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A STUDY ON SUPPLY CHAIN DISRUPTION ON PORT OPERATIONS WITH SPECIAL REFERENCE TO CHENNAI PORT

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Abstract: The maritime supply chain, vital to global trade, faces increasing disruptions from pandemics, geopolitical tensions, and operational inefficiencies. This study examines the impact of such disruptions on Chennai Port, focusing on cargo throughput, vessel turnaround time, labor availability, and hinterland connectivity. Through a mixed-method approach, the research highlights significant slowdowns at Chennai Port during crises, revealing vulnerabilities in port operations. The study also identifies resilience strategies like digital technology adoption, improved coordination, and infrastructure upgrades. It concludes with policy recommendations to enhance the resilience of Indian ports through a technology-driven, integrated supply chain system.

Keywords: Supply Chain Disruption, Port Operations, Chennai Port , Resilience Strategies , Hinterland Connectivity.

I. INTRODUCTION

The maritime industry is essential to global trade, with ports serving as key hubs for the movement of goods. However, recent disruptions—from pandemics and geopolitical tensions to technological changes and climate uncertainties—have significantly impacted port operations. In India, Chennai Port is a crucial gateway for international trade, yet it has faced challenges such as the COVID-19 pandemic, labor shortages, and transportation delays. This study focuses on understanding the causes and effects of these supply chain disruptions on Chennai Port, examining their impact on cargo handling, vessel turnaround time, and logistics performance. It aims to provide insights into how port authorities can enhance resilience and improve operational continuity in the face of future disruptions.

OBJECTIVE

Primary Objectives:

To analyze the impact of recent supply chain disruptions, including the COVID-19 pandemic, natural disasters, and geopolitical tensions have affected the operations of Chennai Port.

Secondary Objectives:

- To identify and assess the key factors that contributed to supply chain disruptions at Chennai Port during recent global events (e.g., COVID-19, geopolitical tensions, natural disasters).
- To evaluate the effectiveness of Chennai Port's response strategies in mitigating the impact of these disruptions on port operations and logistics.
- To examine the role of technological adaptation (e.g., automation, digital tools) in improving resilience and operational efficiency at Chennai Port during and after disruptions.

SCOPE OF THE STUDY

The study focuses on understanding the nature, causes, and consequences of supply chain disruptions on the operations of Chennai Port. It aims to assess both internal and external factors—such as the COVID-19 pandemic, geopolitical developments, and natural disasters—that have impacted the port's performance. The research further explores how Chennai Port has responded to these disruptions, with an emphasis on operational resilience, infrastructure readiness,

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technological adaptation, and stakeholder coordination. The study will also examine specific industry sectors dependent on the port, such as automotive, textiles, and electronics, to evaluate the broader implications of disruptions on regional trade. Geographic scope is limited to Chennai Port, but the findings will be compared, where applicable, with other national or regional ports for benchmarking purposes. The timeframe includes disruptions occurring primarily between 2020 and 2024, a period marked by major global and local supply chain challenges.

II. REVIEW OF LITERATURE

Xu et al. (2021) analyzed 14 major Chinese ports using a panel regression model to examine how macroeconomic factors, epidemic severity, and government policies impacted port performance. Their findings highlighted that timely government interventions were critical to maintaining port efficiency during the pandemic.

Gu et al. (2023) focused on three major Asian ports—Shenzhen, Hong Kong, and Singapore. Using AIS and OxCGRT datasets, the study found that local COVID-19 cases negatively impacted cargo throughput, while global cases paradoxically increased local port activity, suggesting a re-routing of cargoes to safer ports.

Notteboom et al. (2021) compared the COVID-19 pandemic with the 2008–2009 financial crisis. The study emphasized that adaptive strategies such as slow steaming and capacity management helped ports and shipping companies better manage disruptions during COVID-19 than in the previous financial crisis.

Janardhan (2024) highlighted India's growing role in maritime security amid the Red Sea and Somali piracy crises. The Indian Navy's proactive stance has helped maintain the flow of trade in the Indian Ocean.

Yap & Yang (2024) used the Structure-Conduct-Performance (SCP) framework to study container port calls on Asia-Europe trade routes during the Red Sea crisis. They found that longer sailing routes forced shipping lines to reconfigure vessel deployment and port calls, impacting port operations across Asia and the Mediterranean.

III. RESEARCH METHODOLOGY

The research methodology for studying the **impact of supply chain disruptions on port operations**, with special reference to **Chennai Port**, will adopt a mixed-methods approach to gather both qualitative and quantitative data. This will provide a comprehensive understanding of the disruptions, their causes, the responses of port authorities, and the overall impact on various stakeholders.

RESEARCH DESIGN

TYPE OF RESEARCH:
DESCRIPTIVE RESEARCH: This research primarily aims to describe the nature, causes, and impacts of supply chain disruptions on the operations of Chennai Port. It will provide an in-depth understanding of how external disruptions (such as pandemics, geopolitical tensions, and natural disasters) affect port performance, including cargo throughput, vessel turnaround time, and labor efficiency.

SAMPLING TECHNIQUE:
RANDOM SAMPLING:
Random sampling will be employed for the survey portion of the research. This technique ensures that a diverse range of respondents is represented, minimizing sampling bias and enhancing the generalizability of the findings. The aim is to gather a broad spectrum of responses from stakeholders associated with Chennai Port, but not necessarily directly involved in the day-to-day management of port operations during supply chain disruptions.

SAMPLE SIZE:
A random sample of 30 participants from key stakeholders—shipping companies, cargo handlers, logistics managers, and port authorities—will provide a representative view of supply chain disruptions at Chennai Port

DATA COLLECTION METHOD:
Primary Data Collection:
Primary data will be collected directly from stakeholders to gain real-time insights into challenges faced by Chennai Port during disruptions.

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Surveys:
Surveys will gather quantitative data from stakeholders to measure the impact of supply chain disruptions on cargo handling, port performance, and supply chain efficiency. This will help quantify the effects of disruptions on port operations.

OPERATIONAL STRATEGIES OF MAJOR INTERNATIONAL PORTS:

Port of Singapore: has significantly improved its ability to withstand supply chain disruptions through automation and digital integration. At the Tuas Port, cutting-edge technologies such as automated cranes, driverless vehicles, and AI-based resource planning enable faster and more reliable cargo handling. The PORTNET platform facilitates real-time coordination among logistics stakeholders, while TradeNet streamlines customs clearance, reducing delays. The development of the Tuas Mega Port, with a projected capacity of 65 million TEUs, showcases Singapore's strategic foresight. Furthermore, initiatives like the Green Port Programme and ongoing workforce training support sustainability and adaptability—key factors in maintaining port resilience during crises.

Port of Rotterdam: adopts a similar forward-looking approach, emphasizing automation, digital logistics, and environmental sustainability. The Maasvlakte 2 terminal uses Automated Guided Vehicles (AGVs) and remote-controlled cranes to ensure high operational efficiency. Its Portbase platform enhances cargo visibility and document flow, critical for reducing delays and maintaining supply chain continuity. Additionally, the Rotterdam Corridor offers seamless multimodal connectivity with inland Europe, minimizing inland transport disruptions. Green policies aiming for carbon neutrality by 2050 and a strong public-private governance model further position the port as a resilient and competitive global hub.

Key Operational Parameters of Leading Global Ports:

Parameter	Port of Rotterdam	Port of Singapore	Chennai Port
Annual Container Throughput	14.5 million TEUs	39.9 million TEUs	1.8 million TEUs
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

Operational Comparison:
Chennai Port lags behind global ports like Rotterdam and Singapore in operational efficiency due to limited automation, longer vessel turnaround times, and poor hinterland connectivity. The strategies employed by Singapore and Rotterdam provide valuable insights into how Chennai Port can modernize operations, enhance coordination, and build a more resilient supply chain infrastructure.

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ANALYSIS & INTERPRETATION

DESCRPTIVE STATISTICS:

S. No	Questionnaire Statement	N	Mean	Standard Deviation	Minimum Response	Maximum Response
1	Vessel turnaround times increased due to supply chain disruptions.	30	3	1.02	Disagree	Agree
2	Chennai Port demonstrated resilience in recovering from any supply chain disruptions.	30	3.6	0.93	Disagree	Strongly Agree
3	The COVID-19 pandemic had a major effect on supply chain operations at Chennai Port.	30	3.13	1.25	Strongly Disagree	Strongly Agree
4	The port has efficient communication mechanisms to inform customers when any disruptions arise.	30	3.23	1.17	Strongly Disagree	Strongly Agree
5	Chennai Port has implemented better risk management strategies based on past disruptions.	30	3.63	1.03	Disagree	Strongly Agree
6	How effectively has the port integrated green energy and sustainable practices in response to disruptions?	30	3.7	0.99	Ineffective	Very Effective

INTERPRETATION:

The survey results show that Chennai Port is moderately resilient to disruptions, with a mean score of 3.6 (SD = 0.93). While the impact of COVID-19 on operations was noted (mean = 3.13, SD = 1.25), communication effectiveness was seen as inconsistent (mean = 3.23, SD = 1.17). Risk management strategies have improved (mean = 3.63, SD = 1.03), and the port has made strong strides in sustainability (mean = 3.7, SD = 0.99).

CORRELATION

Variables	Chennai Port demonstrated resilience in recovering from any supply chain disruptions	The port's response to supply chain disruptions has improved since the last major event
Chennai Port demonstrated resilience in recovering from any supply chain disruptions	1	0.067
Sig. (2-tailed)		0.727
N	30	30
The port's response to supply chain disruptions has improved since the last major event	0.067	1
Sig. (2-tailed)	0.727	
N	30	30

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INTERPRETATION:

There is a very weak and insignificant correlation (**r = 0.067**, **p = 0.727**) between Chennai Port's resilience and its improved response, indicating no strong link between the two.

FINDINGS OF THE STUDY

The study shows that most employees at Chennai Port are experienced, male, and hold postgraduate degrees. A majority believe supply chain disruptions are minimal, and reduced disruptions have improved efficiency. However, vessel turnaround times are seen to have increased. The port is viewed as moderately resilient, with employees noting quick adaptation, new strategies, and improvements in risk management and sustainability. While natural disasters and labor strikes are seen as disruptive, opinions on the impact of COVID-19 are mixed. Overall, resilience has improved, but there is no strong correlation between resilience and response (r = 0.067, p = 0.727).

SUGGESTIONS AND RECOMMENDATIONS

To improve operations at Chennai Port, focus on gender diversity through targeted recruitment and mentorship. Enhance communication during disruptions by providing real-time updates. Strengthen contingency plans, update risk management strategies, and improve coordination with stakeholders. Invest more in sustainable practices to reduce environmental impacts. Lastly, formalize feedback mechanisms to better integrate lessons learned and improve resilience.

IV. CONCLUSION

The study shows Chennai Port has shown moderate resilience to supply chain disruptions, there are key areas for improvement, including gender balance, communication, contingency planning, and risk management. Investing in sustainability, enhancing operational efficiency, and improving stakeholder coordination will also help mitigate disruptions. By formalizing lessons learned and feedback systems, Chennai Port can better prepare for future challenges, ensuring improved resilience and long-term sustainability in port operations.

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