

**CONCEPTUAL MODEL FOR ANALYSING THE  
OPERATIONAL PERFORMANCE OF INDIAN  
CONTAINER TERMINALS**

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INDIAN INSTITUTE OF TECHNOLOGY DELHI  
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OPERATIONAL PERFORMANCE OF INDIAN  
CONTAINER TERMINALS**

by

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*Submitted  
In fulfilment of the requirements of the degree of Doctor of Philosophy*

*to the*



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## **CERTIFICATE**

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This is to certify that the thesis entitled “**Conceptual Model for Analysing the Operational Performance of Indian Container Terminals**”, being submitted by **Mr. VPS Nihar Nanyam** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** is a bonafide record of the research work carried out by him under my supervision and guidance. The thesis work, in my opinion, has reached the requisite standard, fulfilling the requirements for the degree of Doctor of Philosophy.

The contents of this thesis, in full or in parts, have not been submitted to any other University or Institute for the award of any degree or diploma.

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VPS Nihar Nanyam

## ABSTRACT

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Indian container terminals handle 2% (17 million TEUs as of 2021) of the total global container throughput with two terminals listed among the top 100 world container terminals. Various international container ports such as Singapore, Hong Kong container ports handle more than the entire container traffic handled by Indian container terminals. With the advent of Government of India initiatives such as Sagarmala, Unnati project, etc., container terminals are expected to improve their key performance indicators, thereby enhancing operational performance. In the upcoming years, the container terminals in India can attain more substantial throughput targets by exploiting their untapped potential of throughput. As per the Maritime India vision 2030, the Indian container terminals are expected to handle 25 million TEUs by 2025. There is a requirement for huge scope of improvement in its operational performance for the Indian container terminals. Despite the number of studies on the competition, and performance related aspects of container terminals, most studies are of developed nations, and very few are of developing nations, such as India. Indian container ports are very critical due to their location advantage and their ability to handle transshipment traffic. There is a need to understand their market structure and performance at the micro-level, specifically the terminal level rather than that of the whole port.

Numerous factors may affect the existing terminals' ability to perform to their maximum capability. Despite the significance of the factors, no studies are available on the identification of the factors and their influence on the operational performance of the container terminals in India. Therefore, it is critical to identify the enabling and inhibiting factors and develop a conceptual model that indicates how their relationships affect the

operational performance of the container terminals in India.

This study analyses the concentration and deconcentration tendencies of the container terminals of India through empirical analysis, utilising concentration ratios, Herfindahl Hirschman Index (HHI) and the share-shift analysis (SSA) over the period of 2014–2020. Further, the study examines the development of Indian container terminals over the same period. The growth share matrix was plotted to bifurcate the terminals based on their market share and growth rate. The results indicated a deconcentration trend over the period of six years among the container terminals of India. The HHI index has reduced by over 37% in the six-year period considered, indicating that the market is moving towards perfect competitiveness, thereby increasing the scope for the development of new terminals. There were nine container terminals which demonstrated positive shift over the period of six years. The Adani International Container terminal (AICT) and Chennai International Container terminal (CIT) emerged as the star performers in terms of the growth share matrix over the considered period. Competitive positioning of each of the container terminals were presented. This study is the first of its kind related to the Indian container terminals.

To bifurcate into high and low performing terminals, this study evaluates the performance of container terminals using data envelopment analysis and Malmquist productivity index. Based on the analysis, there were two container terminals namely APM Terminals Mumbai, and the Bharat Kolkata container terminal which were consistently efficient over the period of six years. Reasons for inefficiency for each of the container terminal was presented and it was inferred that scale inefficiency was prominently increasing in the Indian container terminals. It was observed that there is a decline in the operational performance of the container terminals located along the West Coast than that of terminals located along the East Coast. Decline in the operational performance of container terminals operated under major ports was observed when compared to the terminals under non major

ports. Based on the Malmquist index, there were five container terminals, namely Kattupalli International Container Terminal, the Adani Mundra Container Terminal, the Adani Hazira Container Terminal, APM terminals Mumbai, and the Visakha Container Terminal, which were categorised under high performing. The low performing terminals were the Dakshin Bharat Gateway Terminal, the Adani International Container Terminal, Jawaharlal Nehru Port Container Terminal, Tuticorin container terminal and Bharat Kolkata Container terminal. Malmquist index and net shift of each of the container terminals were plotted to identify the high performing terminals with a gain in the market share over the period of six years. There were six container terminals namely Visakha Container Terminal, Vallarpadam International Container Transshipment Terminal, Haldia International Container Terminal, Adani Hazira Container terminal, Krishnapatnam Port Container Terminal, and Kattupalli International Container Terminal which gained the market share over the period of six years and were high performing. The analysis inferred that there is a need to identify the factors affecting the operational performance of container terminals of India.

Grounded theory was utilised to identify twenty-one codes as enabler attributes and were classified under six concepts categorized as enabling factors. Fifteen codes were regarded as inhibitor attributes grouped under three concepts categorized as inhibiting factors. Seven codes were regarded as performance indicators classified under performance factors. These identified attributes were grouped using exploratory factor analysis based on 81 responses obtained from 26 container terminals of India. The analysis yielded five enabling factors namely *infrastructure upgrading and system initiatives, terminal facilities and policy, reefer systems and logistics advantage, concessions and cost initiatives, and systems and processes*, three inhibiting factors namely *management and resource related issues, infrastructure issues and market capture, and policy and procedure related issues* and two performance factors namely *handling and storage related indicators and berth and vessel*

*related indicators*. Hypothesis based on the relationships were established along with a conceptual model. The model was tested using partial least squares structural equation modeling approach. This study yielded a conceptual model consisting of five enabling factors with fifteen enabler attributes, three inhibiting factors with twelve inhibitor attributes and two performance factors with seven performance indicators. The enabling factor titled *infrastructure upgrading and system initiatives* emerged as critical enabling factor with attribute titled *adoption of modern container handling equipment* as the critical attribute. The inhibiting factor titled *management, and resource-related issues* emerged as the critical inhibiting factor with attribute titled *management corruption* emerged as the critical attribute.

Conceptual model was validated using qualitative comparative analysis to understand the combined and interactive effects of three sets of conditions namely the physical characteristics, enabling factors, and inhibiting factors to the operational performance of container terminals. The results indicated that the considered conditions combinedly affect the operational performance. The most commonly occurring conditions identified in the study were *quay infrastructure, yard infrastructure, infrastructure upgradation and system initiatives, reefer systems and logistics advantage*. A conceptual model encompassing all the successful combinations of the conditions was presented in the research.

The outcomes of the study would enable the port authorities, private players, and the port operators to understand the market they are operating in and the strategies to devise for the purpose of improvement of the terminals. This research shall help the port authorities to adopt enabling factors and mitigate the inhibitor factors to improve the operational performance of container terminals. This research can support the decision makers in improving the operational performance of container terminals by adoption of the supporting conditions identified in the study. This study may help port professionals and port operators incorporate these factors and improve the operational performance of container terminals.

Furthermore, this study contributes to the minimal literature available on the factors influencing the performance of Indian container terminals and adds to the existing literature on Indian container terminals' performance

## सार

भारतीय कंटेनर टर्मिनल कुल वैश्विक का 2% (2021 तक 17 मिलियन TEU) संभालते हैं शीर्ष 100 विश्व कंटेनर में सूचीबद्ध दो टर्मिनलों के साथ कंटेनर थ्रूपुट टर्मिनल। विभिन्न अंतरराष्ट्रीय कंटेनर बंदरगाह जैसे सिंगापुर, हांगकांग कंटेनर भारतीय कंटेनर टर्मिनलों द्वारा संचालित संपूर्ण कंटेनर यातायात की तुलना में बंदरगाह अधिक संभालते हैं। भारत सरकार की पहल जैसे सागरमाला, उन्नति परियोजना, आदि के आगमन के साथ, कंटेनर टर्मिनलों से उनके प्रमुख प्रदर्शन संकेतकों में सुधार की उम्मीद है, जिससे परिचालन प्रदर्शन में वृद्धि। आने वाले वर्षों में, कंटेनर टर्मिनलों भारत अपनी अप्रयुक्त क्षमता का दोहन करके अधिक महत्वपूर्ण थ्रूपुट लक्ष्य प्राप्त कर सकता है थ्रूपुट का। मैरीटाइम इंडिया विजन 2030 के अनुसार, भारतीय कंटेनर टर्मिनल हैं 2025 तक 25 मिलियन TEU को संभालने की उम्मीद है। के विशाल दायरे की आवश्यकता है भारतीय कंटेनर टर्मिनलों के लिए इसके परिचालन प्रदर्शन में सुधार। के बावजूद प्रतियोगिता पर अध्ययन की संख्या, और कंटेनर के प्रदर्शन संबंधी पहलू टर्मिनल, अधिकांश अध्ययन विकसित देशों के हैं, और बहुत कम विकासशील देशों के हैं, जैसे भारत। भारतीय कंटेनर बंदरगाह उनके स्थान लाभ के कारण बहुत महत्वपूर्ण हैं और परिवहन यातायात को संभालने की उनकी क्षमता। उनके बाजार को समझने की जरूरत है सूक्ष्म स्तर पर संरचना और प्रदर्शन, विशेष रूप से इसके बजाय टर्मिनल स्तर पूरे बंदरगाह का।

कई कारक मौजूदा टर्मिनलों की उनके प्रदर्शन करने की क्षमता को प्रभावित कर सकते हैं अधिकतम क्षमता। कारकों के महत्व के बावजूद, कोई अध्ययन उपलब्ध नहीं है के परिचालन प्रदर्शन पर कारकों और उनके प्रभाव की पहचान भारत में कंटेनर टर्मिनल। इसलिए, सक्षम और अवरोधक की पहचान

करना महत्वपूर्ण है कारक और एक वैचारिक मॉडल विकसित करते हैं जो इंगित करता है कि उनके रिश्ते कैसे प्रभावित करते हैं भारत में कंटेनर टर्मिनलों का परिचालन प्रदर्शन।

यह अध्ययन की एकाग्रता और विकेंद्रीकरण प्रवृत्तियों का विश्लेषण करता है अनुभवजन्य विश्लेषण के माध्यम से भारत के कंटेनर टर्मिनल, एकाग्रता अनुपात का उपयोग करते हुए, Herfindahl Hirschman Index (HHI) और शेयर-शिफ्ट विश्लेषण (SSA) की अवधि में 2014-2020। इसके अलावा, अध्ययन भारतीय कंटेनर टर्मिनलों के विकास की जांच करता है एक ही अवधि। ग्रोथ शेयर मैट्रिक्स को के आधार पर टर्मिनलों को विभाजित करने के लिए प्लॉट किया गया था उनकी बाजार हिस्सेदारी और विकास दर। परिणामों ने पर एक विकेंद्रीकरण प्रवृत्ति का संकेत दिया भारत के कंटेनर टर्मिनलों के बीच छह साल की अवधि। HHI सूचकांक में कमी आई है माना जाता है कि छह साल की अवधि में 37% से अधिक, यह दर्शाता है कि बाजार आगे बढ़ रहा है पूर्ण प्रतिस्पर्धात्मकता, जिससे नए टर्मिनलों के विकास की गुंजाइश बढ़ जाती है। नौ कंटेनर टर्मिनल थे जिन्होंने छह . की अवधि में सकारात्मक बदलाव का प्रदर्शन किया वर्षों। अदानी इंटरनेशनल कंटेनर टर्मिनल (AICT) और चेन्नई इंटरनेशनल कंटेनर टर्मिनल (सीआईटी) ग्रोथ शेयर मैट्रिक्स के मामले में स्टार परफॉर्मर के रूप में उभरा है विचाराधीन अवधि में। प्रत्येक कंटेनर टर्मिनल की प्रतिस्पर्धी स्थिति थी पेश किया। यह भारतीय कंटेनर टर्मिनलों से संबंधित अपनी तरह का पहला अध्ययन है।

उच्च और निम्न प्रदर्शन करने वाले टर्मिनलों में विभाजित करने के लिए, यह अध्ययन मूल्यांकन करता है डेटा लिफाफा विश्लेषण और मात्मक्रिस्ट का उपयोग करके कंटेनर टर्मिनलों का प्रदर्शन उत्पादकता सूचकांक। विश्लेषण के आधार पर, एपीएम नामक दो कंटेनर टर्मिनल थे टर्मिनल मुंबई, और भारत कोलकाता कंटेनर टर्मिनल जो लगातार थे छह साल की अवधि में प्रभावी। प्रत्येक कंटेनर की अक्षमता के कारण टर्मिनल प्रस्तुत किया गया था और यह अनुमान लगाया गया था कि पैमाने की अक्षमता प्रमुख रूप से बढ़ रही थी भारतीय कंटेनर टर्मिनलों में। यह देखा गया है कि परिचालन में गिरावट आई है टर्मिनलों की तुलना में वेस्ट कोस्ट के साथ स्थित कंटेनर टर्मिनलों का प्रदर्शन पूर्वी तट के साथ स्थित है। कंटेनर टर्मिनलों

के परिचालन प्रदर्शन में गिरावट गैर प्रमुख के तहत टर्मिनलों की तुलना में प्रमुख बंदरगाहों के तहत संचालित देखा गया था बंदरगाह माल्मक्रिस्ट इंडेक्स के आधार पर, पांच कंटेनर टर्मिनल थे, अर्थात् कट्टुपल्ली अंतर्राष्ट्रीय कंटेनर टर्मिनल, अदानी मुद्रा कंटेनर टर्मिनल, अदानी हजीरा कंटेनर टर्मिनल, एपीएम टर्मिनल मुंबई, और विशाखा कंटेनर टर्मिनल, जो उच्च प्रदर्शन के तहत वर्गीकृत किया गया था। कम प्रदर्शन करने वाले टर्मिनल दक्षिण थे भारत गेटवे टर्मिनल, अदानी इंटरनेशनल कंटेनर टर्मिनल, जवाहरलाल नेहरू पोर्ट कंटेनर टर्मिनल, तूतीकोरिन कंटेनर टर्मिनल और भारत कोलकाता कंटेनर टर्मिनल। प्रत्येक कंटेनर टर्मिनल की माल्मक्रिस्ट इंडेक्स और नेट शिफ्ट की पहचान करने के लिए प्लॉट किया गया था छह वर्षों की अवधि में बाजार हिस्सेदारी में वृद्धि के साथ उच्च प्रदर्शन करने वाले टर्मिनल। वहां विशाखा कंटेनर टर्मिनल, वल्लारपदम इंटरनेशनल नाम के छह कंटेनर टर्मिनल थे कंटेनर ट्रांसशिपमेंट टर्मिनल, हल्दिया इंटरनेशनल कंटेनर टर्मिनल, अदानी हजीरा कंटेनर टर्मिनल, कृष्णापट्टनम पोर्ट कंटेनर टर्मिनल, और कट्टुपल्ली इंटरनेशनल कंटेनर टर्मिनल जिसने छह साल की अवधि में बाजार हिस्सेदारी हासिल की और उच्च थे प्रदर्शन कर रहा है। विश्लेषण ने अनुमान लगाया कि प्रभावित करने वाले कारकों की पहचान करने की आवश्यकता है भारत के कंटेनर टर्मिनलों का परिचालन प्रदर्शन।

ग्राउंडेड थ्योरी का उपयोग इक्कीस कोड को एनबलर विशेषताओं के रूप में पहचानने के लिए किया गया था और सक्षम कारकों के रूप में वर्गीकृत छह अवधारणाओं के तहत वर्गीकृत किया गया था। पंद्रह कोड थे अवरोधक कारकों के रूप में वर्गीकृत तीन अवधारणाओं के तहत समूहीकृत अवरोधक विशेषताओं के रूप में माना जाता है। प्रदर्शन कारकों के तहत वर्गीकृत सात कोड को प्रदर्शन संकेतक के रूप में माना जाता था। इन पहचानी गई विशेषताओं को 81 . के आधार पर खोजपूर्ण कारक विश्लेषण का उपयोग करके समूहीकृत किया गया था भारत के 26 कंटेनर टर्मिनलों से प्राप्त प्रतिक्रियाएं। विश्लेषण से पांच सक्षम मिले अवसंरचना उन्नयन और सिस्टम पहल, टर्मिनल सुविधाएं और नीति जैसे कारक, रीफर सिस्टम और लॉजिस्टिक्स लाभ, रियायतें और लागत पहल, और सिस्टम और प्रक्रियाएं, तीन अवरोधक कारक अर्थात् प्रबंधन और संसाधन संबंधी मुद्दे, बुनियादी ढांचे के मुद्दे और बाजार पर कब्जा, और नीति और

प्रक्रिया संबंधी मुद्दे और दो प्रदर्शन कारक अर्थात् हैंडलिंग और भंडारण संबंधित संकेतक और बर्थ और पोत संबंधित संकेतक। संबंधों के आधार पर परिकल्पना की स्थापना a. के साथ की गई थी संकल्पनात्मक निदर्श। आंशिक न्यूनतम वर्ग संरचनात्मक समीकरण का उपयोग करके मॉडल का परीक्षण किया गया था मॉडलिंग दृष्टिकोण। इस अध्ययन ने एक वैचारिक मॉडल प्राप्त किया जिसमें पांच सक्षम कारक शामिल थे पंद्रह एनबलर विशेषताओं के साथ, बारह अवरोधक विशेषताओं वाले तीन अवरोधक कारक और दो सात प्रदर्शन संकेतकों के साथ प्रदर्शन कारक। शीर्षक सक्षम करने वाला कारक बुनियादी ढांचे के उन्नयन और सिस्टम की पहल के साथ महत्वपूर्ण सक्षम कारक के रूप में उभरा आधुनिक कंटेनर हैंडलिंग उपकरण को महत्वपूर्ण विशेषता के रूप में अपना शीर्षक विशेषता। प्रबंधन शीर्षक वाले अवरोधक कारक, और संसाधन से संबंधित मुद्दे महत्वपूर्ण के रूप में उभरे प्रबंधन भ्रष्टाचार शीर्षक विशेषता के साथ अवरोधक कारक महत्वपूर्ण विशेषता के रूप में उभरा।

वैचारिक मॉडल को समझने के लिए गुणात्मक तुलनात्मक विश्लेषण का उपयोग करके मान्य किया गया था परिस्थितियों के तीन सेटों का संयुक्त और अंतःक्रियात्मक प्रभाव अर्थात् भौतिक विशेषताओं, सक्षम करने वाले कारकों, और के परिचालन प्रदर्शन के लिए अवरोधक कारक कंटेनर टर्मिनल। परिणामों ने संकेत दिया कि विचार की गई स्थितियां संयुक्त रूप से प्रभावित करती हैं परिचालन प्रदर्शन। अध्ययन में पहचानी गई सबसे अधिक होने वाली स्थितियां के इंफ्रास्ट्रक्चर, यार्ड इंफ्रास्ट्रक्चर, इंफ्रास्ट्रक्चर अपग्रेडेशन और सिस्टम थे पहल, बादबानी प्रणाली और रसद लाभ। एक वैचारिक मॉडल जिसमें सभी शामिल हैं शोध में परिस्थितियों का सफल संयोजन प्रस्तुत किया गया।

अध्ययन के परिणाम बंदरगाह अधिकारियों, निजी खिलाड़ियों और पोर्ट ऑपरेटर्स को उस बाजार को समझने के लिए जिसमें वे काम कर रहे हैं और रणनीतियां तैयार करने के लिए टर्मिनलों के सुधार का उद्देश्य। इस शोध से पत्तन प्राधिकरणों को मदद मिलेगी संचालन में सुधार के लिए सक्षम करने वाले कारकों को अपना और अवरोधक कारकों को कम करना कंटेनर टर्मिनलों का प्रदर्शन। यह शोध निर्णय निर्माताओं

का समर्थन कर सकता है सहायक को अपनाकर कंटेनर टर्मिनलों के परिचालन प्रदर्शन में सुधार करना अध्ययन में पहचानी गई शर्तें। यह अध्ययन बंदरगाह पेशेवरों और बंदरगाह ऑपरेटरों की मदद कर सकता है इन कारकों को शामिल करें और कंटेनर टर्मिनलों के परिचालन प्रदर्शन में सुधार करें। इसके अलावा, यह अध्ययन कारकों पर उपलब्ध न्यूनतम साहित्य में योगदान देता है भारतीय कंटेनर टर्मिनलों के प्रदर्शन को प्रभावित करता है और मौजूदा साहित्य में जोड़ता है भारतीय कंटेनर टर्मिनलों के प्रदर्शन पर.

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ACMT	Adani CMA Mundra Terminal
AECT	Adani Ennore Container Terminal
AHCT	Adani Hazira Container Terminal
AICT	Adani International Container Terminal
AKPCT	Kattupalli International Container Terminal
AMCT	Adani Mundra Container Terminal
APM M	APM Terminals Mumbai
APM -P	APM Terminals Pipavav
AVE	Average Variance Extracted
BCC	Banker, Charnes, Cooper
BKCT	Bharat Kolkata Container Terminal
BMCT	Bharat Mumbai Container Terminals
CCR	Charnes, Cooper and Rhodes
CCT	Chennai Container Terminal
CFS	Container Freight Station
CIT	Chennai International Container Terminal
CR	Concentration Ratio
CRS	Constant Returns to Scale
DBGT	Dakshin Bharat Gateway Terminal
DEA	Data Envelopment Analysis
DEMATEL	Decision-Making Trial and Evaluation Laboratory
DMU	Decision Making Units

DPD	Direct Port Delivery System
EFA	Exploratory Factor Analysis
ERP	Enterprise Resource Planning
FDH	Free Disposal Hull
GOI	Government Of India
GST	Goods And Service Tax
HHI	Herfindahl Hirschman Index
HICT	Haldia International Container Terminal
HSE	Health, Safety, And Environment
HTMT	Heterotrait-Monotrait
JNPCT	Jawaharlal Nehru Port Container Terminal
JNPT	Jawaharlal Nehru Port Trust
KICT	Kandla International Container Terminal
KMO	Kaiser Meyer Olkin
KPCT	Krishnapatnam Port Container Terminal
K-S	Kolmogorov–Smirnov Test
MICT	Mundra International Container Terminal
MIV	Maritime India Vision
MPC	Mumbai Port - Containers
MPI	Malmquist Productivity Index
MPT	Mormugao Port
NMPC	New Mangalore Port - Containers
NSDP	Net State Domestic Product
NSICT	Nhava Sheva International Container Terminal
NSIGT	Nhava Sheva India Gateway Terminal

OCR	Optical Character Recognition
OTE	Overall Technical Efficiency
PCS	Port Community Systems
PICT	Paradip International Container Terminal
PKCT	PSA - Kakinada Container Terminal
PLS-SEM	Partial Least Squares Structural Equation Modeling
PTE	Pure Technical Efficiency
QCA	Qualitative Comparative Analysis
RFID	Radio Frequency Identification
RQ	Research Questions
RTG	Rubber Tyred Gantry Cranes
SE	Scale Efficiency
SFA	Stochastic Frontier Analysis
SSA	Shift Share Analysis
TAMP	Tariff Authority for Major Ports
TCT	PSA Sical Tuticorin Container Terminal
TEU	Twenty-Foot Equivalent Units
TOPSIS	Technique For Order Of Preference By Similarity To Ideal Solution
VCT	Visakha Container Terminal
VICTT	Vallarpadam International Container Transshipment Terminal
VIF	Variance Inflation Factor
VRC	Vessel Related Charges
VRS	Variable Returns to Scale