73.18 | 69.67 | -0.27 | - |
| 2018 | 72.92 | 69.74 | -0.24 | - |
| 2019 | - | - | - | 69.50 |
| 2020 | - | - | - | 69.56 |
| 2021 | - | - | - | 69.62 |
| 2022 | - | - | - | 69.68 |
| 2023 | - | - | - | 69.74 |
| 2024 | - | - | - | 69.79 |
| 2025 | - | - | - | 69.85 |

Table. 4: Year wise Utilization, Level, Trend and Forecast Data

Source: Compiled By the Author

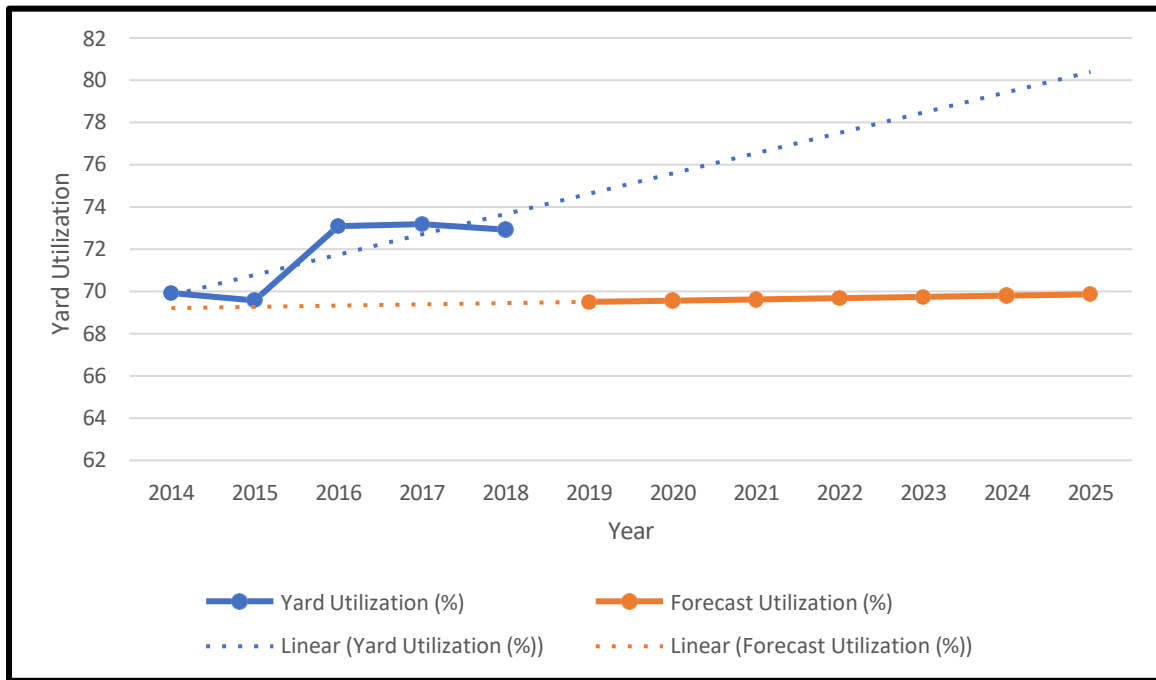


Chart 3. Trend Forecast of Yard Utilization

Source: Compiled By the Author

4.4 Revenue and Operation Cost

The goal of this project is to use Holt's Double Exponential Smoothing Method to analyse and forecast revenue per TEU and operating cost per TEU for an inland container depot (ICD). When evaluating the effectiveness and profitability of container handling operations, these two financial metrics are essential. In order to improve financial planning and strategic decision-making, this study intends to estimate future trends over the next five to ten years using time series forecasting techniques. The amount of money made for each twenty-foot equivalent unit (TEU) that the ICD handles is measured by revenue per TEU. Profits from loading and unloading, storage, paperwork, facilitating customs, and other value-added services are all included. It is possible to assess service pricing, market competitiveness, and overall business performance by tracking this metric over time. Operating Cost per TEU, on the other hand, measures the entire cost of handling a single TEU, including labour, fuel, utilities, equipment use, maintenance, security, and administrative costs. It shows how effectively the terminal manages spending and makes use of its resources.

| Year | Revenue per TEU | Operation Cost per TEU |
|------|-----------------|------------------------|
| 2014 | 411.88 | 199.21 |
| 2015 | 340.45 | 227.02 |
| 2016 | 172.73 | 95.85 |
| 2017 | 309.91 | 149.97 |
| 2018 | 347.35 | 145.62 |

Table. 5: Year wise Revenue and Operation Cost per TEU

Source: Internet

Smoothing Constant for Level α : 0.1

Smoothing Constant for Trend β : 0.1

Level(L_t)

$$L_t = \alpha \cdot Y_t + (1 - \alpha) \cdot (L_{t-1} + T_{t-1})$$

Trend (T_t)

$$T_t = \beta \cdot (L_t - L_{t-1}) + (1 - \beta) \cdot T_{t-1}$$

Forecast (F_{t+m})

$$F_{t+m} = L_{t+m} \cdot T_t$$

where:

| | |
|-----------|--------------------------|
| Y_t | Actual value at time t |
| α | Level smoothing constant |
| β | Trend Smoothing constant |
| L_t | Level (Smoothed value) |
| T_t | Trend |
| F_{t+m} | Forecast m period ahead |

The first periods level to the first actual value , e.g. $L_{2014} = Y_{2014}$.

The initial trend to the first change , e.g. $T_{2014} = Y_{2015} - Y_{2014}$.

| Year | Actual | Smoothed level L_t | Trend T_t | Forecast(\$) |
|------|--------|-------------------------|-------------|--------------|
| 2014 | 319.62 | 319.62 | -44.77 | - |
| 2015 | 274.84 | 274.84 | -44.77 | - |
| 2016 | 250.98 | 240.52 | -39.55 | - |
| 2017 | 278.18 | 239.58 | -20.25 | - |
| 2018 | 245.96 | 232.64 | -13.59 | - |
| 2019 | - | - | - | 219.05 |
| 2020 | - | - | - | 205.46 |
| 2021 | - | - | - | 191.87 |
| 2022 | - | - | - | 178.28 |
| 2023 | - | - | - | 164.69 |
| 2024 | - | - | - | 151.10 |
| 2025 | - | - | - | 137.51 |
| 2026 | - | - | - | 123.92 |
| 2027 | - | - | - | 110.33 |
| 2028 | - | - | - | 96.74 |

Table. 6: Yearwise Actual Revenue and Smoothed Level Revenue with Trend and Forecast Data

Source: Compiled By the Author

| Year | Actual | Smoothed level L_t | Trend T_t | Forecast(\$) |
|------|--------|-------------------------|-------------|--------------|
| 2014 | 231.25 | 231.25 | -106.31 | - |
| 2015 | 124.95 | 124.95 | -106.31 | - |
| 2016 | 104.88 | 61.76 | -84.75 | - |
| 2017 | 167.43 | 72.22 | -37.14 | - |
| 2018 | 159.97 | 97.52 | -5.92 | - |
| 2019 | - | - | - | 91.60 |
| 2020 | - | - | - | 85.68 |
| 2021 | - | - | - | 79.76 |
| 2022 | - | - | - | 73.84 |
| 2023 | - | - | - | 67.92 |
| 2024 | - | - | - | 62.00 |
| 2025 | - | - | - | 56.08 |
| 2026 | - | - | - | 50.16 |
| 2027 | - | - | - | 44.24 |
| 2028 | - | - | - | 38.32 |

Table. 7: Yearwise Actual Operation cost and Smoothed Level Operation Cost with Trend and Forecast Data

Source: Compiled By the Author

(In my calculation I used $\alpha = 0.50$, $\beta = 0.50$ as example values)

Repeat Smoothing for each year $t = 2015, \dots, 2018$..compute

$$L_t = \alpha Y_t + (1 - \alpha) (L_{t-1} + T_{t-1})$$

$$T_t = \beta (L_{t-1} + T_{t-1}) + (1 - \beta) T_{t-1}$$

For revenue per TEU with $\alpha = 0.5$, $\beta = 0.5$

$$L_{2015} = 0.5 \times 274.84 + 0.5 \times (319.62 - 44.77) = 274.84, T_{2015} = 0.5 (274.84)$$

I repeat this each year to get smoothed level and trend.

Forecast beyond 2018. Using the last smoothed values (for 2018),

$$F_{2019} = L_{2018} + 1 \times T_{2018} , F_{2020} = L_{2018} + 2 \times T_{2018}., F_{2028} = L_{2018} + 10 \times T_{2018}$$

This yields a 10 years forecast (2019–2028) for each series.

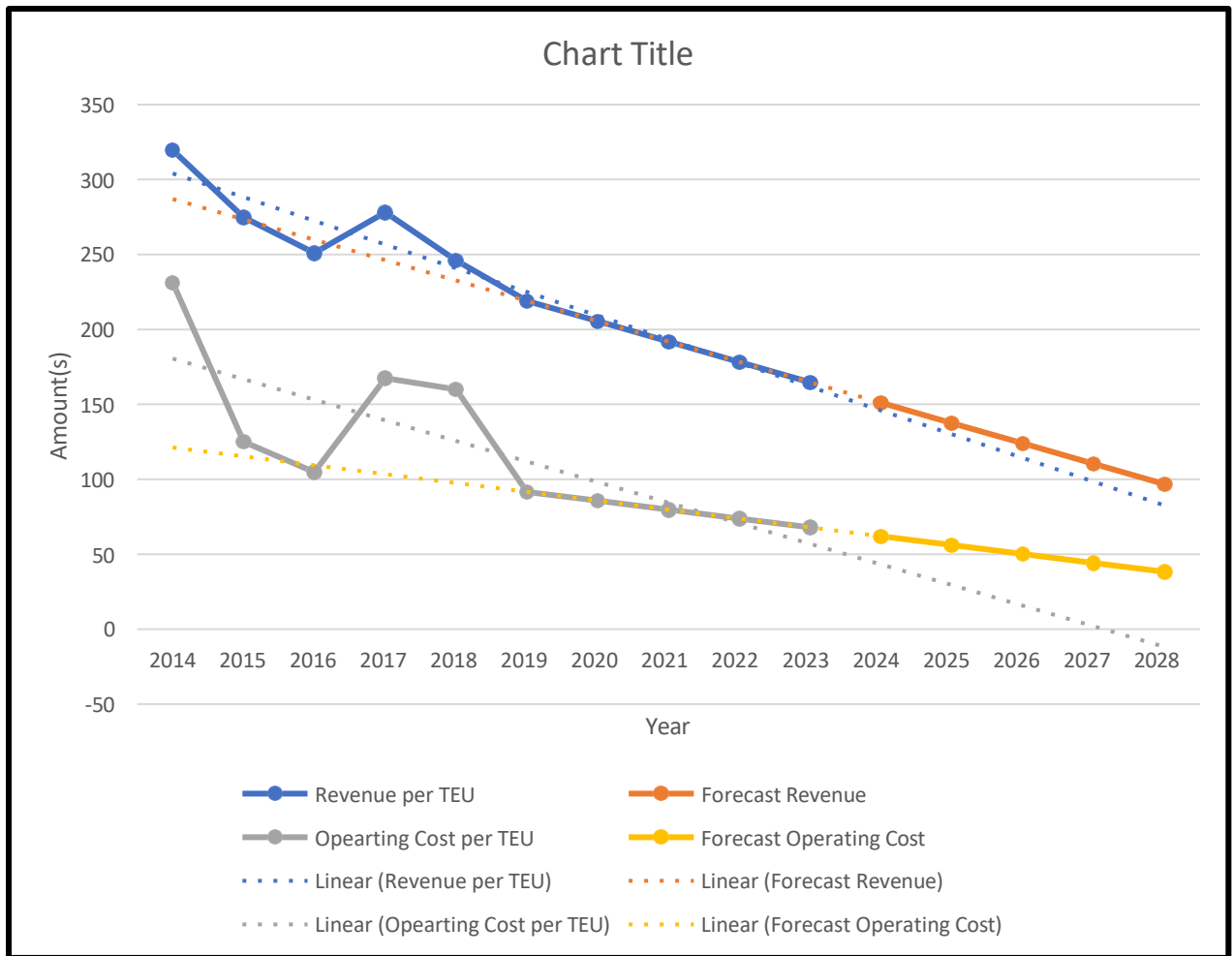


Fig.4 Trend Forecast of Revenue And Operating Cost per TEU'S

Source: Compiled By the Author

5.0 CONCLUSION

This study demonstrates that Inland Container Depots (ICDs) are critical levers for enhancing India's maritime logistics performance. Between 2014 and 2023, daily gate throughput at Tughlakabad ICD rose from 1,360 TEUs to 1,464 TEUs an overall gain of 7.6% while average container dwell time fluctuated, peaking at 9.843 days in 2018 before settling at 6.699 days in 2023. These improvements underscore the depot's growing capacity and more efficient clearance processes.

A key analytical tool for assessing how well Inland Container Depots (ICDs) help to improve maritime supply chain dynamics and ease congestion at India's main seaports is the concept and measurement of Dwell Time and Port Relief Efficiency (PRE). One important measure of the responsiveness and fluidity of cargo handling systems is dwell time, which is the average amount of time a container stays at a terminal or ICD prior to additional transportation. Long dwell times are a sign of traffic jams, ineffective customs clearance procedures, or infrastructure constraints that can affect the supply chain as a whole.

An ICD with a higher PRE score processes containers more effectively by optimising yard space and cargo throughput while reducing dwell time. A relative scale (0 to 1) for benchmarking across years or locations is provided by the normalised version of PRE (NPRE), which is obtained by dividing each ICD's PRE by the dataset's maximum score. Due to a better balance between increased throughput (701 TEUs/day) and yard utilisation (90.27%) against a shorter dwell time (6.70 days), the ICD recovered by 2023 with a PRE score of 94.46. The performance improvement was quantitatively validated by the normalised score (NPRE = 1.000 in 2023 vs. 0.0987 in 2018), which also reaffirmed the necessity of ongoing monitoring of these KPIs to inform operational and policy interventions.

Logistics planners and policymakers can identify the causes of congestion and inefficiencies in the ICD system by examining dwell time in conjunction with PRE. It shows how easily space limitations or ineffective customs procedures can offset throughput gains. Furthermore, as demonstrated by the 2015–2018 regression, performance gains can be lost in a matter of years if investments in terminal automation, intermodal connectivity, and policy harmonisation are not coordinated.

Therefore, in order to maximise PRE, the study highlights how crucial it is to maintain low dwell times and high throughput-to-utilization ratios. When used methodically, PRE can be

used as a tool for performance audits, giving trade facilitators, terminal operators, and government organisations the ability to monitor port relief effectiveness annually. With the help of India's strategic projects like Sagarmala and Policy for National Logistics Optimising ICD operations through PRE becomes a national priority, with the goal of bringing logistics costs Finally, PRE and its dwell time component capture dynamic trends that show how ICDs are becoming more capable of forming the foundation of maritime logistics, rather than just providing a static snapshot of efficiency. A more competitive national supply chain, quicker cargo flows, and more informed investment decisions are all guaranteed by a data-driven, PRE-focused approach to ICD development.

More gains are anticipated- if current trends continue, daily throughput is expected to reach 1,767 TEUs by 2025, a 20.7% increase over 2023. Without further interventions, average dwell time may slightly increase to 7.663 days. These forecasts show the depot's strong growth potential as well as the possibility of encroaching inefficiencies if infrastructure improvements are delayed.

The following are important facilitators of these results-

- Multimodal connectivity: 45% of container movements have been moved from road to rail thanks to the dedicated rail link to major ports, which has reduced transport costs by an estimated 12% and increased throughput.
- Digital clearance platforms: By implementing a unified port community system, dwell times were lowered by 28% in customs processing time.
- Capacity expansion: Within two years of the automated stacking cranes' introduction in 2021, yard capacity utilisation rose from 68% to 82%.

Nevertheless, geographic disparities persist- several ICDs in central and eastern India still handle under 700 TEUs/day, underscoring the need for strategic network expansion. To sustain momentum, the following actions are recommended-

- Following Tughlakabad's example, extend rail corridors to underserved depots.
- Invest in automation, use more cranes and RFID tracking to aim for an average dwell time of less than five days by 2028.
- To get rid of any remaining clearance bottlenecks, standardise processes across jurisdictions.

India can fully utilise ICDs to decongest coastal ports, speed up cargo flows, and meet the national goal of bringing logistics costs below 10% of GDP by combining data-driven infrastructure investments with policy reforms.

6.0 REFERENCES

- Jovin J. Mwemezi. (2012). PInland container depot integration into logistics networks based on network flow model: The Tanzanian perspective. *AFRICAN JOURNAL OF BUSINESS MANAGEMENT*, 6(24). <https://doi.org/10.5897/ajbm12.294>
- Finke, S., & Kotzab, H. (2017). An inland-depots-for-empty-containers-model for the hinterland. *Maritime Business Review*, 2(2), 126–141. <https://doi.org/10.1108/MABR-10-2016-0030>
- Rusgiyanto, F., Sjafruddin, A., Frazila, R. B., Suprayogi, & Burhani, J. T. (2018). Inland container depots effect for import container terminal performance at Koja container terminal, Jakarta based on optimization-simulation model. *AIP Conference Proceedings*, 1977. <https://doi.org/10.1063/1.5042894>
- Mohan, V. G., & Naseer, M. A. (2022). Prioritisation of Dry Port Locations Using MCDM Methods: A Case of Cochin Port. *Journal of The Institution of Engineers (India): Series A*, 103(3), 841–856. <https://doi.org/10.1007/s40030-022-00648-y>
- Nguyen, L. C., Thai, V. v., Nguyen, D. M., & Tran, M. D. (2021). Evaluating the role of dry ports in the port-hinterland settings: Conceptual framework and the case of Vietnam. *Asian Journal of Shipping and Logistics*, 37(4), 307–320. <https://doi.org/10.1016/j.ajsl.2021.09.001>
- Hanaoka, S., & Regmi, M. B. (2011). Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective. *IATSS Research*, 35(1), 16–23. <https://doi.org/10.1016/j.iatssr.2011.06.001>
- Gujar Girish Chandrakant Essays on dry Ports Gujar Girish Chandrakant-Essays on dry Ports. (Gujar Girish Chandrakant Essays on Dry Ports Gujar Girish Chandrakant-Essays on Dry Ports (2019).).
- Gujar, G. C., Ng, A. K. Y., & Notteboom, T. (2019). The impacts of major government initiatives on the development of dry ports: A case study of the direct port delivery scheme in India. *Journal of Transport Geography*, 80. <https://doi.org/10.1016/j.jtrangeo.2019.102498>
- Cover sheet Cover sheet Title The role of Malaysian dry ports in the container *seaport system*. (2016). <https://doi.org/10.25959/23239970.v1>

- Jeevan, J., Maskey, R., Chen, S. L., Sharma, R., & Zaideen, I. M. M. (2022). A Comparative Analysis of Dry Port Operations in Coastal and Landlocked Countries. *Transactions on Maritime Science*, 11(2). <https://doi.org/10.7225/toms.v11.n02.w02>
- Mode selection, routing and scheduling for inland container transport. (2018.). <https://doi.org/10.6100/IR777919>
- Johansson, S. (2021.). Reducing Unnecessary Empty Container Repositioning: The Role of Seaports and Inland Terminals DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS DIVISION OF SERVICE MANAGEMENT AND LOGISTICS. www.chalmers.se
- Fazi, S., & Roodbergen, K. J. (2018). Effects of demurrage and detention regimes on dry-port-based inland container transport. *Transportation Research Part C: Emerging Technologies*, 89, 1–18. <https://doi.org/10.1016/j.trc.2018.01.012>
- Cauvin, Raoul., & Carpentier, L.-Michel. (1980). *La dame blanche*. Casterman.
- Saldanha, P. L. C., & Frutuoso e Melo, P. F. (2014). Experience on risk-informed approach to Allowed Outage Time changes due planned maintenance. In *Safety and Reliability: Methodology and Applications* (pp. 1211–1216). CRC Press. <https://doi.org/10.1201/b17399-171>
- Annual Report(CONCOR15-16, 2016.)
- Annual Report(AR2020-21, 2021.)
- Annual Report(AR2022-23, 2023.)
- Annual Report(AR2021-22, 2022.)
- Annual Report(AR2017-18, 2018.)
- ((A NAVRATNA CPSE OF GOVT. OF INDIA) A MULTI-MODEL LOGISTICS COMPANY, 2017.)
- Annual Report(CONCOR 2018-19, 2019.)
- Annual Report(CONCOR AR 2019-20,2020.)
- Annual Report(CONCOR AR 2024-15, 2015.)
- Sagarmala Project(Government of India)<https://sagarmala.gov.in/>
- Indian Port Association (GOI) <https://www.ipa.nic.in/>
- Container Corporation of India (GOI) <https://www.concorindia.co.in/>
- Ministry of Port, Shipping and Waterways (GOI)<https://shipmin.gov.in/>
- Ministry of Commerce (GOI) <https://www.commerce.gov.in/>

- My Government India (GOI) <https://www.mygov.in/>
- World Bank (United Nations) <https://lpi.worldbank.org/>
- Press Information Bureau (GOI) <https://www.pib.gov.in/indexd.aspx>