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MANAGING PORT DWELL TIME AT CHENNAI PORT: "STRATEGIES TO IMPROVE CARGO PROCESSING"

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Abstract: This study investigates the key factors contributing to high cargo dwell time at Chennai Port, which averages 3–5 days—significantly higher than global benchmarks. The research identifies inefficiencies such as limited automation, manual documentation, inadequate stakeholder coordination, and delays in customs clearance. Using descriptive statistics, regression, and chi-square tests based on stakeholder surveys, the study finds that while the port benefits from a skilled workforce and sufficient berth space, only electronic document processing systems have a statistically significant impact on reducing dwell time. Benchmarking global ports like Singapore and Rotterdam highlights best practices in automation, real-time tracking, and inter-agency collaboration. The study recommends infrastructure modernization, digital integration, process audits, and stakeholder coordination improvements. These strategic interventions are essential for enhancing cargo throughput, reducing delays, and positioning Chennai Port as a competitive and sustainable maritime hub.

Keywords: Dwell time, automation, stakeholder coordination, digital integration, customs clearance

I. INTRODUCTION

Chennai Port plays a vital role in South India's trade landscape, yet faces persistent challenges with high cargo dwell time—averaging 3–5 days compared to global best practices of 1–2 days. Key issues include aging infrastructure, manual documentation, poor stakeholder coordination, limited automation, and customs delays. These inefficiencies hinder cargo throughput, increase costs, and reduce port competitiveness.Efficient cargo processing—through streamlined handling, digital documentation, real-time coordination, and smart technologies—is essential for reducing dwell time. Global ports like Rotterdam and Singapore demonstrate how automation, collaborative frameworks, and policy alignment can lead to operational excellence.To remain competitive, Chennai Port must adopt a multi-pronged strategy: modernizing infrastructure, enhancing digital systems, improving inter-agency coordination, and leveraging national initiatives like Sagarmala. This project explores these areas to offer strategic recommendations for transforming Chennai Port into a globally efficient and sustainable maritime hub.

OBJECTIVE

PRIMARY OBJECTIVE: Focus on analyzing the current situation at Chennai Port, identifying the main contributing factors for dwell time and proposing improvement strategies.

SECONDARY OBJECTIVE:

To study of integration technology such as automation, digital platforms, and real-time tracking in improving cargo processing at Chennai Port.

To analyze the level of coordination among key stakeholders and its impact on reducing port dwell time and enhancing operational efficiency.

To examine global best practices in cargo handling and benchmark them against Chennai Port's operations to identify potential areas for improvement.

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SCOPE OF THE STUDY:

The study will focus on Chennai Port in India, specifically analyzing its container handling and cargo processing operations. The research will look at various operational aspects such as container handling, from unloading to dispatch, the efficiency of customs procedures and paperwork, truck management systems, gate operations, and the impact of port infrastructure on operational efficiency. It will also examine the role of key stakeholders, including port authorities, customs authorities, shipping lines, transporters, clearing agents, and external stakeholders such as government regulations and logistics companies. The study will investigate strategic solutions, including technological advancements like automation, real-time tracking, and digital platforms, as well as process optimization for customs clearance, documentation, and transportation. Furthermore, it will address infrastructure improvements at the terminal and examine policy interventions to improve overall efficiency. The ultimate goal of the study will be to reduce cargo dwell time, enhance cargo throughput, improve port performance, and reduce economic costs and environmental impact, such as carbon emissions from delays

II. LITERATURE REVIEW

Moini et al. (2012) used data mining techniques to identify and estimate factors affecting container dwell time (CDT), highlighting yard space, stacking methods, and shipment characteristics. Their models showed that optimizing these variables could significantly improve terminal capacity and revenue.

Ayutia et al. (2023) investigated congestion at Tanjung Priok Port, identifying delays due to ship congestion, faulty truck scheduling, and equipment issues. Solutions included implementing the Truck Arrival System (TAS) and Chassis Exchange Terminal (CET) to streamline operations.

De Armas Jacomino et al. (2021) proposed using ordinal regression models to better predict container dwell times, leading to more efficient stacking and reduced reshuffling compared to traditional classification models.

Port of Santander study introduced a decision-support system combining machine learning and simulation to forecast truck arrivals and congestion, enabling better planning, optimized land use, and improved port-city logistics.

Phal (2024) highlighted how the first-come-first-serve (FCFS) berthing system contributes to ship idling and emissions. The study advocated for just-in-time (JIT) scheduling to cut fuel use and emissions by up to 21%.

III. RESEARCH METHODOLOGY

This study adopts a systematic research methodology to investigate ways to reduce cargo dwell time and enhance cargo processing efficiency at Chennai Port. It involves designing research questions, reviewing relevant literature, and applying appropriate research designs. Data is collected through surveys with stakeholders, operational observations, and analysis of historical port data. The findings are analyzed using statistical tools to identify bottlenecks and recommend actionable improvements in port operations.

RESEARCH DESIGN:

TYPE OF RESEARCH:
DESCRIPTIVE RESEARCH: Descriptive research is concerned with describing the current state of affairs without manipulating the environment. In this study, the current PORT dwell time at Chennai Port will be thoroughly described, including factors contributing to delays. The goal is to quantify the existing problem—how long cargo stays in the port before leaving, the bottlenecks, and why these delays are happening.

SAMPLING TECHNIQUE:
RANDOM SAMPLING:
Random sampling will be used for the **survey** portion of the research. This approach helps ensure that a **broad cross-section** of respondents is represented, minimizing bias in the sample and improving the generalizability of the findings. The aim here is to gather a diverse range of responses from the various stakeholders who are involved with Chennai Port but may not be directly involved in the management of PORT dwell time.

SAMPLE SIZE:
30 Participants from the broader pool of stakeholders (e.g., truckers, cargo handlers, and transport managers) will be selected using random sampling for the survey phase.

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DATA COLLECTION METHOD:
Primary data collection:
Primary data refers to information that is collected firsthand from original sources, which can offer direct insights into the specific issues surrounding PORT dwell time and cargo processing at Chennai Port.

SURVEYS:
To collect quantitative data from a larger, more diverse group of stakeholders involved in port operations. This method helps to quantify issues and gather broader perspectives.

OPERATIONAL STRATEGIES OF MAJOR INTERNATIONAL PORTS:

PortofSingapore:
The Port of Singapore has enhanced efficiency and competitiveness through automation and smart technologies. At the new Tuas Port, automated cranes, driverless vehicles, and AI-driven resource planning have streamlined cargo handling. The PORTNET digital platform enables real-time coordination among logistics stakeholders, while the TradeNet system speeds up customs clearance. Singapore is also building the Tuas Mega Port with a 65 million TEU capacity. Environmental sustainability is promoted via the Green Port Programme, and regular workforce training ensures adaptability to new technologies.
PortofRotterdam:
The Port of Rotterdam focuses on automation, digitalization, and sustainability. The Maasvlakte 2 terminal uses AGVs and remote-controlled cranes for efficient operations. The Portbase system enhances cargo visibility and simplifies documentation. The "Rotterdam Corridor" connects the port to Europe via multimodal transport. Green initiatives target carbon neutrality by 2050, and deep-water terminal expansions maintain capacity for large vessels. A public-private governance model supports innovation and long-term investment.

KEY OPERATIONAL PARAMETERS OF LEADING GLOBAL PORTS:

Parameter	Port of Rotterdam	Port of Singapore	Chennai Port
Annual Container Throughput	14.5 million TEUs (2023)	39.9 million TEUs (2023)	1.8 million TEUs (2023)
Average Container Dwell Time	Approx. 4.8 days	Approx. 2.5 days	Approx. 6.4 days
Vessel Turnaround Time	18–24 hours	12–15 hours	2.5–3 days
Crane Productivity	35–40 moves per hour	40–45 moves per hour	20–25 moves per hour

OperationalComparison:
Chennai Port handles around 1.8 million TEUs annually, much lower than Rotterdam (14.5 million) and Singapore (39.9 million), indicating a need for capacity expansion. Its average container dwell time is 6.4 days—longer than Rotterdam's 4.8 and Singapore's 2.5 days—pointing to inefficiencies in cargo and customs processes. Vessel turnaround at Chennai takes2.5–3 days, compared to 18–24 hours in Rotterdam and 12–15 hours in Singapore, reflecting slower operations. Crane productivity is also lower at 20–25 moves per hour, versus 35–40 in Rotterdam and 40–45 in Singapore, reducing overall efficiency.

ANALYSIS & INTERPRETATION:

DESCRPTIVE STATISTICS:

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INTERPRETATION: The results indicate that berth space (mean score: 3.53) and dwell time efficiency (3.60) are perceived as strengths at Chennai Port. However, lower scores for equipment adequacy (2.70), electronic documentation systems (2.35), and modernization (2.53) point to significant technological deficiencies. While automation received a relatively favorable rating (3.23), the overall findings suggest a pressing need for targeted technological upgrades to enhance operational efficiency.

CHI SQUARE TEST ANALYSIS:

Hypothesis:

S. No.	Questionnaire Statement	N	Mean	Standard Deviation	Minimum Response	Maximum Response
1	The port has sufficient berth space to handle high volumes of cargo efficiently	30	3.53	0.51	Agree	Strongly Agree
2	The port uses advanced equipment to ensure faster and safer cargo handling	30	2.7	0.92	Strongly Disagree	Strongly Agree
3	Automated systems (e.g., automated gates, RFID) significantly reduce dwell times at the port	30	3.23	0.43	Agree	Strongly Agree
4	The port uses electronic systems for faster document processing and clearance	30	2.35	0.66	Strongly Disagree	Agree
5	The port infrastructure is modern and up to date with current industry standards	30	2.53	0.78	Strongly Disagree	Strongly Agree
6	Shorter dwell times contribute to better use of existing port space, leading to higher throughput	30	3.6	0.5	Agree	Strongly Agree

NullHypothesis(H_0):
There is no significant relationship between age and the perception of automation in port operations.

AlternativeHypothesis(H_1):
There is a significant relationship between age and the perception of automation in port operations.

Age Group	Observed Frequency (O)	Expected Frequency (E)	Residual (O − E)
Less than 30	3	7.5	-4.5
30–39	8	7.5	0.5
40–49	11	7.5	3.5
50 and Above	8	7.5	0.5
Total	30	—	—

Test Variable	Chi-Square Value (χ^2)	Degrees of Freedom (df)	Significance Level (p-value)
Age	4.4	3	0.221

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INTEPRETATION: With a p-value of 0.221 (> 0.05), the test shows no significant link between employee age and their views on port automation, indicating age does not affect perceptions of automation effectiveness.

REGRESSION:

NullHypothesis(H_0):
There is no significant relationship between the independent variables (operational factors) and the effectiveness of automated systems in reducing dwell time at the port.

Alternative Hypothesis (H_1):
There is a significant relationship between the independent variables and the effectiveness of automated systems in reducing dwell time at the port.

Model Summary Table:

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Linear Regression	0.66	0.435	0.32	0.35

INTEPRETATION:
R = 0.66 shows a moderate positive link with dwell time reduction. R^2 = 0.44 means the model explains 44% of the variation. Adjusted R^2 = 0.32 indicates a moderate model fit, and the standard error of 0.35 shows average prediction deviation.

ANOVA:

Source	Sum of Squares	df	Mean Square	F
Regression	2.36	5	0.47	3.78
Residual	3	24	0.13	
Total	5.37	29		

INTEPRETATION: The ANOVA result (F = 3.78) indicates the model is statistically significant, meaning the five predictors collectively explain variation in dwell time reduction and support the model's fit for analyzing port efficiency.

COEFFICIENTS TABLE

Predictor Variable	Unstandardized B	Std. Error	Standardized Beta	t	Sig. (p-value)
(Constant)	2.71	1.2	—	2.25	0.034
Advanced equipment for faster & safer cargo handling	-0.23	0.16	-0.38	-1.46	0.157
Efficient vessel scheduling	-0.07	0.31	-0.07	-0.24	0.812
Electronic systems for faster document processing	0.52	0.15	0.69	3.38	0.002
Regulatory compliance reduces delays	0.1	0.17	0.12	0.61	0.546
[Numeric/Unspecified Variable]	-0.07	0.22	-0.07	-0.3	0.765

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INTEPRETATION:
The analysis supports the alternative hypothesis for electronic systems (p = 0.002), showing a significant impact on reducing dwell time. Other factors like equipment, scheduling, and compliance were not statistically significant.

FINDINGS OF THE STUDY:

The workforce at Chennai Port is highly experienced, with 73% having 20–30 years of service and 63% holding postgraduate degrees. Most stakeholders (36%) are aged 40–49, and the gender ratio is 60% male to 40% female. Stakeholders unanimously agree that the port has sufficient berth space, effective infrastructure, and operational systems that support efficient cargo handling. Automated systems like RFID are widely seen as reducing dwell time. However, views on advanced equipment and electronic document processing are mixed, and 60% believe inter-agency collaboration is lacking. The regression model (F = 3.78) confirms the significance of selected predictors, with only electronic systems showing a statistically significant impact (p = 0.002) on reducing dwell time. A chi-square test (p = 0.221) found no link between age and automation perception.

SUGGESTIONS AND RECOMMENDATIONS:

Chennai Port should introduce a mentorship program to transfer expertise from seasoned staff to newer employees. Regular infrastructure audits are needed to maintain operational efficiency as cargo volumes grow. Creating joint task forces with terminal operators, customs, and shipping companies will enhance coordination and reduce processing delays. E-processing by customs agencies (e.g., PQ/FSSAI) and greater investment in electronic document systems are essential to speed up cargo clearance. Lastly, ongoing workforce training on new technologies will strengthen operational readiness and port performance.

IV. CONCLUSION

The study shows Chennai Port has a skilled workforce and efficient infrastructure that support smooth operations and reduced dwell time. However, gaps in stakeholder coordination, use of advanced equipment, and electronic documentation remain. Strengthening digital systems, collaboration, and process consistency is key to further improving efficiency.

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