ANALYSIS AND MANAGEMENT OF BARRIERS IN THE MARITIME SUPPLY CHAINS OF CONTAINERIZED FREIGHT

A thesis submitted to the
University of Petroleum and Energy Studies

For the award of
Doctor of Philosophy

in

Transportation Management

By

Vishal Kashav

May 2021

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Department of Transportation Management
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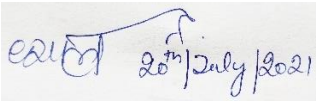
With the blessings of Lord Shree Ram,

I dedicate this thesis to my parents

for their endless love, immense support, and encouragement

Declaration

I hereby declare that the work in this dissertation titled "Analysis and Management of barriers in the maritime supply chains of containerized freight" has been carried out by me at the Department of Transportation management, School of Business (SoB), University of Petroleum and Energy Studies (UPES), Dehradun - India. The information derived from literature has been duly acknowledged in the text and a list of references provided. Therefore, to the best of my knowledge and belief, it contains no material previously published or written by another person, nor material that has been accepted for the award of any other degree or diploma at the University of Petroleum and Energy Studies or any other institution of higher learning, except where due acknowledgment has been made in the text.



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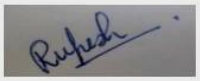

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Abstract

On the account of phenomenal growth in container volumes in the last ten years, the maritime supply chains (MSCs) have been expanding in India. With growing container volumes, it becomes important to develop, modernize and manage the maritime supply chains. Amid ferocious competition, efficiency, productivity, effectiveness, and cost reduction are the key elements for maritime supply chains to remain sustainable for long. However, the presence of barriers or constraints has obstructed the smooth flow of containerized freight and the entire maritime supply chain system is crippled. Barriers or constraints have surged costs and led to immense operational inefficiencies. Additionally, the long-term impacts of the barriers and constraints have led to many of the actors and stakeholders in maritime supply chains undergoing financial distress and even bankruptcy. The sector has largely become unattractive and the rivals in the neighboring countries are getting benefitted. For instance, despite significant efforts over years, ports in India have not been able to attract India's transshipment volume which is handled by Port of Colombo and other neighboring ports. The maritime supply chain is comparatively a new concept in the research world and only a few researchers have tried their hands on it. The implications of existing studies on maritime supply chains are either region-specific or in context to global. Moreover, these studies focused on barriers to integration and information technology implementation in the maritime supply chains. There exists no study which proposes a strong integrated model/framework for evaluating barriers/constraints specific to containerized freight and strategies to subjugate the influence of barriers, which makes it a predominant research gap. This study has funneled down the research gap further to only containerized freight, which is an untapped area to work on. Most importantly, a part of the current study is motivated by Dr. Manmohan Singh's (Former Prime Minister) doctoral research thesis with the title "India's export performance, 1951–1960, export prospects and policy implications" pursued at the University of Oxford.

In the first part of this research, categories, and sub-categories of the barriers and strategies to overcome those barriers/constraints are discerned by thoroughly reviewing available literature. Additionally, Drewry Maritime Research and Drewry Supply Chain Advisors provided immense support through the latest research reports and data intelligence on barriers/constraints. Delphi survey technique was employed to finalize the set of categories and sub-categories of barriers and strategies to subjugate these barriers. Subsequently, the Fuzzy Analytic Hierarchy Process (FAHP) is employed to prioritize categories and sub-categories of the barriers by calculating their weights and ranks. The analysis exhibits that the Infrastructural barriers (IFBs) are censorious in nature and are the foremost inhibitor in the entire maritime supply chains of containerized freight. Likewise, legal barriers (LGBs) are ranked second most critical in nature and thus need the utmost attention of strategists and policymakers. Among sub-categories, LGB2 i.e., "Unsupportive government policies, laws, and regulations for the actors in the maritime supply chains" is ranked one, and TEB2 i.e., "Poor quality of equipments and cranes at ports" is ranked second most critical in nature. Similarly, ECB2 i.e., "Steady growth of cargo generating sectors" is ranked three among sub-categories of the barriers.

Identically, the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS or Fuzzy TOPSIS) is engaged to derive ranks of the strategies to subjugate the barriers/constraints. The analytical case of maritime supply chains of containerized freight in India is put on the test to exhibit the use of the propounded integrated framework. The ranking obtained with the FTOPSIS method exhibit top three strategies as; Identification and development of dedicated feeder and hub ports infrastructure, Competitive port charges and Modern cranes and equipments like Automated Guided Vehicles (AGVs), Global Positioning System (GPS), Automated Gate Systems (AGS), Radio Frequency Identification (RFID), Ship profile scanning system, etc., that need immediate attention of the actors and stakeholders. This research propounds a precise, effective, and organized decision support environment for stage-wise executing the strategies to boost the effectiveness and competence of the maritime supply chains.

Key Words: *Maritime supply chains; Barriers; Strategies; Fuzzy AHP-TOPSIS; Sensitivity Analysis; India*

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I would like to express my deep and sincere gratitude to my guides, Dr. Rupesh Kumar and Dr. Chandra Prakash Garg, for providing invaluable assistance, guidance, support, and direction. Without their expertise and knowledge of the domain, this dissertation would not have been possible. Their dynamism, vision, sincerity, motivation have deeply inspired me. It was a great privilege and honour to work and study under their guidance.

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Thank you!

(Vishal Kashav)

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List of Abbreviations

Abbreviations	Full Name
ADPB	Administrative and Political Barriers
AGV	Automated Guided Vehicle
AHP	Fuzzy Analytic Hierarchy Process
AI	Artificial Intelligence
ANP	Analytic network process
APCCIF	Andhra Pradesh Chambers of Commerce and Industry
ASEAN	Association of Southeast Asian Nations
ASSOCHAM	Associated Chambers of Commerce and Industry of India
BCO	Beneficial Cargo Owner
BRICS	Brazil, Russia, India, China, and South Africa
BWM	Best-Worst Method
CAG	Comptroller and Auditor General
CAGR	Compound Annual Growth Rate
CFA	Confirmatory Factor Analysis
CFS	Container Freight Station
CHA	Custom House Agent
CMA CGM	Compagnie Maritime d'Affrètement and Compagnie Générale Maritime
CONCOR	Container Corporation of India
COSCO	China Ocean Shipping Company
CRM	Customer Relationship Management
CTO	Container Train Operator
DC	Distribution Center
DFCs	Dedicated Freight Corridor
ECB	Economic Barriers
EFA	Exploratory Factor Analysis
EXIM	Export Import

FDI	Foreign Direct Investment
FFFAI	Federation of Freight Forwarder's Associations in India
FMCG	Fast Moving Consumer Goods
GDP	Gross Domestic Product
GHG	Green House Gases
GMSC	Global Maritime Supply Chain
GPS	Global Positioning System
GSC	Global Supply Chain
IB	Information Bottleneck
ICD	Inland Container Depot
IFB	Infrastructural Barriers
IoT	Internet of Things
IPA	Indian Ports Association
ISM	Interpretive Structural Modeling
IWs	Inland Waterways
JIT	Just-In-Time
JNPT	Jawaharlal Nehru Port Trust
LGB	Legal Barriers
LPI	Logistics Performing Index
MAUT	Multi-Attribute Utility Theory
MCA	Minimum Guaranteed Cargo
MCDM	Multiple-Criteria Decision-Making
MGR	Minimum Guaranteed Revenue
ML	Machine Learning
MSC	Mediterranean Shipping Company
MSC	Maritime Supply Chain
NMDP	National Maritime Development Programme
NVOCC	Non-Vessel Owning Common Carrier
NYK	Nippon Yūsen Kabushiki Kaisha

OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OGB	Organizational Barriers
OOCL	Orient Overseas Container Line
PIL	Pacific International Lines
PPP	Public-Private Partnership
PSA	Port of Singapore Authority
PSU	Public Sector Undertaking
RFID	Radio-Frequency Identification
SCI	Shipping Corporation of India
SCM	Supply Chain Management
SEZ	Special Economic Zone
SME	Small and Medium Enterprises
TAMP	Tariff Authority for Major Ports
TEB	Technological Barriers
TEU	Twenty-foot Equivalent Unit
TFN	Triangular Fuzzy Number
ToC	Theory of Constraints
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
UNCTAD	United Nations Conference on Trade and Development
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje

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Chapter 1

Introduction and Background

Overview

The first chapter exhibits the background of current research with a detailed introduction to the theme "*maritime supply chains*". Chapter one elucidates some relevant concepts which are imperative to comprehend the quintessence of the entire thesis. This chapter also sheds light on how India's containerized freight trade has developed over time, and how barriers/constraints are holding back the growth of this sector. The business problem and research problem are drafted separately in this chapter. Further, the first chapter draw research questions and research objectives. Additionally, this chapter explores the barriers in the maritime supply chains of Indian containerized freight with shreds of evidence.

1.1 Background of the Study

India, being an ancient civilization and one of the fastest-growing economies in the world, has shown a rich maritime culture in the past, evidence of which can be traced back to the Indus valley civilization (Jarrige and Meadow, 1980). The excavation of Lothal's dock gave signs of maritime activities and possible trade between ancient India and other parts of the world (Leshnik, 1968). During excavations at the sites of Harappan civilization settlement, a huge man-made basin alongside the settlement zone was found. However, many sites across India are still being excavated (e.g., Sinauli in Uttar Pradesh, Keezhadi in Tamil Nadu, Singrauli in Madhya Pradesh) and more pieces of evidence will be unearthed in the coming times. In recent history, i.e., during the Mughal era, several industries flourished in India, and the arrival of the Portuguese, the Dutch, and the English not only uplifted the trade but also helped and developed maritime trade and routes (Irwin, 1991). Many ports prospered and flourished the trade along the coastline during this era. Bowen (2002) concluded Company rule was a foremost

source that helped in the establishment of the British Empire in India which further took control of administrative and public finances. Foreign invaders did set up industries and developed maritime supply chains to produce, manufacture and export but only for their interests.

Indian politician and renowned writer Shashi Tharoor (2016) wrote, “When the East India Company gained control of the country, in the mayhem that ensued post disintegration of the Mughal Empire, India’s share in the world GDP (Gross Domestic Product) was 23%”. However, when the Britishers left, it was just above 3%. In the last couple of centuries, trade and transportation evolved gradually in the Indian sub-continent. Around 1956, a trucking company owner named Malcolm Mclean introduced the concept of containerization which revolutionized the shipping industry because of its inter-modalism (later replaced with multi-modal transportation). With time, efficient supply chain networks were evolved to minimize costs. Since then, containerization has evolved year by year, and in the present times, we see modern ports, bigger and faster container ships delivering cargo complying with the concept of just-in-time. Over a period of time, maritime facilities and inland transportation modes were developed to reach the current stage. Similarly, the maritime supply chain or MSC is comparatively a new concept for India and is gaining importance, however, further growth and development of the maritime supply chains is hindered because of the presence of internal and external barriers/constraints/bottlenecks. Not just that, because of the presence of barriers; actors and stakeholders in the maritime supply chain sector are suffering huge monetary losses every year, which is mentioned in detail in the business problem section. There is a lack of literature and understanding on the maritime supply chains of containerized freight in the Indian context. The goal of this study is management and analysis of the barriers of the maritime supply chain of Indian containerized freight. Therefore, the primary aim of this study is to identify and assess those barriers and understand the criticality and relationship among them. Thereafter, to subjugate the impact of these barriers, strategies are discerned and evaluated.

1.2 Concepts and Operating Definitions

Before understanding the data and methods for analysis, it is imperative to understand crucial concepts and definitions. Therefore, this section exhibits a brief introduction and understanding of some important concepts such as; containerization and containerized freight, container shipping; maritime supply chains, and barriers in the maritime supply chains.

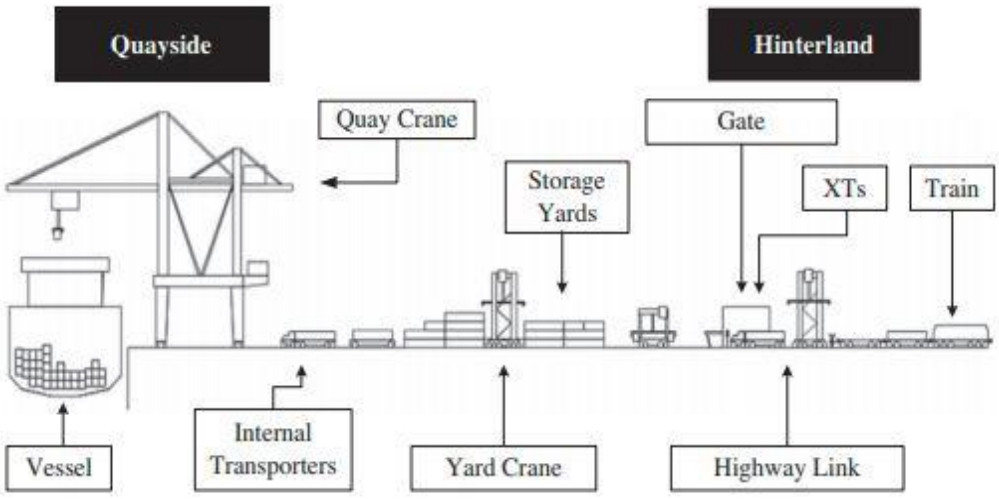
1.2.1 Containerization or containerized freight

Containerization is the practice of properly packing and stuffing finished or semi-finished commodities in maritime containers (20ft and 40ft containers are most commonly used in international maritime trade) for transportation from the importer to the exporter's premise. Before the concept of containerization, freight was transported in loose form and this used to take longer transit time i.e., the time between picking the shipments at origin and delivering at the destination. Earlier, different types of goods were handled and transported together in the same vessels and this would lead to delay in shipments reaching their respective destinations. Also, before containerization, freight transportation services were costly, time-consuming, inefficient, unproductive, and unreliable. The concept of containerization gained importance in a very short period of time because it is comparatively easy for maritime containers to change the mode of transport. Containerization has become the most optimal mode of freight transportation and this can be supported by the fact that there are different types of containers available for transporting a variety of commodities for example; dry containers, high cube containers, open-top containers, flat rack containers, open side container, reefer, and tank containers, etc.

1.2.2 Container shipping

Malcolm Mclean is the person who began the practice of transporting freight in maritime containers in 1956, and also, patented the first container ship. The reason why container shipping was widely accepted and practiced because it is an economical mode of transport, whether one wants to ship perishables, industrial tools, machines, cars, tractors, electronic gadgets, or clothing. Container shipping is also called liner shipping because container ships have pre-defined schedules on pre-determined routes. In container shipping, containers stuffed with commodities (laden containers) are brought to the seaports using multiple modes (such as railways, roadways, and inland waterways or IWs) and then loaded onto the dedicated cellular container ships with the help of port cranes and other equipments. Similarly, at the destination port, containers are unloaded from ships and transported further to the importer's premises. In container shipping, a shipper is also called Beneficial Cargo Owner (BCO). Since its invention, container shipping has evolved over time and today we see most modern cellular container ships and dedicated seaports and terminals to handle those ships.

Figure 1.1 Container shipping cycle

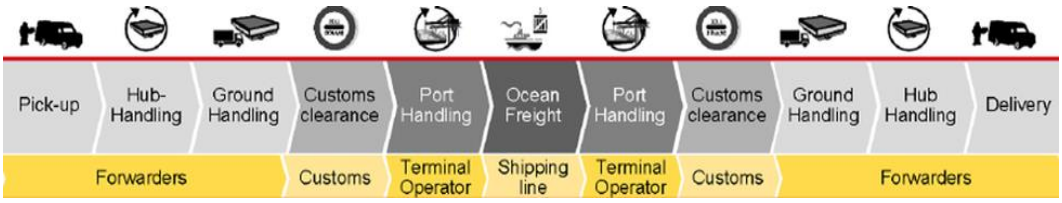


Source: Taner et al. (2014)

1.2.3 Maritime Supply Chains (MSCs)

As IGI Global - a leading international academic publisher headquartered in Pennsylvania (US) explained, Global Maritime Supply Chains (GMSCs) as the movement of freight and related support services involving two substantial locations (which are; origin and destination) using maritime and land transport modes. A maritime supply chain or MSC is a concept of integration between various activities that take place when the cargo is transported from the importer's premises to the exporter's premises using various modes. In simple words, a maritime supply chain is a nexus of the freight transportation system through which cargo is moved from its origins to the destinations using maritime and land mode (which are; roadways, railways and inland waterways, etc.). Also, Lam (2015) explained the maritime supply chain in the context of container shipping as 'the connected series of activities pertaining to shipping services which are concerned with planning, coordinating and controlling containerized freight from point of origin to the point of destination. The global network of the maritime supply chain is called as GMSCs, which is a relatively new area and less explored. Lam (2011), Lam and Yap (2011), and Lam and Zhang (2014) investigated maritime supply chains from different perspectives. Lam and Bai (2016) unveiled the relatively low visibility in maritime supply chains and thus created awareness on this issue. Below is a diagram of different stages in maritime supply chains of containerized freight.

Figure 1.2 Different stages in maritime supply chains (MSCs) of containerized freight



Source: Tavasszy et al. (2014)

Apart from containerized freight, there exist maritime supply chains of bulk cargo (Dry and Wet bulk) and commodity-specific maritime supply chains (e.g., crude oil, LNG/LPG, coal, various types of minerals, etc). As illustrated in the above figure, the forwarder stage consists of actors like shippers (BCOs), warehousing companies, ICDs (Inland Container Depots), freight forwarders and forwarding agents, CHAs (Custom House Agents), CTOs (Container Train Operators), and shipping lines. CFSs, stevedoring companies, ship chandelling, and provision companies, bunkering companies, dredging, towage, and pilotage service companies are some more actors and stakeholders who are located at seaports. Also, customs and central excise is yet another important stakeholder whose role is very important.

1.2.4 Barriers in the maritime supply chains

In the age of automation and digitalization, numerous opportunities lie before us but the need is to make efforts in order to gain benefits out of such opportunities. However, bringing modern technological reforms is not so easy because of the presence of barriers in entire the maritime supply chains, which is what the situation of India is. Because of the presence of barriers, the efficiency, reliability, and productivity of maritime supply chains are jeopardized. Also, the presence of barriers has surged costs and transit time of freight in the maritime supply chains. For instance, the criticality of these barriers affected Indian shippers and port companies and they are losing approximately $400 million every year. In fact, the theory of constraints (ToC) suggests that a constraint is anything that prevents the system/process from achieving its goal. There are many ways that constraints can show up during a process. Constraints can be external or internal to the network and are also termed as bottlenecks and barriers. In a business sense, a barrier can be defined as a hindrance to the business process which blocks productivity and profitability, similar is the case with maritime supply chains of containerized freight. In coming chapters, the presence of barriers in the maritime supply chains is confirmed by reviewing available literature and through experts' feedback.

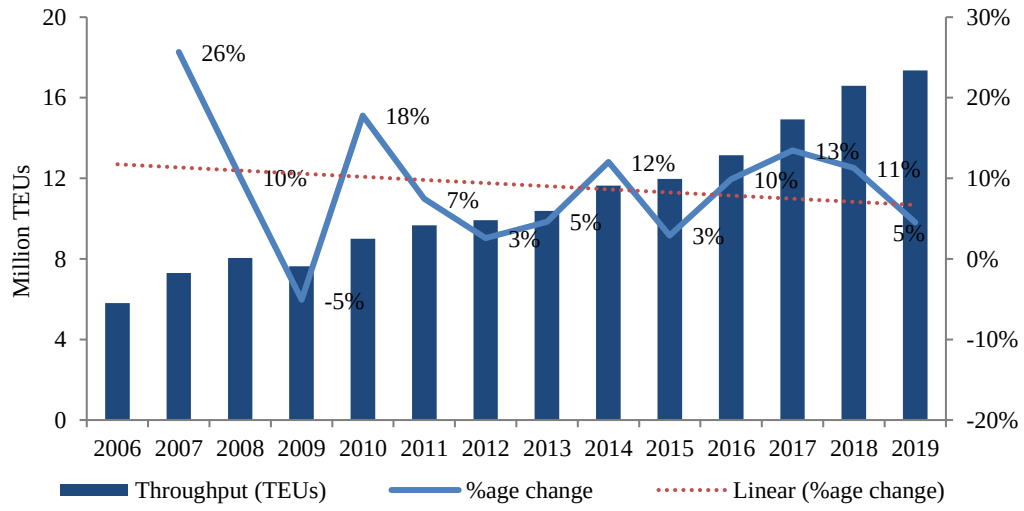
1.3 Development of containerized freight trade and actors in the maritime supply chains

The concept of containerization was introduced around 1970 in India but the first-ever scheduled main trade liner service was commenced at Mumbai port in the 1980s by American President Line or APL line. However, the concept of containerization failed to gain momentum initially as the government didn't feel the need of setting up basic infrastructure which could support maritime supply chains of containerized freight. But as the impact of containerization increased globally, the Indian government also realized its importance and went on to set up Jawaharlal Nehru port in Mumbai, a dedicated container port. Subsequently, the Container Corporation of India (or CONCOR), which is now a Navratna Public Sector Undertaking (PSU), was incorporated in 1988. And this is how; CONCOR established the country's first-ever Inland Container Depot at Tughlaqabad in New Delhi. This was like a boon for shippers located deep in the hinterland as they got custom clearance services in the ICDs themselves.

In the last two decades, the country's GDP grew incrementally on the back of a set of factors that includes the export and import trade volume. BCOs are progressively digressing from general or bulk shipping to container transport because it is a time and cost-saving mode. With more and more bulk commodities being containerized, the country's share of container traffic has increased steeply in the global market. With this, the facilities like container freight stations (CFSs) and inland container depots (ICDs) have been established all across the country, and these are proved to be prominent elements of the maritime supply chains. CFSs carry a significant responsibility in relieving congestion at container ports, and this adds value to the existing maritime supply chain network. Also, ICDs regale the container traffic generated from various clusters in the hinterland, which is a result of industrial activities. The likelihood of solid growth and heftier profits in the future has led to inject funds in the CFS and ICD infrastructure. The CFSs and ICDs are anticipated to grow on the account of rising containerization levels. For ICDs and CFSs to grow, all CFS/ICD operators need to intensify

integration with actors and stakeholders in the maritime supply chain. Since maritime is a dependent sector and can only flourish if it is supported by export/import bound cargo generating industry. In recent times, Indian goods have become quite attractive in the global market e.g., currently, demand has risen for Indian finished vehicles in Turkey, and for Indian fruits and nuts in the United Kingdom and the United Arab Emirates. India is in limelight for rising up as a key automotive manufacturing hub and Original Equipment Manufacturers (OEMs) around the world are investing significantly in the country to increase the production capacity. This is a motivating factor for the actors and stakeholders in the maritime supply chain domain. India has opened the gates for 100% foreign direct investments in the maritime sector because of which many of the foreign entities have invested in India. Today, the country is blessed with flourishing container ports on both the east and west coast of the country. The below graph depicts the growth of India's containerized freight volume over years.

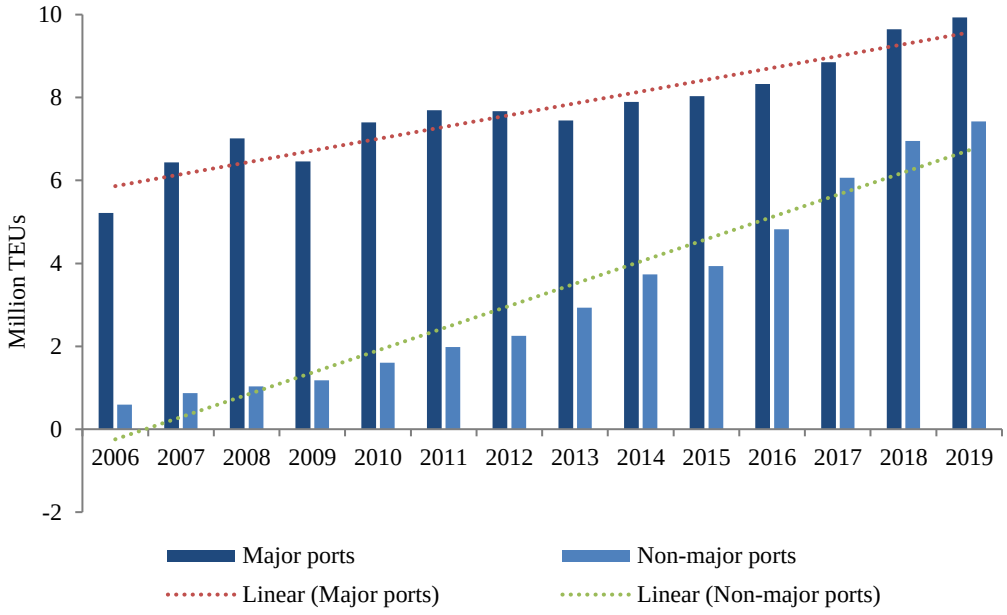
Figure 1.3 Historical growth of India's throughput with a year-on-year growth rate



Source: Drewry Maritime Research database

In the last decade, the performance of non-major/private ports has been better than major/government-owned ports in the context of handling containerized freight. There have been several reasons why container throughput at major ports is declining e.g., lack of good facilities, uncompetitive port tariff, lack of 24X7 hassle-free services, and lack of good connectivity with the hinterland. Because of the above reasons, the container volume is being shifted to non-major ports. The below graph illustrates how throughput on the major and non-major ports has progressed over the years where one can see that the non-major ports are performing far better than major ports in case of handling container traffic. The trendline indicates the gap between volume share of major vs non-major ports is shrinking gradually over time.

Figure 1.4: Comparison of historical port throughput of major ports vs non-major ports in India

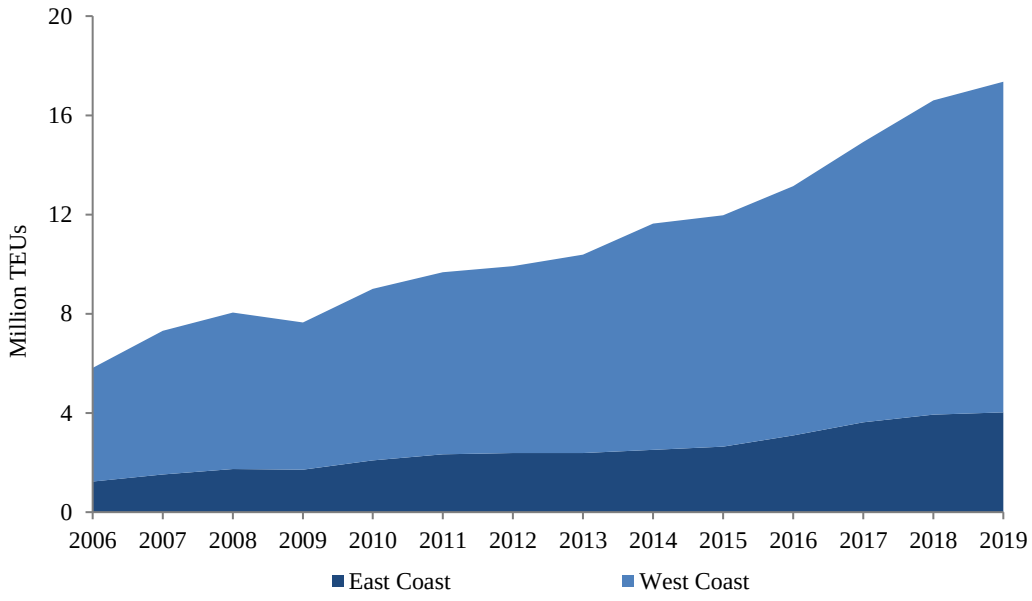


Source: Drewry Maritime Research database

Similarly, the Indian coastline is divided into two parts which are; West Coast and East Coast. The below table illustrates the domination of the west coast over the

east coast in terms of handling containerized freight. Because of prominent ports like JNPT (Jawaharlal Nehru Port Trust) in Mumbai, Adani ports in Mundra and Hazira, and APM Terminals in Pipavav, the share of the west coast in handling containerized freight has increased immensely over the east coast. However, ports on the West coast were dominating right from the beginning.

Figure 1.5: Comparison of historical port throughput of East coast vs West coast ports in India



Source: Drewry Maritime Research database

1.4 Problems in the maritime supply chain domain-Indian context

The maritime supply chain or MSC sector is in an amateur stage in India. Despite several policy-level decisions that have been taken by the governments (Central & State) and foreign investments infused over the years, there is still a long way to go. Being the sixth-largest economy in the world, India is still ranked 35th on Logistics Performance Index and this clearly indicates that the logistics facilities are not as good as they should be. The logistics cost in India is 14% of the GDP, wherein, it is around 8-9% in developed economies. Talking about fleet

ownership, India is ranked 18th globally (UNCTAD). The Shipping Corporation of India (or SCI) is nowhere in the top 20 shipping lines in the world and has a fleet of very old ships which are not allowed to enter ports in the developed countries. Jawaharlal Nehru Port (or JNPT) is the leading container port in India which is ranked 28th globally, whereas, its biggest rival Colombo has 22nd rank globally. These are some broad facts that indicate that India is standing long behind when it comes to the maritime supply chain sector. There are many reasons which impact the performance of this sector.

Owing to the presence of barriers/bottlenecks/constraints which have hindered the smooth working of maritime supply chain network. As per the CAG report of the year 2010 on major ports which found that the cargo handling facilities at major ports were inefficient, as the ports did not have the dedicated facilities that were necessary for quick handling of containers. This directly affected port productivity and ports failed to attract more cargo and cargo from new clients. Also, the report mentioned the cargo handling equipments which has exceeded economic life but is still employed with ports.

The wider regulatory framework makes stricter entry barriers into the industry for foreign players. The Indian flag has some disadvantages with regard to tax and duty structures inhibiting the FDI flow in the maritime supply chain sector. The vessel fleet owners around the world believe that India is not a commercially feasible destination for registering vessels. However, in the year 2004, India implemented the globally adopted taxation system for the maritime industry by enforcing a tax that is applied on the basis of the cargo-carrying capacity of vessels. The tonnage tax - sovereignty that allows 95% of the vessel fleet to operate - trimmed the tax outgo of the vessel-owning firms in India to 1-2% of their earning, as matched with the corporate tax rate of 33.9%.

Doorstep delivery consignment is challenging in India where the transport network is overburdened and in a wretched state. This escalates the repair and maintenance cost of the vehicles which results in increased logistics cost for

service buyers. Also, the logistics sector is on the back foot due to the cartel controlling part of the government bodies, this soars the costs because of bribery. A serious effort to bring in transparency and better regulations will without any doubt streamline the maritime supply chain domain. Through digital streamlining of connections among actors and stakeholders and instigating an infrastructural and policy amendment, the maritime supply chain domain in India can transpire as a crucial segment in the country's economy.

As per NITI AAYOG's report, the cost of freight movement by road is ₹2.58/ton-km as compared to ₹1.41/ton-km for rail and ₹1.06/ton-km for waterways. At present, the road is dominating the freight transport segment in India with a market share of 59%. Similarly, 35% of the market share is with railway and 6% with the waterways. Therefore, the need is to shift a significant amount of cargo to rail and waterways so that the congestion on roads can be eased up. However, India's rail network is significantly over-utilized. For instance, the eastern corridor containing Delhi to Howrah and Western Corridor having Delhi to Mumbai are being utilized between 115% to 150%. As we know that passenger and freight trains run on the same tracks so overutilization of rail tracks simply puts pressure on the rail tracks and results in the slow movement of freight trains. Putting more pressure on the overutilized rail network brings down efficiency and productivity and this issue can be treated as a barrier, shortages of capacity also impede mode shift by retrograding the service standard, mentioned in the NITI AAYOG's report briefly.

At present, freight rail transportation in India costs ₹2 per ton-km less than the road, while in the U.S., where railways grapple furiously with roadways for freight market share. In terms of cost, the difference between road and rail is around ₹15 per ton-km.

The foremost cause for the high rail haulage charges is cross-subsidization between freight and passenger movement. This decreases the demand for the

railway to carry freight and impedes the movement of non-governmental finances to fund upgrades into the freight rail network says NITI AAYOG's report.

So, these are some broad facts that either indicate or give a hint of the presence of barriers and challenges in the transportation of containerized freight in India. Due to these barriers or bottlenecks, the stakeholders (various companies and institutions) in Maritime Supply Chain (MSC) industry are facing hindrances in order to pursue their businesses.

1.5 Motivation/need for the research

If the actors and stakeholders can forecast or identify the barriers/bottlenecks before they hamper the growth of the maritime supply chains, they can comprehend the situation better and take corrective action in order to overcome these barriers, and the performance of this sector can be improved.

The existence of various types of barriers in the maritime supply chains is a result of inefficiencies that hamper the growth of related sectors as well. The manufacturing sector is an example that may get affected if the maritime supply chain networks are not efficient.

The primary aim of this study is to discern specific barriers in MSC so that the real picture of barriers can be captured. Also, as we will identify and assess these specific barriers and their criticality, the business problems associated with them can also be traced and understood better. Also, just identification and assessment of these barriers is not sufficient, and therefore, strategies to overcome these barriers are also discerned and prioritized. Actors and stakeholders of maritime supply chains cannot work simultaneously on all these strategies or it is difficult to implement practically, therefore; a priority list may be helpful to implement them on a priority basis. The overall analysis will help the actors and stakeholders to better manage the operational, managerial, and financial matters.

Analysis performed in this work will identify and evaluate the barriers/bottlenecks which will help stakeholders to manage financial matters accordingly.

The identified categories and sub-categories will be used to build a model to assess the criticality of the barriers which will help governments and policymakers to take suitable actions.

The model developed in this study will also help governments and policymakers to assess maritime supply chains.

Knowing the fact that a study in barriers/bottlenecks of maritime supply chains has not been done in context to a developing country, this study becomes a need of the hour to figure out operational and managerial inefficiencies.

1.6 Business Problem

The presence of barriers in the maritime supply chain of containerized freight in India has crippled the complete freight transport system on various nodes. This has led to a loss of business and unprofitability in the existing business. Drewry Maritime Research mentioned that the presence of barriers has paralyzed the entire maritime supply chain network in India. For instance;

- It has been estimated that 75% of transshipment cargo at Colombo is India bound with a business loss of $54 million in a year. The additional cost is $80-100, or Rs 5,000-6,500, per TEU paid by shippers.
- On the inland front, it takes around 8-9 days transit by rail (because of the average speed of 25kmph, carriers 90 TEUS at once while in China they carry 290 TEUS at once.) but considering China where factories are located near to ports and it takes 1-2 days (with around 60kmph of speed). Also, the majority share of freight has shifted to roads.
- Inland waterways just possess 6% of the market share which is very for such a low-cost mode of transport. There is certainly a significant amount of business loss, and less cost saving.

- Lesser connected North-East India and low-quality logistics infrastructure and due to that, the region in less exposed to international trade. There is a huge unrealized international business opportunity.
- Considering all these aspects, the following business problem statement has been prepared for current research work:

Business problem statement: Actors in maritime supply chains of containerised freight are either losing business to their rivals or not profitable to run current business or not able to attract new business. In 2020, Indian BCOs and port companies lost about $400 million of business because of the presence of barriers in the entire maritime supply chains of containerized freight.

1.7 Research Problem

The entire network of maritime supply chains of containerized freight has been torrefied because of the presence of barriers/constraints/bottlenecks. The presence of censorious barriers has led to numerous business problems, which are already mentioned in the previous section. The interest of actors and stakeholders in maritime supply chains of containerized freight has not been considered, because the presence of the barriers is discussed at a very macro level and no groundwork is done to eradicate the impact of these barriers. The relevant government bodies have failed to realize the presence of barriers and their criticality and that is why this problem has become severely critical.

The theoretical gap exhibits that there is insufficiency to subjugate the influence of the barriers on the part of government and other actors and stakeholders. This can be realized from a large number of business problems occurring in the maritime supply chain sector, leading to actors and stakeholders losing their wealth and investments.

Identification and analysis of the barriers and their criticality are supported and aligned with the Theory of Constraints (ToC) which suggests that if we minimize

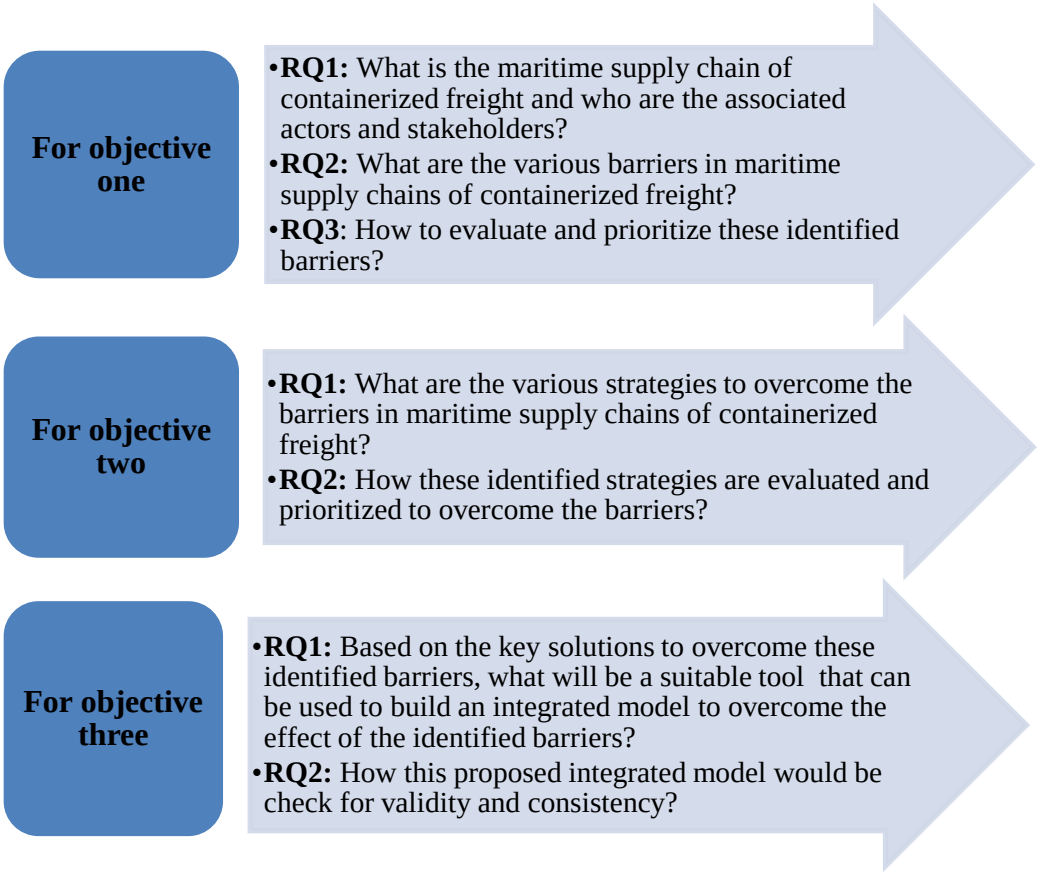
the impact/influence of barriers/bottlenecks/constraints present in a process then this may uplift the performance of the entire process.

To assess the occurrence of this situation, it is necessary to develop a model for analyzing barriers in the maritime supply chains of containerized freight. Strategies to overcome these barriers are also discerned and evaluated through this framework as just identification of barriers is not sufficient.

There is relatively scarce literature related to the management and analysis of the maritime supply chain barriers of containerized freight, and very few publications have presented robust identification and analysis of these. Moreover, during the literature review, a gap was identified which was related to the analysis of the maritime supply chain barriers to classify, prioritize and evaluate them for determining their relative concern in the Indian context. There are many reasons which are influencing actors and stakeholders of the maritime supply chain but the presence of barriers cripples the maritime supply chain of containerized freight. It is desirable to subjugate the influence of these barriers in order to manage the maritime supply chain of containerized freight efficiently. The first important gap which has been recognized after in-depth literature is that none of the studies has proposed and prioritized the solutions or strategies to subjugate the barriers of the maritime supply chain of containerized freight. Thus, a flexible framework based on the Fuzzy AHP and Fuzzy TOPSIS approach is suggested to overcome the maritime supply chain barriers of containerized freight.

1.8 Research Questions (RQs)

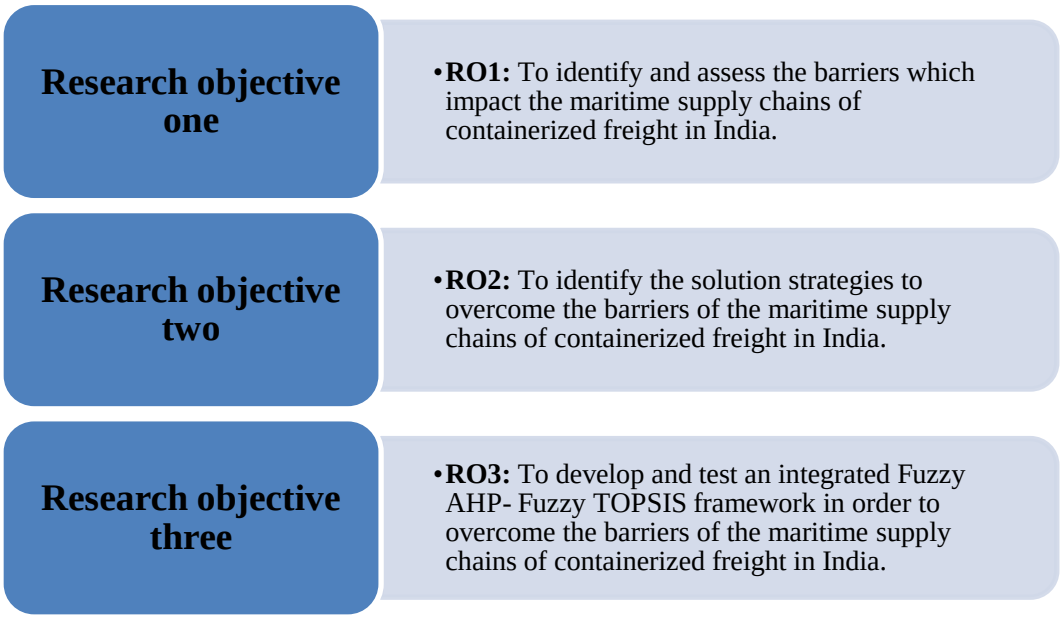
Figure 1.6 Research questions (RQs)



Source: Author's composition

1.9 Research Objectives (ROs)

Figure 1.7 Research Objectives (ROs)



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1.10 Organization of the Thesis

The organization of the present research work has been spread across seven chapters as shown in Figure 1.8. Details of each chapter are given below:

Chapter 1

This chapter provides the introduction to containerization and containerized freight, container shipping; maritime supply chains, and barriers in maritime supply chains. This chapter outlines the current status of the industry and the problems and challenges it faces in India. This chapter also draws the motivation/need to pursue current research. This section covers the business problem, research problem, research questions, and research objective to address the gaps. Additionally, the chapter also gives details of the contents of each section of the thesis.

Chapter 2

This chapter reviews the literature on four themes;

- Literature on the understanding of the maritime supply chains (MSCs) – Global and Indian context
- Literature on the presence of the barriers in the maritime supply chains (MSCs) of containerized freight – Global and Indian context.
- Literature on strategies to overcome the impact/influence of barriers in the maritime supply chains (MSCs) - Global and Indian context.
- Literature on modeling of barriers in different contexts – Global and Indian context.

This chapter also provides existing literature on the *Theory of Constraints (ToC)*, which is the most relevant theory in this context. This chapter reviewed existing literature (in global and Indian context) on the themes under which prior studies have been conducted on the maritime supply chains. The review of global and India-based studies, on the mentioned four themes, helps in deciding the direction of current research by highlighting the prevalent inferences and gaps in the studies performed to date.

Chapter 3

This chapter details out the research methodology used in the ranking of categories and sub-categories of barriers and also the ranking of strategies to subjugate the influence of identified barriers. This chapter explains the details of the research design, research philosophy, questionnaire design, sampling, data collection procedure and tools, and the research methods used to perform analysis.

Chapter 4

This chapter enlightens in detail on the understanding of maritime supply chains of containerized freight. The major source of data/literature to establish this chapter was existing studies and feedback from domain experts. This chapter also talks about each actor and stakeholder and their role in maritime supply chains.

Chapter 5

This is an important chapter of this dissertation which provides in detail information on six categories of the barriers and also draws 46 sub-categories. This chapter describes the steps adopted for the Fuzzy AHP method of ranking and also performs analysis with available identified data. Further, sensitivity analysis is performed to check how robust the Fuzzy-AHP analysis is. Also, the significance of the final ranked list of categories and sub-categories is briefly discussed.

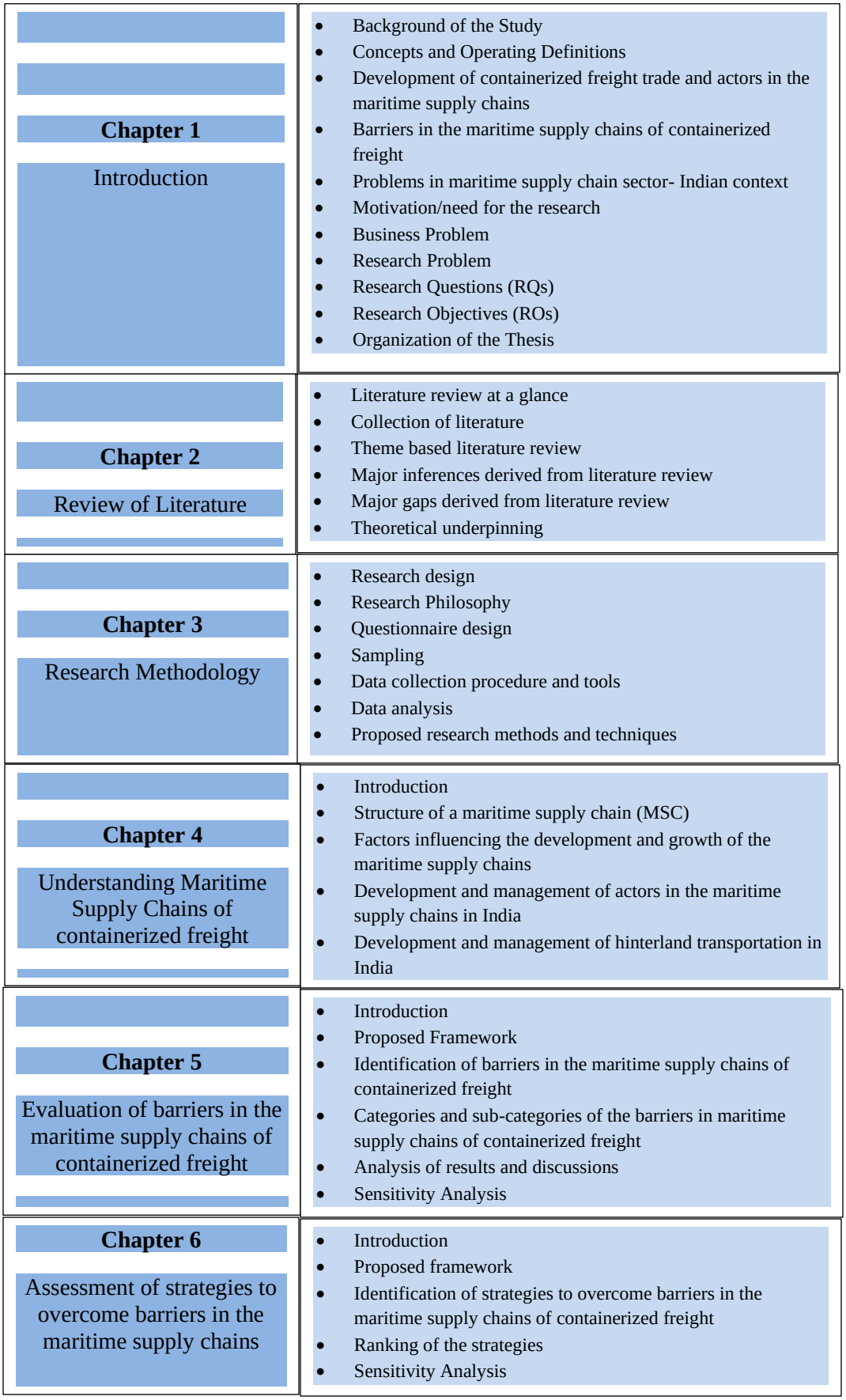
Chapter 6

This is yet another important chapter of this dissertation which provides information on 25 identified strategies to overcome the impact of barriers. This chapter describes the steps adopted for the Fuzzy TOPSIS method of ranking and also performs analysis with available identified data. Further, sensitivity analysis is performed to check how robust the Fuzzy-TOPSIS analysis is. Also, the significance of the final ranked list of strategies is briefly discussed.

Chapter 7

This chapter provides a full overview of the performed research work and the derived major findings. Also, the contribution of the present study to the existing literature is described. This chapter further discusses the practical implications of the findings and the benefits the maritime supply chain sector can obtain from this study. This chapter also explains the limitations of this study and provides areas for future research.

Figure 1.8 Organization of the thesis



Chapter 7 Conclusion and future research	• Introduction • Contributions of this research to literature • Recommendations and Conclusions • Limitations • Scope of Further Research

1.11 Chapter summary

This chapter discussed the fundamentals of maritime supply chains. The chapter explained the growth in the maritime supply chain domain and reviewed the situation of the presence of barriers in the entire maritime supply chain. Further, this chapter propounded business problem and research problem as well. Also, the research questions and research objectives addressing these questions are described in detail. The next chapter reviews theme-wise literature on barriers in the maritime supply chains of containerized freight.

Chapter 2

Review of Literature

Overview

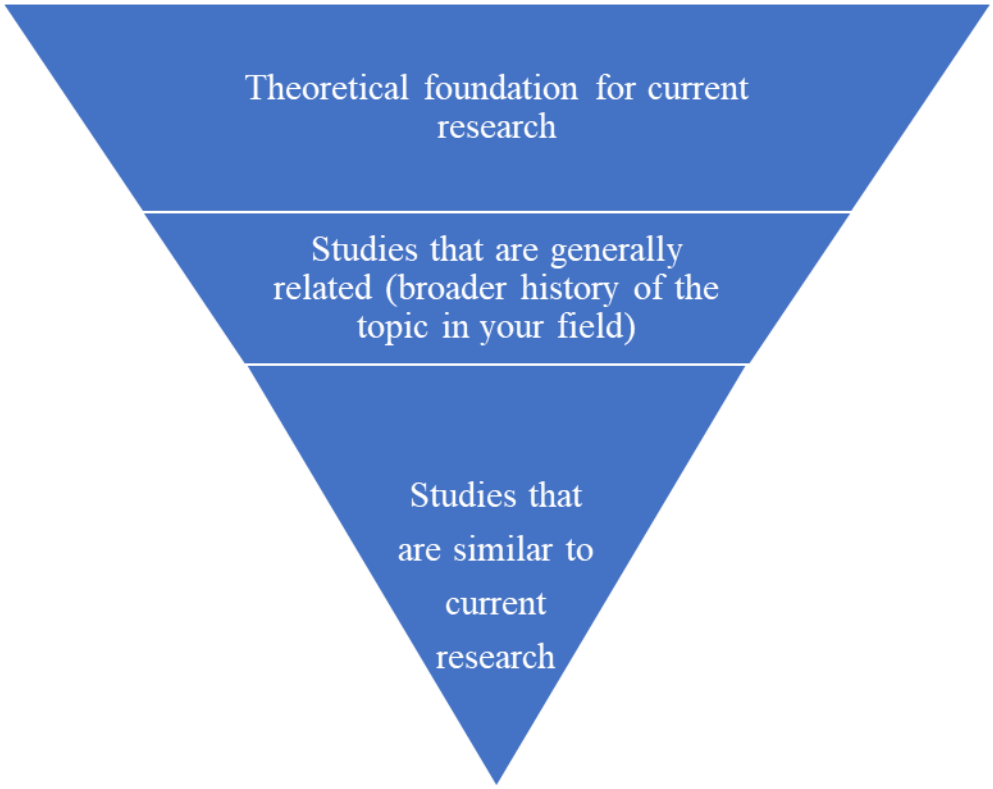
This chapter thoroughly reviews relevant literature on the barriers of the maritime supply chains of containerized freight and also literature on strategies to overcome these barriers, both in the global or Indian context. To make it simple and systematic, the available literature is assessed on four major themes. Additionally, literature on the theory of constraints is also reviewed, which is aligned with the topic of the current dissertation. Further, major inferences and gaps are derived by analyzing literature that became an inspiration to conduct current research. Moreover, studies on the discerning and prioritization of barriers in varied contexts using different models/frameworks/techniques contexts are also examined.

2.1 Literature review at a glance

A study conducted by Bodolica and Spraggon (2018) advised that literature review is a vital step for exploring prevalent gaps in a particular domain. Existing literature is examined to check the extent of work already done in a particular area. Literature reviews are conducted to explore and evaluate the notions and arguments mentioned in a wide range of studies in order to discern and comprehend gaps so that researches can be done in the future to fill those gaps (Rewhorn, 2018; Koons, et al., 2019). Existing literature is reviewed in-depth for understanding conceptual and theoretical contributions says Watson and Webster (2020). Also, what range of audience will be addressed with future research and whether there will be benefits conducting future research, should be argued among scholars and sector experts. In the below figure, a researcher starts with the topmost broader part which is the analysis of the initial theoretical foundation which leads to gathering broader studies related to the area/domain of research.

This funnels down the scope and studies specific to one particular topic (which is selected for research) are reviewed. Thereafter, the research gap is discerned which is developed into research work in order to fulfill that gap.

Figure 2.1 Identifying research gap from existing literature



Source: https://precisionconsultingcompany.com/literature-review.shtml

In this section, the following objectives have been fulfilled with the help of structured review and assessment of literature:

1. Specific and relevant subjects, themes, techniques, frameworks, and issues have been discerned and summed up.
2. A conceptual outline and theoretical framework; integrated frameworks and models for barrier-related studies, issues, and challenges have been developed.

There is a very limited amount of literature available in context to maritime supply chains and that too specific to countries other than India. The maritime

supply chain is a new area of research and the existing studies are in the global context, that hasn't covered India. Further, when we talk about maritime supply chains of containerized freight, this even funnels down the existing literature and we are left with no study in context to India. Therefore, it becomes important to review articles that help in contributing towards a better understanding of this area and indicate relevant research gaps. Additionally, to acquire utmost output, only recent and relevant topics/issues are reviewed. The literature review deemed both qualitative and quantitative aspects for a better understanding of the content and relevancy of the research area.

2.2 Collection of literature

Despite being an unexplored area of maritime supply chains, literature is collected by investing a significant amount of time so that as much as pertinent studies can be analyzed. The below table exhibits the list of keywords used to get a wide range of journals and to find relevant literature which is useful in carrying out the current study. The table also illustrates a set of databases searched in order to obtain relevant research papers/articles.

Table 2.1 Below table illustrates set of databases searched in order to obtain relevant research papers/articles

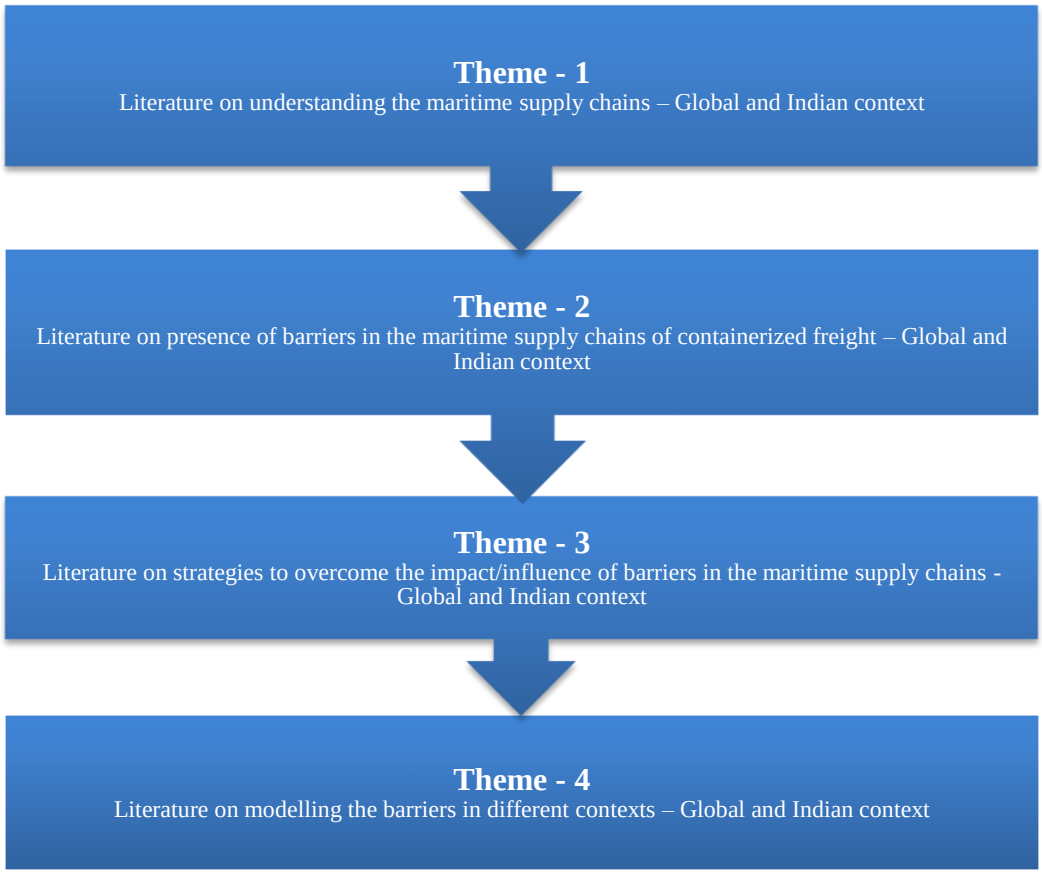
Key Words Used	Databases
1. Barriers in Container Shipping (India and Global) 2. Barriers in Maritime Supply Chain (Global and India) 3. Liner Shipping barriers (Global and India) 4. Barriers in Inland containerized freight transportation (Global and India) 5. Modelling barriers in maritime supply chains (Global and India) 6. Issues and challenges of maritime supply chains (Global and India) 7. Solution and strategies to subjugate barriers in maritime supply chains (Global and India) 8. Strategies to overcome barriers framework in maritime supply chains (Global and India) 9. Strategies to overcome barriers in Inland containerized freight transportation (Global and India) 10. Strategy framework for subjugating barriers in maritime supply chains of containerized freight (Global and India)	Scopus Taylor & Francis Elsevier Google-scholar Science Direct, Web of science, Emerald, Inderscience, IEEE, Springer, Sage, Wiley, University of Bath Growing science

Source: Author's composition

2.3 Theme based literature review

The literature is reviewed in below mentioned four themes which are;

Figure 2.2 Major chunk of the literature review is based on above-mentioned themes



Source: Author's composition

Table 2.2 Below table illustrates theme-wise literature, inferences and gaps derived

Themes	Authors	Inference	Gaps
Literature on understanding the maritime supply chains - Global and Indian context	Vanelslander and Sys (2020), (Lam, 2011), Honglu et al. (2018), Garg and Kashav (2019), Banomyang, (2005), Lam (2015), Lai et al. (2019), Polatidis et al. (2018), Zavitsas et al. (2018), Wan et al. (2019), Vilko et al. (2019),	Reasons found for barriers in maritime and supply chain sector and their impact on actors, stakeholders, and the overall industry. Specific issues/factors listed for the company/country which led to this situation.	Limited studies at industry level. Lack of framework-based approach. No study was done in context to effect of barriers on actors and stakeholders in MSCs of

	Jasmi and Fernando (2018), Barnes and Oloruntoba (2005), Van Dyk et al. (2008), Norbis et al. (2013) and Yang (2011), Mallidis et al. (2018)		containerized freight.
Literature on barriers in the maritime supply chains of containerized freight - Global and Indian context	Prahalathan and Vijay, (2010), Yuen and Thai (2017), Lam, (2013), Chen et al. (2019), Venkatesh et al. (2017), Ishiguro and Inamura (2005), Zhang and Lam (2019), Tanguy and Napoli (2016), Napoli (2016), Konstantinus et al. (2019), Carlan et al. (2017), Ringsberg and Cole (2020), Wan et al. (2016), Wan et al. (2019)	Maritime supply chain techniques/models are tested with different methods/data and results are found with different levels of accuracy of prediction. Also, models and techniques used to identify barriers in other sectors are analyzed.	Limited studies build on a framework to assess the barriers present in maritime supply chains and the impact of barriers on stakeholders.
		Barriers present in the maritime supply chains are identified using different techniques and data. Also, models and techniques used to identify barriers in other sectors are analyzed.	No studies in context to India build on a framework to assess barriers in the maritime supply chains of containerized freight and their impact on the stakeholders.
Literature on strategies to overcome the impact/influence of barriers in the maritime supply chains.	Patil and Kant (2014), Kabra and Ramesh (2015), Agarwal et al. (2020), Sirisawat and Kiatcharoenpol (2018), Phochanikorn et al. (2020), Malviya and Kant (2018), Prakash and Barua (2015)	Maritime supply chain techniques/models are tested with different methods/data and results are found with different levels of accuracy of prediction. Also, models and techniques used to identify barriers in other sectors are analyzed.	Limited studies build on a framework to assess barriers present in the maritime supply chains and their impact on the actors and stakeholders.
		Barriers present in maritime supply chains are identified using different techniques and data. Also, models and techniques used to identify barriers in other sectors are analyzed.	No studies in India build on a framework to assess the barriers in the maritime supply chains of containerized freight and their impact on the stakeholders.

Source: Author's composition

2.3.1 Theme 1: Literature on understanding the maritime supply chains – Global and Indian context

Studies under this theme draw focus on understanding what maritime supply chains are. How this concept was evolved, what was the need, its importance in international trade, and how it is catering to global containerized freight trade. As compare to Global supply chains (GSCs) or Supply chains (SCs), maritime supply chain (MSC) is an uncommon/unheard concept. IGI Global defines maritime

supply chains (MSCs) as *"the movement of freight and related support service involving two substantial locations using maritime and land transportation modes."* Likewise, a book written by Vanelslander and Sys (2020) mentions that a *"maritime supply chain is a concept of breaking the maritime chain into components, consistently relating them to the overall integrated supply chain"*. There are some prominent researchers who have conducted studies on the maritime supply chains in context to their respective countries and regions but there is no study in context to India. Below are some researches performed to understand the process and nature of maritime supply chains-

A maritime supply chain in the context of container shipping is referred to as the connection between series of shipping service activities that are concerned with planning, coordinating, and controlling containerized freight from origin to destination. Shippers, shipping lines, and ports are the major actors and stakeholders in the maritime supply chains (Lam, 2011).

Honglu et al. (2018) say that maritime supply chains are the largest complex network of containerized freight transportation in the world, where shipping lines and ports are the major stakeholders. Honglu et al. (2018) performed an in-depth model-based study to discern and evaluate vulnerabilities in the maritime supply chains.

Garg and Kashav (2019) described maritime supply chains as a set of sequenced activities while importing and exporting cargo, performed by a variety of actors and stakeholders like BCOs, cargo packing companies, shipping lines, freight forwarders, CHAs (Custom House Agents), CTOs (Container Train Operators), ICDs (Inland Container Depots) or Inland port companies, Warehousing companies, etc. Container ports and shipping lines are one of the most involved stakeholders. CFSs, stevedoring companies, ship chandelling, and provision companies, bunkering companies, dredging, towage, and pilotage service companies are some stakeholders at seaports.

The maritime supply chain is a structured integration of maritime services (while cargo is at ports and while being transported inland) and transshipment functions (purely maritime front activities at ports) says Banomyang, (2005).

In this modern era where products are available at doorsteps, global shipping lines face strenuous situations with BCOs who are nagging supply chain solutions, whereas, demanding lesser freight rates/buy rates from carriers. This pushes higher level of amalgamation accross the maritime supply chain says Lam (2015).

Some more studies performed on the maritime supply chains are; Lai et al. (2019) and Polatidis et al. (2018) that highlighted risks and sustainability in the maritime supply chains. Zavitsas et al. (2018) measured the impact of flexible environmental policy on the resilience of the maritime supply chains. Song et al. (2016) employed a two-stage non-cooperative game-theoretical approach in order to model the horizontal and vertical competition among stakeholders in the maritime supply chains. Adding on, Wan et al. (2019) assessed risks in the maritime supply chains using a fuzzy Bayesian-based FMEA approach. Similarly, Vilko et al. (2019) calculated risks in the maritime supply chains in Finland. Jasmi and Fernando (2018) identified drivers and factors for greening the maritime supply chains. Barnes and Oloruntoba (2005), Van Dyk et al. (2008), Norbis et al. (2013), and Yang (2011) wrote extensively on security in the MSCs. Mallidis et al. (2018) studied the influence of Sulphur limit fuel regulations on the maritime supply chain network design.

Research gaps in Theme 1

- Literature indicates that there exists no study on the maritime supply chains in context to India. Mentioned studies are performed in the general context.
- There is a lack of studies performed on “MSCs of containerized freight” and no such study available in context to India.

- There is an absence of studies that intends to enhance understanding of the integrated perspective of various activities performed at ports and in the inland transport system in context to containerized freight in India.

2.3.2 Theme 2: Literature on the presence of barriers in the maritime supply chains of containerized freight – Global and Indian context

Studies under this theme draw focus on the presence of a variety of barriers in activities related to container ports and inland transportation system, which often leads to delays, congestions, long turnaround time, inefficiencies, accidents, pilferage, delays, high transport costs, high carbon and Sulphur emissions and many more. The presence of barriers in the maritime supply chains is a situation that not just cripples the management and operations of entire maritime supply chains but also surges costs significantly. Increased presence and severity of barriers hamper efficiency and productivity of the maritime supply chains. In such a situation, the first and foremost challenge for top management is to identify and understand these barriers so that corrective measures can be taken to subjugate their impact. Developing maritime supply chains to the world standard is arduous in growing nations like India, majorly because of the strong presence of barriers. For instance, it is strenuous to enter the maritime supply chain sector as an actor because of rigid regulatory compliance and acts (Prahalathan and Vijay, 2010). Also till now, researchers argued on maritime and hinterland transportation separately but have totally missed the integrated perspective.

Yuen and Thai (2017) mentioned that very little attention has been paid to the barriers that inhibit integration among various activities in maritime supply chains. This study discerned a set of 21 barriers with the assistance of sector experts (shipping lines only) and through the Exploratory Factor Analysis (EFA) technique. This study was an extended work of (Lam, 2013). The major limitation of this study was that it was limited to only Singapore and also solutions weren't studied at all.

Lam (2013) inspected (theoretically and empirically) the presence of barriers that hinders collaboration among various members in the maritime supply chains. The

study found that level of integration is directly proportional to the amount of value generated for clients/customers. This study also investigated various benefits obtained by shipping lines globally. The limitation of this study was that it was in context to Singapore.

Similarly, Chen et al. (2019) established a Fuzzy DEMATEL analytical framework to evaluate barriers to alternative maritime power application for green port construction in China. This study discerns and evaluates 12 major restrictions using the Fuzzy DEMATEL method.

Venkatesh et al. (2017) discerned a variety of barriers that hinder coastal shipping development using the Delphi method and analyzed them using the Fuzzy DEMATEL approach. The top-ranked barriers in this study were related to government legislation, infrastructure, under-development of smaller ports, and lack of collaboration among stakeholders in the maritime supply chain sector. Though the study was in context to India, it was restricted to coastal shipping/short-sea shipping.

Ishiguro and Inamura (2005) discerned the presence of barriers in both ports and hinterland transportation of the freight. The presence of barriers creates hindrances for both operations and management of the maritime supply chain sector. Ishiguro and Inamura (2005) stated that the higher costs in transportation are because of costly labor and infrastructure.

Furthermore, Zhang and Lam (2019) considered the case of maritime organizations and explored and analyzed various barriers to the adoption of big data analytics using fuzzy Delphi-AHP-TOPSIS methodology. Out of all the barriers identified and analyzed in this research, managerial, cultural, and technical related ones were the most serious.

Not exactly barriers but Tanguy and Napoli (2016) considered a case of maritime supply chains of energy and designed a multi-agent system to evaluate the degree of vulnerability. Tanguy and Napoli (2016) argued on the presence of maritime territories that possess risks for maritime transport considering the environment,

human activities, or deliberate actions. Largely, this study threw a limelight on barriers and risks in the maritime supply chains.

Konstantinus et al. (2019) wrote that in a maritime supply chain, the dwell time of cargo at a port is the most among all the activities happening in the entire maritime supply chain. Time has value and in the era of just-in-time transportation of freight, such delays (because of any reason) are considered as a barrier.

In a study executed by Carlan et al. (2017), barriers to digital innovations were discerned and assessed. This study inspects 32 information and communications technology innovation cases. Also, actors in the maritime supply chains were surveyed to get feedback on the success of each digital innovation.

Ringsberg and Cole (2020) propounded a conceptual framework to investigate the barriers to maritime security. The barriers in this study were identified using a mixed-methods approach.

Adding on, Wan et al. (2016) analyzed risks in the maritime supply chains from varied perspectives. This study developed an advanced risk analysis framework using Bayesian network, Fuzzy logic, and FMEA to run analysis.

Somewhat similar to above, Wan et al. (2019) utilized the Delphi method to perform analysis of risk factors inhibiting operations and management of maritime container supply chains.

Research gaps in theme 2

- There are a handful of studies performed on the maritime supply chains of containerized freight but there is no evidence of any study conducted to discern barriers in the maritime supply chains of containerized freight in India.
- There exists no study that evaluated the barriers of the maritime supply chains in India.
- There is a lack of analytical studies on the integrated perspective of various stages i.e., maritime supply chains of containerized freight in India.

2.3.3 Theme 3: Literature on strategies to overcome the impact/influence of barriers in the maritime supply chains (MSCs) – Global and Indian context

Studies under this theme focus on management and analysis of various strategies identified to overcome/subjugate the impact of barriers in maritime supply chains of containerized freight. As argued in the previous theme, there exist a handful of studies on barriers in the maritime supply chains of containerized freight, and that is why this area has remained unexplored in India. Further to this, studies with strategies or solutions to overcome/subjugate the influence of barriers are even less, which is a prominent gap. Moreover, existing studies are also either performed on supply chains in general or related to the port and maritime sector alone. However, this section helped in understanding to what level of work is done to overcome/subjugate the impact of barriers and the research gap left.

For instance, Patil and Kant (2014) propounded the Fuzzy AHP-TOPSIS model in order to rank solutions for adopting knowledge management in the supply chain to subjugate barriers. In the first part, AHP is employed to obtain weights of the barriers, and the Fuzzy TOPSIS technique is employed to secure solutions' ranking. The importance of ranking is explained by the fact that it is difficult to implement all the solutions at once, therefore ranking is done for step-wise implementation.

Likewise, Kabra and Ramesh (2015) propounded a Fuzzy AHP-TOPSIS framework to model constraints to integration in humanitarian supply chain management (HSCM), propounded solutions, and prioritized them to subjugate the constraints. This research discerned a group of 23 barriers, thereafter, identified and analyzed 15 solutions to subjugate the impact of barriers. This research has strong implications for strategists and managers in the field of humanitarian logistics.

Similar to the above, Agarwal et al. (2020) identified 29 HSCM barriers and 20 solutions to subjugate their influence. Post this, a hybrid fuzzy SWARA – Fuzzy WASPAS model was designed and employed to perform analysis. This study has strong implications for humanitarian logisticians to formulate better strategies.

Sirisawat and Kiatcharoenpol (2018) carried out a study on analyzing the solution to control the influence of barriers with the help of the Fuzzy AHP-TOPSIS approach. In response to 29 barriers, this study discerned a total of 14 solutions to overcome them. This study was performed considering Thailand's electronic industry as a case.

Phochanikorn et al. (2019) and Malviya and Kant (2018) employed Fuzzy ANP-VIKOR and fuzzy AHP-VIKOR approaches respectively to analyze solutions that are discerned to subjugate the impact of barriers. These studies can become a motivation for sectors where such kind of work is not yet done.

Prakash and Barua (2015) integrated AHP and TOPSIS methodologies for categorizing solutions to constraints in reverse logistics adoption. This study considered the case of the electronic industry in India.

Research gaps in theme 3

- Existing studies provide solutions to either ports or supply chains (in general) to overcome barriers but no study was done to understand and analyze strategies or solutions to overcome barriers in the maritime supply chains of containerized freight.
- There exists no study that propounds an integrated framework to subjugate barriers in the maritime supply chains of containerized freight in the global context.
- The maritime supply chain is an unexplored domain when it comes to India, and therefore, there is no study available that discerns and assesses strategies using an integrated framework.

2.3.4 Theme 4: Studies on modeling the barriers in different contexts – Global and Indian context

Table 2.3 Below table illustrates different types and names of the models/techniques and studies were done in past on these models/techniques.

Types of Models/ Techniques	Name of Models/ Techniques	References
Generic models/techniques	MICMAC analysis	Chandra and Kumar (2018), Dube and Gawande (2016), Katiyar et al. (2018), Mangla et al. (2018), Dubey et al. (2017)
	Confirmatory Factor Analysis (CFA)	Ogunsanya et al. (2019), Ambekar and Hudnurkar (2017), Maldonado-Guzmán et al. (2017), Klein et al. (2018)
	Interpretive Structural Modelling (ISM)	Jayant and Azhar (2014), Faisal (2010), Agrawal et al. (2019), Muruganantham et al. (2018), Majumdar and Sinha (2019)
	DEMATEL approach	Kaur et al. (2018), Costa et al. (2019), Bhatia and Srivastava (2018), Singh et al. (2020), Singh and Sarkar (2020)
	Best Worst Method (BWM)	Sahebi et al. (2017), Gupta et al. (2020), Gupta et al. (2020), Gupta and Barua (2018), Khan et al. (2019)
	VIKOR method	Singh et al. (2019), Rostamzadeh et al. (2015), Rajesh (2018), Zhang and Xing (2017), Rathore et al. (2020)
	Analytic network process (ANP)	Govindan et al. (2016), Patil et al. (2020), Sangari et al. (2020), Faisal et al. (2007)
	ISM-MICMAC based framework	Ruben et al. (2018), Khaba and Bhar (2018), Tripathi and Singh (2018), Kumar and Sharma (2018)
Specific to the maritime supply chain (MSC) sector	Fuzzy AHP	Zhang and Lam (2019), Tseng and Cullinane (2018), Göçer et al. (2019), Mangla et al. (2017), Vishwakarma et al. (2019), Kumar and Kansara (2018), Lamba et al. (2020), Othman et al. (2020)
	Fuzzy TOPSIS	Fan et al. (2020), Sahin et al. (2020), Phruksaphanrat and Borisutiyanee (2019), Lamba and Thareja (2020), Gupta and Barua (2018)

Source: Author's composition

MICMAC analysis is widely used for evaluating barriers in a variety of contexts. In a number of studies, MICMAC is integrated with other techniques of MCDM

in order to perform a model-based analysis. For instance, studies performed by Chandra and Kumar (2018), Dube and Gawande (2019), Katiyar et al. (2018), Mangla et al. (2018), and Dubey et al. (2017) assessed barriers that are hindering smooth operations and management of supply chains in different contexts. Chandra and Kumar (2018) analyzed problems in the vaccine supply chain in context to growing countries using Fuzzy MICMAC analysis. In this study, a total of 25 issues were discerned and the MICMAC analysis was carried out to prepare a model. In the analysis, the top three most critical factors were interaction among supply chain actors, better demand anticipation, and correct planning and scheduling. Thereafter, the results were argued with the domain specialists. Somewhat similar to this, Dube and Gawande (2016) examined barriers in green supply chains by employing the integrated ISM-Fuzzy MICMAC method. A total of 14 barriers were identified and evaluated in this study. This study helps in comprehending the fact that how important these barriers are and how they interact with each other. The results produced in this study are of great help to the industry managers. Likewise, Mangla et al. (2018) considered the case of circular SCM in a growing country and appraised barriers that are impeding their smooth working. A thorough review of literature and response gathered from experts led to discern a list of 16 important barriers. The findings cultivated in this research will help in economic development, subjugate the issue of global warming, and will help in generating employment as well. Correspondingly, Dubey et al. (2017) modeled the sustainability of supply chains using MICMAC analysis. An in-depth literature review was conducted in this study for the selection of drivers of supply chains. This research also debated on various methods which could have been used to run analysis.

There have been a handful of studies conducted on the evaluation of barriers in global supply chains using confirmatory factor analysis (CFA), for instance, Ogunsanya et al. (2019) assessed barriers to inbound logistics of raw material i.e., sustainable procurement of construction material by employing factor analysis and limiting its scope to Nigeria. In this study, the data was gathered from 300

questionnaires filled by industry experts. The main reason why this study was conducted because the speed of adopting sustainable procurement solutions is slow and the reason was unknown. However, the study the reason to be lack of quality knowledge available. Likewise, Ambedkar and Hudnurkar (2017) considered the manufacturing and service industry of India and examined barriers to six sigma implementations by employing the factor analysis method. Although the study was conducted in context to India its scope was very wide and not specific to any domain. An in-depth literature review helped in finding 15 barriers and also 168 sector experts were taken feedback from, using a structured questionnaire. Maldonado-Guzmán et al. (2017) considered an example of Mexico and computed constraints to innovation in service SMEs using factor analysis technique. The types of barriers inspected in this study were external environmental, financial and human, of which, external environmental barriers were censorious. Klein et al. (2018) also studied the nature of barriers in the manufacturing sector by using factor analysis. In this study, 14 experts from 5 different companies were interviewed. A total of 25 barriers to smart service businesses were identified and assessed.

Interpretive Structural Modelling or ISM is yet another technique that is widely used by scholars and researchers to study barriers. There exist studies on barriers in the supply chains of different commodities and contexts, for example, a study performed by Jayant and Azhar (2014) utilized the Interpretive Structural Modelling method to analyze barriers hindering the execution of green SCM. The primary goal of this paper was to analyze the relationship among barriers and to discern critical ones. In total, 20 constraints were discerned in this study. Similarly, Faisal (2010) understood the mutual relationship among constraints to CSR in supply chains and assessed them with the help of the ISM technique. This research revealed that not all the discerned barriers are highly relevant to CSR in supply chains but there is a set of barriers that need extra attention by the top management. Likewise, Agrawal et al. (2019) used the ISM technique and performed an in-depth analysis of barriers in accomplishing the digital

transformation of supply chains. The idea of this research is to introduce digitalization in supply chains to bring agility and this can be done only by discerning barriers and evaluating them. Most importantly, this research propounded the 4 most impactful barriers that impede digital implementation in supply chains and needs the maximum attention of the industry managers and top management. A study performed by Muruganantham et al. (2018) undertook the automotive sector and analyzed barriers to total quality management practices implementation with the help of ISM based model. This study discerned and assessed 21 barriers in total which are grouped into 4 different categories and aims to help the decision-makers. In a similar way, Majumdar and Sinha (2019) inspected the presence of barriers in green textile SCM in Southeast Asia and assessed them by employing ISM method. In total, 12 constraints were discerned through a thorough analysis of literature and questionnaire survey and attempted to analyze barriers with the most influence.

DEMATEL is also an effective method that is widely used to assess barriers in different sectors and in context to various countries and regions, for instance, research conducted by Kaur et al. (2018) considered a case study of manufacturing firms in Canada and inspected the presence of barriers in green supply chains by employing DEMATEL based approach. The results derived in this study discerned 3 main categories of barriers which are related to knowledge, commitment, and product design. This study is one of few which are conducted from a Canadian perspective. A study performed by Costa et al. (2019) conducted 8 structured interviews to understand the most influential barriers and employed the DEMATEL technique run analysis and also to comprehend the nature and impacts of barriers to improvise CRM practices among construction supply chain management. Similarly, Bhatia and Srivastava (2018) did thorough research on external barriers to remanufacturing with the help grey-DEMATEL technique. The research was done from an Indian perspective. Correspondingly, Singh et al. (2020) analyzed barriers to achieving lean practices in the manufacturing sector with the use of the DEMATEL approach. The most influential barriers discerned

in this study are the lack of means to gather used products and the unwillingness of the customers to return the products.

Best-Worst Method or BWM of MCDM is also widely used on a global platform to analyze barriers. In fact, the BWM approach is one of the most common techniques used to model the presence of barriers in global supply chains. In a study conducted by Sahebi et al. (2017) a total of 22 barriers to humanitarian supply chains were evaluated which were grouped into 9 categories. Here, the evaluation process was done using the BWM technique that helped in understanding the importance of each barrier. Additionally, a case study of Iran was taken into consideration in this study. Moving on, Gupta et al. (2020) considered a case study of the manufacturing sector and discerned a set of barriers that impede espousing, implementation, and upscaling of innovation in the supply chains. The results produced with the help of the BWM technique exhibited that absence of technical expertise and training is censorious among all. Similarly, Gupta and Barua (2018) propounded a framework to evaluate and subjugate barriers to green innovation in 4 identified Indian SMEs. Here, the BWM technique was used to rank these barriers. In this study, 7 main categories and 36 sub-categories of barriers were discerned, and further to subjugate the impact of these barriers, 20 strategies to subjugate these barriers were also identified and analyzed. Further, Khan et al. (2019) explored and assessed barriers present in the halal supply chain by implementing the BWM approach.

Vlsekriterijumska Optimizacija I Kompromisno Resenje or most commonly known as the VIKOR technique is also accepted widely and utilized globally by researchers and scholars to evaluate barriers in a variety of contexts. Singh et al. (2019) discerned critical barriers to green manufacturing in the SME sector of India. The group of various challenges faced in the adoption of green practices is obtained through literature review and questionnaire survey conducted among SMEs. The results obtained after reviewing the literature and questionnaire study are further analyzed used factor analysis and finally assessed with the VIKOR method. Out of all the discerned challenges, economic constraints gained high

rank which makes it a censorious category and needs immediate attention of the top management and decision-makers. In a similar way, Rostamzadeh et al. (2015) used the Fuzzy VIKOR method in the assessment of green SCM which indicates the application of the VIKOR method in any sub-domain of the global supply chain management. This research demonstrated a case of a laptop manufacturer in Malaysia. Moving on, a study conducted by Rajesh (2018) assessed barriers to resilience in the supply chains of the manufacturing sector using the VIKOR approach. The first step in this study is to sort the set of barriers and consider only those which are the most important and have high influence. Post-this, the VIKOR technique will be implemented to prioritize these barriers. Likewise, Zhang and Xing (2017) developed a framework using the VIKOR method to assess supply chain initiatives. This study also mentioned that the firms need to assess their performances precisely when it comes to the implementation of global supply chain initiatives. Adding on, Rathore et al. (2020) investigated risks that are threatening operations and management of the food grain supply chain and propounded a methodology to mitigate risks using the VIKOR approach. The results of this research exhibit that risks associated with technology have the most influence.

Analytic Network Process or ANP is also a prominent MCDM technique that is widely used to perform analysis and a very useful tool in problems related to decision making. As with other MCDM methods, the application of ANP is also very wide. For instance, Faisal et al. (2007) mentioned the presence of a variety of risks across supply chains that hampers overall operations and management of the supply chains. The aim of this study was to developed suitable strategies to subjugate these risks, hence, the ANP method is used to evaluate risks. Govindan et al. (2016) also applied the ANP technique for assessing barriers present in remanufacturing of automotive parts in context to India. This study was performed because existing studies lacked in-depth analysis on barriers and bottlenecks. The analysis performed in this study and results obtained exhibited that heftier cost and absence of customer acceptance are the two foremost

dominant constraints in auto parts remanufacturing in India. Further, Patil et al. (2020) reviewed the available literature and interviewed relevant stakeholders in the humanitarian supply chain in developing nations, and discerned a list of 17 barriers. Identification of barriers was from a variety of aspects like strategic, technological, organizational, economic, and operational. Thereafter, the barriers were ranked using the ANP method which is based on the level of influence they have. Similarly, Sangari et al. (2020) considered the case of manufacturing industries and assessed barriers in green supply chains using ANP based framework. This study concluded that the barriers related to customer, market, social and managerial are the most important and need extra attention.

In many of the barrier assessment-related studies, an integrated ISM-MICMAC (or Imperative Structural Modelling- Matrice d'Impacts croises-multiplication appliqúean classment) framework is developed and put into use. For instance, Ruben R. et al. (2018) designed an integrated ISM-MICMAC model for the assessment of lean six-sigma barriers. This research discerned a total of 20 critical barriers that are identified through extensive literature review and consulting experts from relevant sectors and academia. Thereafter, results are procured through the ISM-MICMAC model which indicates that barriers named problems in adoption of environmental strategies, strict government policies, negative mindset towards sustainability concepts, and inappropriate communication are censorious. This study helped researchers, decision-makers, and strategists to remove key critical barriers. Likewise, Khaba and Bhar (2018) conducted a study with an aim to designed and validated a model for constraints to lean implementation in the coal mining sector of India. This research discerned 14 critical inhibitors to lean implementation absence of top management dedication, financial restraints, and coordination among departments are the top-ranked barriers. Similarly, Tripathi and Singh (2018) developed an ISM-MICMAC-based integrated framework to analyze barriers to women entrepreneurship. Data to perform analysis was acquired through a survey that involved 15 domain experts. On the basis of feedback provided by the experts, the 10 most relevant barriers

were chosen to perform analysis. These barriers were ranked using the ISM-MICMAC framework and a casual relationship among barriers was discerned. Additionally, Kumar and Sharma (2018) evaluated key barriers to the growth of rural healthcare using the ISM-MICMAC-based framework.

So far literature on the application of various MCDM techniques on barriers in the global supply chains and some other sectors is discussed. However, the applicability of the above-argued techniques in the maritime supply chains is not so recommended/valid/fruitful as compare to Fuzzy AHP, which is used previously in the maritime supply chain-related studies by prominent researchers and scholars. Research conducted by Zhang and Lam (2019) considered a case of maritime organizations and discerned barriers in the installation of big data analytics. This research validated that the Fuzzy AHP based model is perfect for barrier-related study in the maritime sector. Also, this study mentioned that such types of studies are not at all done in the maritime domain. The results exhibited that managerial, cultural, and technical barriers are censorious in nature. Adding on, Lin et al. (2008) used literature review and factor analysis as a tool to discern 16 characteristics impacting knowledge sharing, thereafter, Fuzzy AHP is employed to evaluate the preference weights and ranking of these characteristics. This study undertook an pragmatic case of the Taiwanese maritime sector to exhibit the application of the propounded framework. The foremost benefit of this study is for policymakers, decision-makers, and strategists. Likewise, Tseng and Cullinane (2018) identified a set of criteria i.e., influencing the choice of Arctic shipping route, and applied the Fuzzy AHP technique of MCDM to carry out the analysis. The challenging part of this study was to discern criteria that impact the decision of maritime carriers w.r.t. using the Arctic route. This study concluded the most influential criteria to be around safety and political domains. Correspondingly, Göçer et al. (2019) studied drivers and barriers of Turkish container ports using the Fuzzy AHP technique. The final results concluded that customer relations was the most important factor among all. Othman et al. (2020)

also studied factors to cargo imbalances in Malaysia minor ports using the Fuzzy AHP method.

Like Fuzzy AHP, Fuzzy TOPSIS is also the most suitable method for studies on the evaluation of inhibitors and strategies. To show the applicability of the Fuzzy TOPSIS technique for studies related to the maritime supply chain domain, some of the existing studies are reviewed such as; Fan et al. (2020) employed the Fuzzy TOPSIS method to form a framework in order to assess accident avoidance policy articulation from a maritime viewpoint. To prevent maritime accidents, the three most effective and recommended strategies are information, clear order, and safety culture. Similarly, Sahin et al. (2020) employed the Fuzzy TOPSIS technique for the choice of dry bulk carriers. The questionnaire survey method is used to gather data set which is further analyzed using the Fuzzy TOPSIS method. Likewise, Phruksaphanrat and Borisutiyanee (2019) conducted a study intending to discern barriers in IT adoption in the industrial sector, identify and rank strategies to subjugate these constraints. Data in this research was collected from bigger firms in the sector and analysis is performed with the help of the Fuzzy TOPSIS technique. Lamba and Thareja (2020) analyzed barriers of green SCM using the Fuzzy TOPSIS technique. Here, the TOPSIS technique helped in the ranking of barriers and understanding how critical each barrier is.

2.4 Major inferences derived from literature review

2.4.1 Globally, limited studies have been carried out on barriers in the area of maritime supply chains. There are few which are generalized in nature and not specific to containerized freight transportation. These relate to the country`s specific regulations, market, or operational issues. Data gathered to conduct these studies is limited and often not from reliable sources. Available studies are limited to particular shipping lines or ports that have gone bankrupt or in financial distress.

2.4.2 Maritime supply chains are least studied in developing countries like BRICS nations or South Asian countries, therefore, there is a lack of thoroughly performed study which analyze barriers in the maritime supply chains of containerized freight in context to India.

2.4.3 Additionally, there exists no concrete study which integrates decision-making models in the maritime supply chains of containerized freight in India, which is yet another significant gap.

2.4.4 It is quite understood that identification of barriers is not done as of now, and therefore, no question arises of providing strategies or solutions to overcome/subjugate the impact of barriers. Hence, the absence of strong literature on overcoming barriers is a prominent gap.

2.4.5 In India, studies on the barriers of the maritime industry are in context to inland logistics system, seaport or short-sea-shipping, as a result, maritime supply chains of containerized freight is still an unexplored area.

2.4.6 Limited studies are available in the context of India and they have not used any formal method for identifying barriers. Basically, barriers from all the possible aspects haven't been discerned.

2.4.7 Models developed for identifying barriers in various product-based supply chains or coastal shipping in India are derived from other industries/sectors and hence are prone to commit errors.

2.4.8 In India, there exist no research which has framed a containerized freight maritime supply chain barrier model with an intention to help policymakers, think tanks, managers, and strategists.

2.4.9 Container trade is relatively younger than other segments of shipping and is in a growing stage, therefore, requires a brief model-based study so that barriers and bottlenecks are rectified and eliminated to speed up the growth.

2.4.10 Inland transportation of containers is yet another sector in itself which struggles to gain efficiency and productivity (because of the presence of barriers) in

developing countries like India. There is no model-based study performed which talks about identifying barriers and bottlenecks with an aim to satisfy stakeholders.

2.5 Major gaps derived from literature review

2.5.1 Studies carried out on the barriers have either focused on port business or coastal shipping. There is no formal framework or methodology that identifies key barriers in the maritime supply chains of containerized freight.

2.5.2 There exists no model-based study that discerns and inspects barriers in the maritime supply chains of containerized freight.

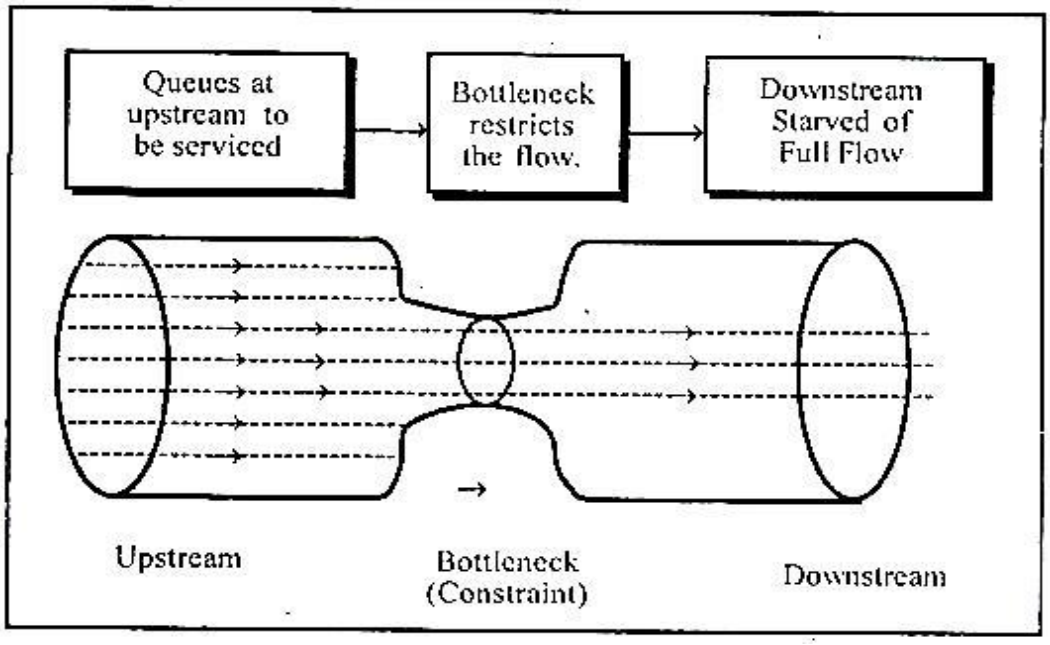
2.5.3 There exists no study that identifies and analyses strategies in order to subjugate the impact of barriers present in the maritime supply chains of containerized freight.

2.5.4 There is no model-based study conducted to identify and analyze strategies.

2.6 Theoretical underpinning

The presence of the bottlenecks or constraints or barriers in the maritime supply chains dwindles productivity and efficiency by inhibiting the smooth flow of cargo. Barriers in the maritime supply chains result in operational delays and also disturb the entire flow of cargo which further leads to excess inventory of cargo and this causes accident and escalated costs. Some of the studies that confirmed the presence of barriers in the maritime logistics domain are; Chen and Yang (2018), Vural et al. (2020) and Ozdemir et al. (2020). In the figure drawn below, the presence of a barrier/bottleneck (can be a set of barriers/bottlenecks) between upstream and downstream stages of the process is depicted, which inhibits the smooth flow of containerized freight in the maritime supply chains. As discussed earlier, the presence of the barrier/bottleneck is obstructing the whole process by narrowing the process track. As a result of this phenomenon, the information passing from upstream to downstream stages (which is containerized freight in this study) is losing its quantity and quality.

Figure 2.3 Illustration of the presence of bottlenecks or barriers in a process decreasing the quantity and quality of the output



Source: http://blog-bhaskaruni.blogspot.com

A key fact to be considered here is that bottlenecks or barriers are the deciding factors and their appearance is censorious in order to decide the success rate of a maritime supply chain. In the above figure, if the passage around the barrier widens, then the quantity and quality of data flow will improve; similarly, if an obsolete ship-to-shore crane is replaced with a newer and upgraded one then the port productivity and efficiency will improve automatically. Likewise, if the outdated rail tracks are exchanged with dedicated freight corridors, then obviously the speed of hinterland transport will increase which will save huge costs in a long run. But if the barrier becomes more censorious than before, then the performance of the entire maritime supply chains will plummet. Therefore, it becomes necessary to identify and eliminate barriers/bottlenecks from maritime supply chains. There have been instances where despite cutting costs, actors in the maritime supply chains could not firm up the output because the existence of

perilous barriers/bottlenecks were ignored or left unidentified. The cost incurred by an actor due to the barriers/bottleneck is usually calculated per hour which is equal to one hour of loss in the entire maritime supply chain and is also spread among various actors. Bottleneck theory of operations management defines bottlenecks or barriers in a business. Studies conducted by Puche et al. (2016), Lowalekar and Basu (2019), Jiang and Wu (2013), Gupta et al. (2013), Jiang et al. (2013), and Zivaljevic (2015) explained very well and clear how bottleneck theory is relevant in case of freight transportation and how it helps to understand the existence of barriers in the transportation of containerized freight.

The theory of constraints (ToC) is a management model that considers any tractable structure as restricted in attaining extra of its targets by a diminutive number of inhibitors. There is incessantly at minimum one inhibitor, and ToC utilizes a concentrating procedure to discern the inhibitor and rearrange the remaining corporation all over. ToC embraces the usual idiom "a chain is no stronger than its weakest link". This signifies those procedures, corporations, etc., are pregnable due to the frail personnel or link can seldom break down or go bad or negatively influence the end results. The ToC is principally a management ideology put forward by Eliyahu M. Goldratt in his 1984 book titled "*The Goal*", which is all set to assist corporations continually attain their targets.

The Information Bottleneck (or IB) theory was presented by Tishby et al. (2015). This theory is a data compacting procedure that is derived from Shannon's rate-distortion conjecture. The clustering technique is formulated on IB theory, and this was extensive research in the modern era. Sun et al. (2014) and Liu et al. (2011) suggested a comparable congregate technique that is formulated on the MapReduce framework, is evolved in which a parallel information bottleneck theory clustering method formulated on MapReduce is put forward to ascertain the earlier clustering centre.

Reynier et al. (1998) use bottleneck theory in the field of genetic science wherein the research problem assists the bottleneck theory of swift separation of mtDNA genotypes amid initial oogenesis.

Yang and Huang (1997) mention that a time-varying pricing framework of a road constraint with elastic traffic demand is composed utilizing the optimal control conjecture. It is presumed that the excellent use of the bottleneck is attained when social interest over the entire time horizon of research is amplified.

The impact of barriers/bottlenecks on the stakeholders is hindering foreign investments in the maritime supply chain sector, higher logistics costs, and limited facilities to order to do business profitably. Therefore, it becomes necessary to identify and overcome these barriers.

Barriers in the maritime supply chain sector are regarded as bottlenecks in the process. There is hardly any study that describes bottlenecks in the transportation of containerized freight. Bottlenecks in maritime supply chains have a pessimistic influence on the productivity and proficiency of the carriers and transport modes, and therefore, this leads to fewer profits or even losses. Therefore, it becomes very important to study these bottlenecks or barriers.

2.6.1 Identification of gap by reviewing the literature on theoretical premise

Narayana et al. (2014) discuss the participation of various stakeholders in Reverse logistics in the pharmaceuticals industry which has a set of stakeholders. Similarly, because of the presence of barriers and bottlenecks, the stakeholders in maritime supply chains of containerized freight are facing various types of challenges. Therefore, the presence of barriers/bottlenecks at each stage of maritime supply chain creates challenges and risks for the stakeholders to remain profitable in the business.

The presence of barriers leads to business loss; a very common example quoted in this study is Indian ports losing India-bound cargo to their rival ports like Colombo, Singapore, and Port Klang.

Not just this, the absence of private investments is yet another barrier e.g. there are very minimal private investments in Inland Waterways due to which the development is happening at a slow pace, as the pace of work and interest of government agencies is very less.

High taxes and strict laws and regulations demotivate foreign investments, an example is APM Terminals decided to wind up India business as it was in a tussle with TAMP to reduce rates.

Containerized freight trains and passenger trains run on the same tracks which often leads to unnecessary delays. This makes investments in freight trains business quite unattractive. Additionally, the license fee is also quite high.

North-East India region is one of the most under-developed in the country. There are business opportunities but because of poor infrastructure and strict laws, maritime supply chain actors and stakeholders are not investing there and those who are present there are at loss.

Environmental clearances are difficult to get in India which delays project execution and this leads to business loss for various actors and stakeholders and all this creates an unattractive business environment for new investors.

On the other hand, the bottleneck theory is a clarification of what occurs when a specific chunk of the production process or complete supply chain performs at a lower rate than the rest of the system. It indicates the presence of a bottleneck that needs to be identified and resolved so that the lost productivity and efficiency can be brought back.

After going through available literature, a number of barriers in the maritime supply chains of the containerized freight are found at the maritime transport front, at seaports, and at the inland transportation of the containerized cargo which decreases the efficiency of freight transport and increases time and costs.

The average turnaround time at Indian ports is about 2.08 days while at Singapore, Shanghai, Yokohama and Port Klang have 1-2days, 0-1day, 0-1day, and 0-1day respectively (Ministry of Shipping).

In 2017-18, Indian Railway had the poorest on-time functioning in the last three years. A record 30% of trains ran belatedly in 2017-18, as reported in official data presented by CAG. Container trains and passenger trains are made to run on the same tracks and because of congestion on tracks, delays are experienced.

North-Eastern states of India appear to have a natural ambition of taking to export trade in the region of ASEAN, a vibrant economy and trade. They have a national gateway to the ASEAN region through Myanmar a new developing member of ASEAN but because of the presence of a number of barriers/bottlenecks, the region is under-developed.

There are policy-level bottlenecks that have avoided a substantial quantity of foreign investments in the country. A high tax is one such example. Likewise, there is a number of bottlenecks/barriers, which this study aims to identify.

2.7 Chapter summary

The foremost aim of this chapter was to explore and assess relevant literature and identify gaps. To achieve this aim, literature was reviewed on four major themes which are; Literature on understanding the maritime supply chains – Global and Indian context, literature on the presence of the barriers in maritime supply chains of containerized freight – Global and Indian context, literature on strategies to overcome the impact/influence of barriers in the maritime supply chains - Global and Indian context and literature on modeling the barriers in different contexts – Global and Indian context. Research gaps are discerned in each theme. The section next reviewed was studies conducted on the Theory of Constraints (ToC) and how it reports the need of pursuing a study on barriers in the maritime supply chains and strategies to overcome these barriers. Additionally, literature is reviewed on various MCDM techniques utilized in the evaluation of barriers in

the global supply chains and some other contexts with global and Indian perspectives, with an aim to understand and implement same in context to the maritime supply chains. The next chapter focuses on the research methodology adopted in this study.

Chapter 3

Research Methodology

Overview

This chapter discusses the methodology adopted for achieving the research objectives mentioned earlier chapter. The best possible methods are selected and employed to rank and analyze the barriers and strategies. Research design and research philosophy are debated in this chapter. Also, this chapter talks in detail about the designed questionnaire and sample of experts selected to get feedback. Further, the data collection methods are also argued in this chapter.

3.1 Research design

Research design is a strategy and the first stage in research methodology which is chosen to incorporate different elements of a study in a well-organized and logical way. Research design is structured in order to make sure that the research objectives are addressed effectively. Yin (2009) and Akhtar (2016) mentioned that research is valid and accepted when its conclusion is error-free. An effective research design is a blueprint for such research. There are two types of research designs which are; exploratory and conclusive. Here, exploratory research is used to examine a problem that is not properly defined, for instance, barriers in the maritime supply chains of containerized freight. This method provides a brief understanding of the issue and is widely used to arrive at the objectives of a study. On the other hand, conclusive research can be further categorized into descriptive and causal, wherein, descriptive research focuses on defining the nature of a demographic segment or group. Therefore, the focus of this research is both on “why” and “what” is happening in the area of maritime supply chains.

Causal research on a research area is performed to assess the paradigm of relationships among variables. Casual research is carried out to discern the magnitude and nature of cause-and-effect relationships. Therefore, casual research is employed to discern and evaluate the relationship among variables. In this study, a conclusive research design is used in the evaluation of the barriers in maritime supply chains of containerized freight and has utilized independent and dependent variables to construct a relationship that leads to a set of results. Not just conclusive research design but a blended approach mixing all the above methods of research designs have been used in this study. The combination of these designs provides a holistic and structured view of the research problem. These research designs further complement and support each other for this study. The step-wise detail of the research flow is as follows:

Step 1:

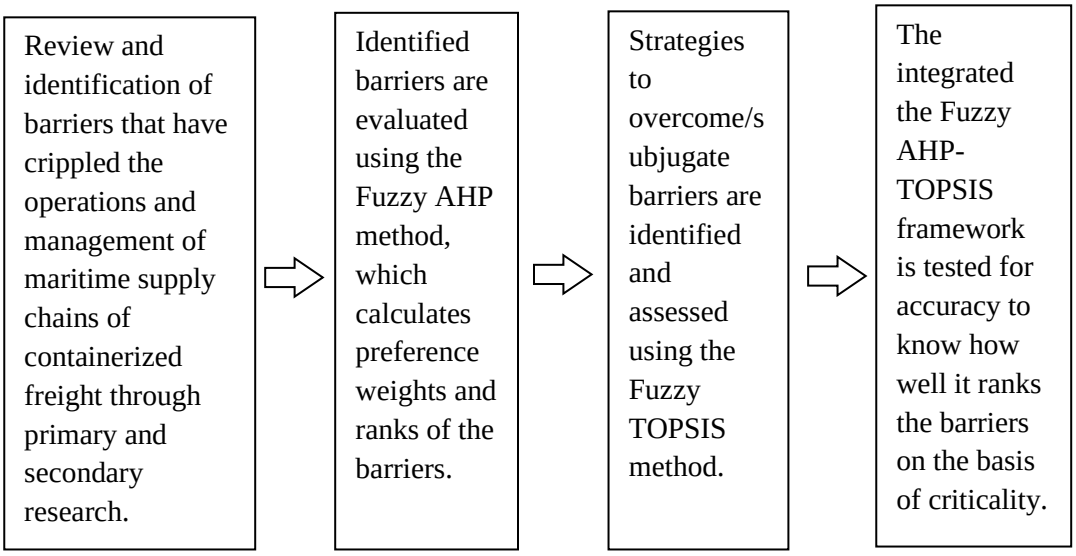
A review of barriers in the maritime supply chains of containerized freight was conducted based on prior studies. This study identified key categories and sub-categories of barriers from various sources, which are present in the maritime supply chains of containerized freight. Primary data is collected through the Delphi survey. Similarly, secondary data is collected from published reports/journals/articles/papers or other sources such as Drewry Maritime Research. The identified categories of the barriers are;

- Economic Barriers (ECBs)
- Infrastructural Barriers (IFBs)
- Legal Barriers (LGBs)
- Technological Barriers (TEBs)
- Administrative and Political Barriers (ADPBs)
- Organizational Barriers (OGBs)

Step 2:

The multi-criteria decision-making (or MCDM) method is employed to assess critical barriers which are crippling the smooth operations and management of the maritime supply chains of containerized freight.

The significance and ranking of the barriers, based on their influence on the maritime supply chains of containerized freight, is acquired from domain experts. Thereafter, the Fuzzy AHP technique is employed on the data set having categories and sub-categories of the barriers to derive the final priority list, and this technique calculated preference weights and ranks of the categories and sub-categories of the barriers.



Step 3:

In the next step, keeping barriers in mind, strategies to overcome/subjugate the influence of these barriers are discerned. As barriers, strategies are also ranked using the Fuzzy TOPSIS method. The criteria to rank the strategies is based on how impactful they are in terms of overcoming barriers. Therefore, the overall idea of this study is to propound a combined Fuzzy AHP-TOPSIS framework in order to rank the barriers and then rank strategies to overcome/subjugate these barriers.

Step 4:

This thesis developed a combined Fuzzy AHP-TOPSIS framework which is tested for accuracy in its evaluation of the barriers. The barriers with the highest preference weights or we can say foremost ranks should get treated first, that is why strategies with foremost ranks should get implemented first so that censorious barriers can be treated on priority.

3.2 Research Philosophy

Research philosophy is defined as "a belief about the ways in which data about an event or situation should be collected, assessed and utilized". Traditionally, there has always been a debate on the choice between research philosophies of positivist or interpretivist and among the research methods of quantitative or qualitative analysis. Accordingly, "interpretive researchers assume that access to reality (given or socially constructed) is only through social constructions such as language, consciousness, shared meanings, and instruments". The evolution of interpretivist philosophy is formulated on the evaluation of elation in social sciences. Correspondingly, this philosophy stresses qualitative examination over quantitative investigation. The elucidative technique is formulated on a realistic technique of data gathering such as interviews and surveys. Secondary data investigation is also well liked with interpretivism philosophy. In this sort of research, meanings emanate normally towards the conclusion of the research procedure.

Positivism is depending on the quantifiable observations leading to statistical analysis. It has been noted that "as a philosophy, positivism is in accordance with the empiricist view that knowledge stems from human experience. It has an atomistic, ontological view of the world as comprising discrete, observable elements and events that interact in an observable, determined and regular manner". Crowther and Lancaster (2008) argue that as a common rule, positivist studies generally embrace a deducible approach, whilst the analytical investigative technique is generally connected with a phenomenology philosophy.

Furthermore, elation associates to the belief that the researcher requires to focus on actuality, whilst phenomenology focus on the meaning and has provision for person interest. According to pragmatism research philosophy, a research query is a vital antecedent of the research philosophy. Pragmatics can integrate both, positivist and interpretivism locations inside the extent of single study as per the character of the research question. Thus, this study aims to embrace pragmatism as the study aims to focus on facts and also integrates human interest into a study.

3.3 Questionnaire design

Referring to the set objectives, a questionnaire is developed based on literature review and experts' feedback (refer appendix A and B). From the available literature, 50 sub-categories of barriers are identified. Thereafter, domain experts were consulted to assess the identified set of barriers. As guided by the experts, only 46 sub-categories under six major categories of barriers were finalized to conduct analysis. Finally, a questionnaire is designed to suggest the pairwise comparison in order to estimate the impact of barriers present in the maritime supply chains of containerized freight. Similarly, 30 strategies were discerned through an in-depth study of existing literature, of which, 25 strategies were finalized to proceed with the analysis. This way, data for research objectives 1, 2, and 3 is collected from the sample of 30 sector experts. The domain experts have not just helped in finalizing the barriers and strategies but also have contributed to add new ones which weren't discussed earlier in the existing literature.

3.4 Sampling

It is very imperative to choose suitable and workable samples to attain the objectives of the study. Sampling methods are predominantly classified into two groups which are; probability sampling and non-probability sampling. While developing samples, one has to undergo a number of phases such as; sampling method selection, defining sampling structure, target population identification, estimation of sample size, etc. In the course of sample selection, the foremost issue

is whether the sample is sector-specific or not. Reviewing of literature and experts' feedback revealed that almost every sector meets with specific barriers/bottlenecks that is why, the sample should obviously be sector-specific as it will provide specific, workable, beneficial feedback and will fill the gap through research findings for that sector. Also, the respondents selected in the sample should possess excellent knowledge and vast experience so that unexplored and problematic areas can be identified accurately. In this research, respondents are chosen from middle and senior-level management working with various actors in the maritime supply chains of containerized freight.

The target population is established in terms of elements, sampling units, extent and time. The target population for the current research is mentioned below:

Elements – Management and operations personnel (middle or upper-level managers)

Sampling units – Professionals from actors and stakeholders in the maritime supply chains.

Time – July 2019 to Dec 2019.

Extent – Pan India

The elements of current research are professionals from various actors in the maritime supply chains. While collecting data, an expert panel of 30 professionals was prepared. Professionals are chosen considering a set of criteria which has; their total industry experience, their experience in the area of maritime supply chains of containerized freight, their role in the industry, their education qualification, their level in the organization, etc. Professionals chosen for the current research are extremely proficient personnel in their area and possess immense knowledge of the maritime supply chain sector.

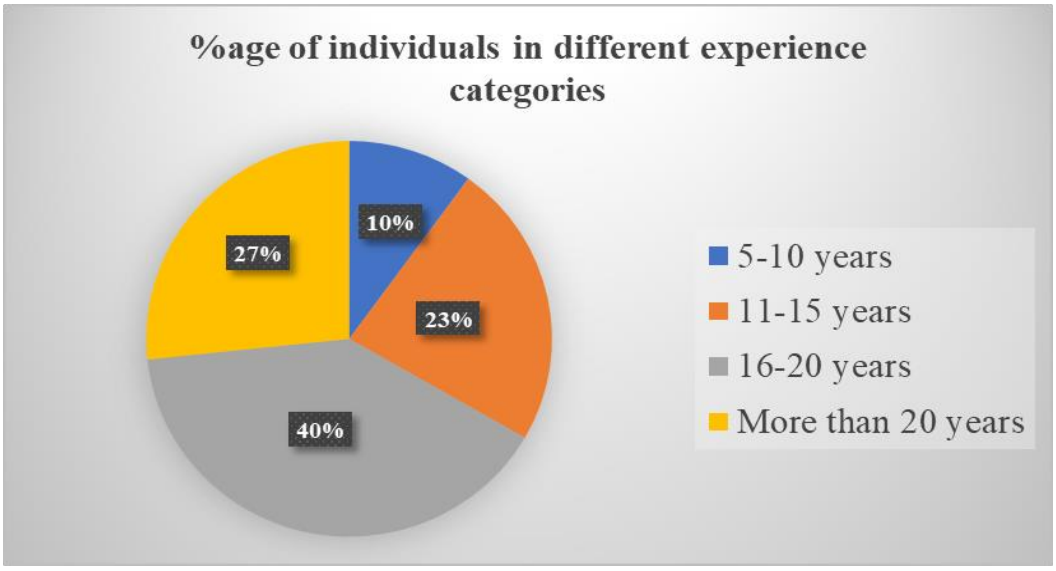
It is necessary to access the experience of the respondents in the maritime supply chain industry. Data collected on the work experience of respondents (in years) is suggested in Table 3.1.

Table 3.1 Sector experience of the respondents

Respondents' sector experience (In years)	Number of individuals	In percent
5-10 years	03	10%
11-15 years	07	23%
16-20 years	12	40%
More than 20 years	08	27%
Total	**30**	**100%**

Source: Author's composition

Figure 3.1 This figure illustrates %age of individuals in different range categories of experience.



Source: Author's composition

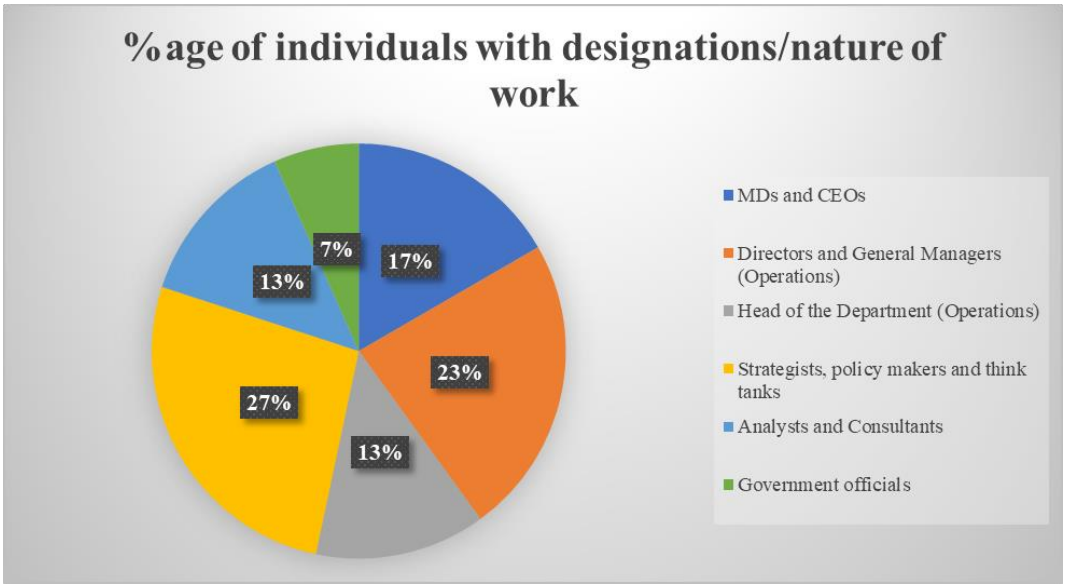
It is very vital to contemplate the profile of the informant as experienced and higher-level professionals have access to more knowledge and resources and it is highly possible that they will provide quality feedback. Information on the profile of the respondents and the number of individuals is mentioned below (Table 3.2);

Table 3.2 Profile of the respondents

Profile of the respondents (In Numbers)	Number of individuals	In percent
MDs and CEOs	05	17%
Directors and General Managers (Operations)	07	23%
Head of the Department (Operations)	04	13%
Strategists, policy makers and think tanks	08	27%
Analysts and Consultants	04	13%
Government officials	02	7%
Total	**30**	**100%**

Source: Author's composition

Figure 3.2 This figure demonstrates %age of individuals in sample with different designations/nature of work



Source: Author's composition

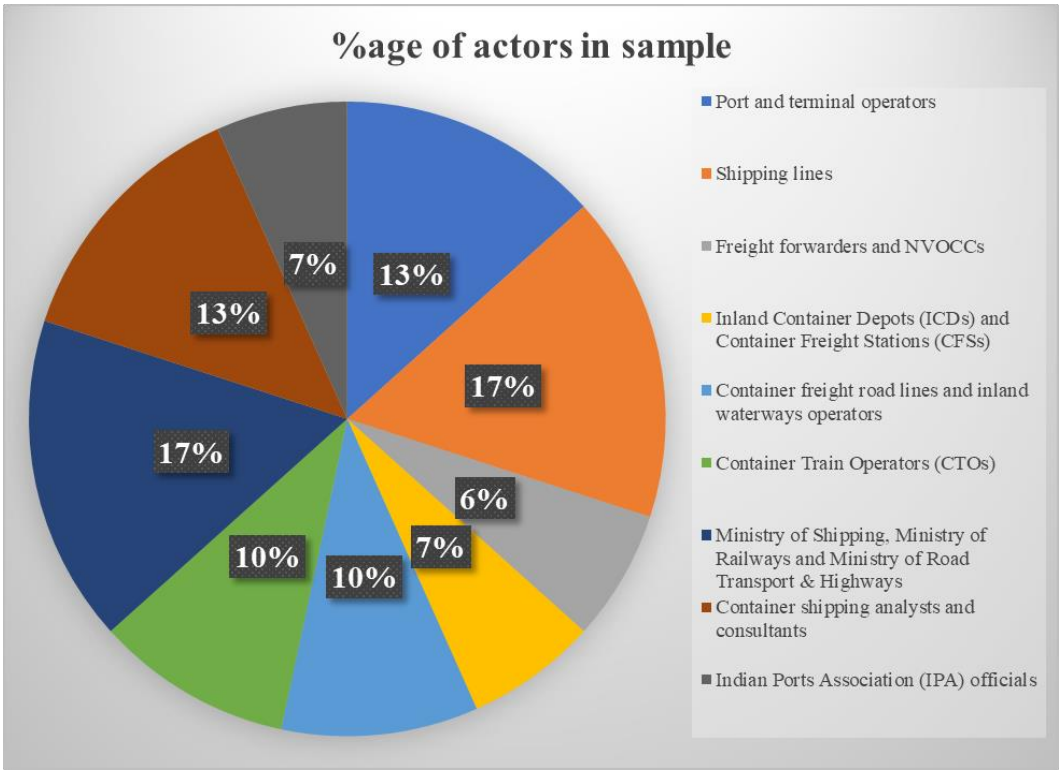
Adding on, it is important to know about the type of actors in the maritime supply chains consulted and taken feedback from, as each actor plays a certain defined role in the entire maritime supply chain without whom the entire chain is incomplete. Below table (Table 3.3) provides information on the type of actors approached to get feedback in order to complete this study;

Table 3.3 Type and number of actors contacted

Type of actors	Number of actors	In percent
Port and terminal operators	4	13%
Shipping lines	5	17%
Freight forwarders and NVOCCs	2	7%
Inland Container Depots (ICDs) and Container Freight Stations (CFSs)	2	7%
Container freight road lines and inland waterways operators	3	10%
Container Train Operators (CTOs)	3	10%
Ministry of Shipping, Ministry of Railways, and Ministry of Road Transport & Highways	5	17%
Container shipping analysts and consultants	4	13%
Indian Ports Association (IPA) officials	2	7%
Total	**30**	**100%**

Source: Author's composition

Figure 3.3 This figure elucidates %age of the actors interviewed



Source: Author's composition

3.5 Data collection procedure and tools

Data collection was carried out for objectives 1, 2, and 3:

Objective 1: To understand the nature and status of the maritime supply chains of containerized freight in India (See Chapter 4 for more details).

Objective 2 and 3: To develop an integrated Fuzzy AHP-TOPSIS model for the evaluation of barriers and prioritization of the strategies to overcome the impact of these barriers present in the maritime supply chains of containerized freight in India (see Chapter 5 and 6 for more details).

The main sources of barriers and strategies data are both primary and secondary. The sources of primary data are domain experts who are consulted to obtain relevant feedback. A questionnaire survey is conducted to discern categories and sub-categories of the constraints and to identify strategies to overcome these barriers. In terms of secondary data, in-depth analysis of the literature review is done. A wide range of quality journals and research papers are reviewed which are written over a period of time. Additionally, research reports written by Drewry Maritime Research private limited on this subject are reviewed thoroughly.

3.6 Data analysis

An in-depth analysis of the data was performed to achieve desired objectives. Collected data was reviewed and evaluated by using different methods to accomplish the objectives and provide answers to the research questions. The techniques employed to assess the data collated along with the findings that are presented in the subsequent chapters of the thesis.

3.7 Proposed research methods and techniques

As discussed earlier in detail, the first objective of this study is achieved by considering primary and secondary data. The available literature is reviewed thoroughly and a questionnaire survey is conducted to discern a list of barriers in

the maritime supply chains of containerized freight and strategies to overcome/subjugate the impact of these barriers.

Further, this study employed MCDM or Multi-criteria decision-making methods to rank the barriers. Precisely, the Fuzzy AHP approach is employed for ranking of the barrier because this method helps in transforming Fuzzy inputs from domain experts into specific ranks for a list of alternatives. This technique is used to build the priority list and is aimed at achieving the second research objective. The technique adopted is explained in detail in the next section.

Thereafter, the Fuzzy TOPSIS method of MCDM is espoused to perform analysis of strategies to overcome identified barriers. With this technique, a priority list of strategies is obtained. The method is further explained in the next section.

3.7.1 Fuzzy AHP technique

The Analytic Hierarchy Process (or AHP) technique was suggested by Satty (1980), a statistical investigation method that is beneficial in the decision-making exercise that has both quantitative as well as qualitative qualities. Analytic Hierarchy Process is a decision-making and approximation technique that produces the percentage issuance of decision points as per alternatives impacting decision, which is utilized if the decision hierarchy is defined. The notion of Fuzzy AHP is an outcome of some previous and succeeding studies in different domains by Thomas L. Saaty. The technique of AHP helps in dismantling a complex, unorganized condition into its constituent segments; organizing these segments into a hierarchical arrangement; consolidate the decisions to comprehend/ascertain which variables have obtained the highest priority and must be considered/treated first in order to impact the end result. As mentioned earlier, it utilizes a hierarchical arrangement to summarize, dismantle, arrange and manage the complication of the decision including numerous features, and it utilizes feedback from domain experts to calculate the comparative value of these features and consolidate an end result. Analytic Hierarchy Process is among the most appropriate techniques to assess logistics and supply chain related problems.

Because AHP alone has some shortcomings because of fuzzy environment, and therefore, the Fuzzy concept is integrated to minimize these imperfections (Prakash and Barua, 2015; 2016a; 2016c). By employing Fuzzy procedure, this unpredictability can be lessened (1965). In sooth, triangular fuzzy numbers (TFNs) are normally deployed as demonstrated in table 3.4.

Table 3.4 TFN of linguistic comparison matrix

Linguistic variables	Assigned TFN
Equal	(1, 1, 1)
Very Low	(1, 2, 3)
Low	(2, 3, 4)
Medium /Average	(3, 4, 5)
High	(4, 5, 6)
Very High	(5, 6, 7)
Excellent	(6, 7, 8)

Source: Author's composition

Chang (1992) method:

Definition 1 If $\tilde{N}_1 = (p_1, q_1, r_1)$ and $\tilde{N}_2 = (p_2, q_2, r_2)$ are representing two TFNs then algebraic operations can be stated as follows-

$\tilde{N}_1 \oplus \tilde{N}_2 = (p_1, q_1, r_1) \oplus (p_2, q_2, r_2) = (p_1 + p_2,\ q_1 + q_2, r_1 + r_2)$ ….. (1.1)

$\tilde{N}_1 \ominus \tilde{N}_2 = (p_1, q_1, r_1) \ominus (p_2, q_2, r_2) = (p_1 - p_2,\ q_1 - q_2, r_1 - r_2)$ ….. (1.2)

$\tilde{N}_1 \otimes \tilde{N}_2 = (p_1, q_1, r_1) \otimes (p_2, q_2, r_2) = (p_1 p_2,\ q_1 q_2, r_1 r_2)$ …… (1.3)

$\tilde{N}_1 \oslash \tilde{N}_2 = (p_1, q_1, r_1) \oslash (p_2, q_2, r_2) = (p_1/p_2,\ q_1/q_2, r_1/r_2)$ …… (1.4)

$\alpha \otimes \tilde{N}_1 = (\alpha p_1, \alpha q_1, \alpha r_1)$ where $\alpha > 0$ ……. (1.5)

$\tilde{N}_1^{-1} = (p_1, q_1, r_1)^{-1} = \left(\frac{1}{r_1}, \frac{1}{q_1}, \frac{1}{p_1}\right)$ …….. (1.6)

To apply the fuzzy analytical hierarchical process according to the method of Chang's (1992) extent analysis used. Steps are given below-

$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3 \ldots \ldots, M_{g_i}^m$ Where g_i is the goal set (i = 1, 2, 3, 4, 5 ….....n) and all the $M_{g_i}^j$ (j = 1, 2, 3, 4, 5 ....., m) are TFNs given in Table 3.4.

Step 1: Determine S_i (fuzzy synthetic extent value) w.r.to the i^{th} criterion

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \quad \text{.....……..} \quad (1.7)$$

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} p_{ij}, \sum_{j=1}^{m} q_{ij}, \sum_{j=1}^{m} r_{ij}\right)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} r_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} q_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{ij}}\right)$$

Where p is the lower limit value, q is the most promising value and r is the upper limit value.

Step 2: The degree of possibility of

$S_2 = (p_2, q_2, r_2) \geq S_1 = (p_1, q_1, r_1)$ is defined as below

$V(S_2 \geq S_1) = \sup_{y \geq x}[\min(\mu_{S_1}(x), \mu_{S_2}(y))]$

and x and y are membership values and can be written as given in equation 1.8 below:

$$V(S_2 \geq S_1) = \begin{cases} 1 & \text{if } b_2 \geq b_1 \\ 0 & \text{if } a_1 \geq c_2 \\ \dfrac{p_1 - r_2}{(q_2 - r_2) - (q_1 - p_1)} = \mu d, & \text{otherwise} \end{cases} \quad \text{…….. (1.8)}$$

Where µd is the maximum membership point μ_{S_1} and μ_{S_2} (refer below Figure 3.4)

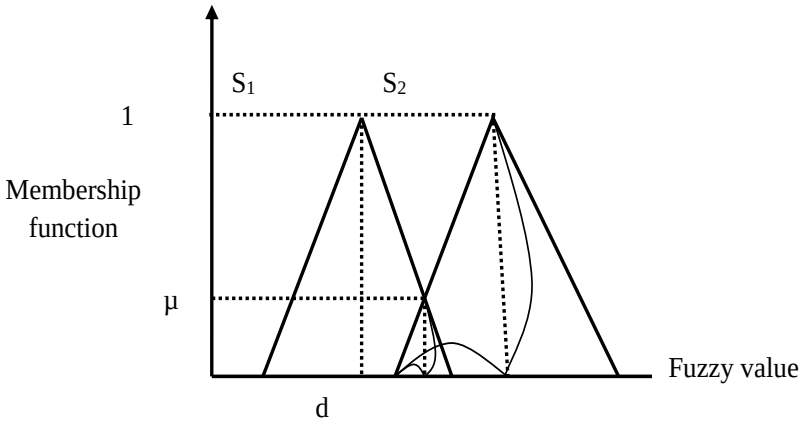


Figure 3.4: The intersection of Fuzzy numbers
Source: Author's composition

To compare S1 and S2 we need both V(S1 ≥ S2) and V(S2 ≥ S1).

Step 3: The degree of possibility for a convex fuzzy number S to be greater than k convex fuzzy numbers Si (i= 1,2,.....,k) can be defined by

V (S≥S1,S2,.....,Sk)

= V [(S≥S1) and (S≥S2) and .....and (S≥Sk)]

= minV (S≥Si), i= 1,2,.....,k

Assume that d′(Ai) = min V(Si≥ Sk) ……...(1.9)

For k = 1, 2, …, n, k ≠ i, Than the weight vectors are given in equation 1.10 as,

W'= (d'(A1), d'(A2),.....,d'(Am))T ……..…….….(1.10)

Step 4: Finally, normalized weight vectors are known in equation 1.11 as,

W= (d (A1), d (A2),.....,d (Am))T …… (1.11)

3.7.2 Advantages of using Fuzzy AHP technique

3.7.2a Fuzzy Analytic Hierarchy Process considers the relative priorities of all the alternatives chosen/selected for analysis and finds out the criticality level of each alternative, indicating the censorious ones.

3.7.2.b Fuzzy Analytic Hierarchy Process produces an easy and pliable framework in a given situation.

3.7.2.c Fuzzy Analytic Hierarchy Process presents an uncomplicated and applies able decision-making framework that helps the decision-maker to accurately determine the end results.

3.7.2.d While employing the Fuzzy AHP approach, besides objective and subjective elements, quantitative and qualitative data play a dominating role throughout the decision exercise.

3.7.2.e Variety of attributes about the top-ranked alternatives can be drawn in this method. By doing this, the outline of the top-ranked alternatives can be depicted effortlessly.

3.7.2.f The use of Fuzzy Analytic Hierarchy Process technique is very broad such as; strategic business planning, cost and benefit analysis, risk analysis, and of course strategic decision making.

3.7.2.g Fuzzy AHP depends on the decisions of domain specialists from various actors among a sector, which helps to assess the situation effortlessly from different angles.

3.7.2.h A strategist or a decision-maker can examine the adaptability and validity of the end result by running sensitivity analysis.

3.7.2.i This technique is helpful in measuring the stable decision-making ability of the decision-makers.

3.7.3 Fuzzy TOPSIS technique

The process of decision-making becomes complex when it involves qualitative and quantitative variables. In such situations, the MCDM approach can be utilized to handle multiple attributes and conflicting decision system structures (Luthra et al., 2018). There are numerous MCDM tools available, but among them, the Fuzzy TOPSIS approach based on the distance priority method is the most relevant that assists in the prioritization of robust selective attributes and optimizes from multiple responses. The final ranking is obtained based on the closeness coefficient values of an individual attribute. The steps of the Fuzzy TOPSIS technique are elaborated below:

Level 1: Score is allocated to each criterion to obtain a matrix for strategies as per scale is given in table 3.5.

Table 3.5 Score for linguistics variable

Assessment rating	Specific TFNs
Very Poor	(1, 2, 3)
Poor	(2, 3, 4)
Average	(3, 4, 5)
High	(4, 5, 6)
Very High	(5, 6, 7)
Excellent	(6, 7, 8)

Source: Prakash and Barua (2016)

Level 2: Calculation of cumulative Fuzzy values for the alternatives

If the Fuzzy value of the Nth expert is $\dot{F}_{abN} = (l_{abN}, p_{abN}, u_{abN})$ over here a =1,2,3,……..m, b=1,2,3……..n then the aggregated Fuzzy score $\dot{F}_{ab}$ of the strategies w.r. to the specific barrier is denoted by $\dot{F}_{ab}(l_{ab}, p_{ab}, u_{ab})$, where

$$a = \min_N\{l_{abN}\},\ b = \frac{1}{N}\sum_{N=1}^{N} p_{abN},\ c = \max_N\{u_{abN}\} \quad (3.5)$$

Level 3: Determine normalized values

Normalized values are determined by $\check{G}$ where:

$\dot{G} = \lfloor p_{ij} \rfloor_{mxn}$ Where i = 1,2,3,…….m and j = 1,2,3,…….n

$$\check{x}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = \max c_{ij} \text{ (benefit criteria)} \quad (3.6)$$

$$\check{x}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{ and } a_j^- = \min a_{ij} \text{ (Cost criteria)} \quad (3.7)$$

Level 4: Determine the Standardized weight score by applying the Eq.

$$\dot{Y} = \lfloor \check{p}_{ij} \rfloor_{mxn} \quad \text{where } \check{p}_{ij} = \check{x}_{ij} \otimes w_j \quad (3.8)$$

Level 5: Obtain Fuzzy ideal solution for positive and negative values as follows respectively:

$$Z^+ = \{\rho_1^+, \ldots\ldots, \rho_n^+\}, where\ \rho_j^+ = \{\max(\rho_{ij}) if\ j \epsilon J; min(\rho_{ij}) if\ j \epsilon J'\},\ j = 1 \ldots\ldots n \quad (3.9)$$

$$Z^- = \{\rho_1^-, \ldots\ldots, \rho_n^-\}, where\ \rho_j^- = \{min(\rho_{ij}) if\ j \epsilon J; max(\rho_{ij}) if\ j \epsilon J'\}, j = 1 \ldots\ldots n \quad (3.10)$$

Level 6: Calculate Fuzzy positive values and negative values for a solution using given Equations below-

$$\psi_i^+ = \left\{\sum_{j=1}^{n} (\rho_{ij} - \rho_{ij}^+)^2\right\}^{1/2}, \quad i = 1 \ldots\ldots\ldots\ldots m$$

$$\psi_i^- = \left\{ \sum_{j=1}^{n} \left(\rho_{ij} - \rho_{ij}^- \right)^2 \right\}^{1/2}, \quad i = 1 \ldots\ldots\ldots\ldots m \tag{3.11}$$

Level 7: Obtain the nearness coefficient value (CC_i) using equations

$$CC_i = \frac{\psi_i^-}{\psi_i^- + \psi_i^+} \qquad i = 1 \ldots\ldots\ldots m . \quad C_i \epsilon (0, 1) \tag{3.12}$$

Level 8: Priority list of the strategies.

3.7.4 Advantages of using Fuzzy TOPSIS technique

3.7.4 a. The Fuzzy TOPSIS is a rational and intuitive method to sensibly address human subjectivity.

3.7.4 b. The Fuzzy TOPSIS is easy to use and imbibe efficient computational power.

3.7.4 c. The Fuzzy TOPSIS can deliver scalar value that deals with both best and worst choices potential to calculate the relative functioning for each substitute in an uncomplicated empirical arrangement.

3.7.4 d. The Fuzzy TOPSIS provides possible visualization of the result mathematically and philosophically.

In this work, a combined Fuzzy AHP-Fuzzy TOPSIS approach is employed to accomplish the research objectives of the research work. The broad goal is to provide a flexible framework in order to rank the solutions to subjugate the constraints of the maritime supply chains of containerized freight in India. This amalgamated hybrid technique with multi-faceted decision support systems would progress which will subjugate the intricacy of a practical world judgment procedure and it will give a close real-world, coherent, straightforward, and effectual strategy in decision making as well. This research amalgamates FAHP with the FTOPSIS mixed framework to construct a brilliant decision support framework to overcome the barriers present in the maritime supply chains of containerized freight in India. The coalescence of FAHP with other methods may

also be bind to its convenient empirical basis, effortless to utilize, and pliablity. Another logic for coalescence is that the solitary methods hold idiosyncratic benefits that permit for flattering benefaction to the FAHP technique (Prakash and Barua; 2015).

3.7.5 Some of the recently performed studies where combined Fuzzy AHP-TOPSIS is used

Table 3.6 Below table illustrates recently performed studies using the Fuzzy AHP-TOPSIS framework

S. No.	Author/s (Year)	Modeling techniques used	Context
1	Yildiz et al. (2020)	Fuzzy AHP - Fuzzy TOPSIS	Appraisal of ATM site selection problem
2	Yousefzadeh et al. (2020)	Fuzzy AHP - Fuzzy TOPSIS	Selection of best technique out of 5 selected hydrometallurgical technique
3	Singh and Sarkar (2019)	Fuzzy AHP - Fuzzy TOPSIS	Prioritization of strategies to mitigate the constraints in the enforcement of eco-design procedures in SMEs
4	Sarkar and Biswas (2021)	Fuzzy AHP - Fuzzy TOPSIS	To elucidate multicriteria decision-making (MCDM) problems with completely unknown weights of criteria
5	Beskese et al. (2020)	Fuzzy AHP - Fuzzy TOPSIS	Appraisal of a wind turbine in Turkey
6	Venkatesh et al. (2019)	Fuzzy AHP - Fuzzy TOPSIS	Selection of supply ally choice in assisting humanitarian supply chains
7	Ocampo (2019)	Fuzzy AHP - Fuzzy TOPSIS	Discerning the content strategy for imperishable manufacturing for food production
8	Wang et al. (2019)	Fuzzy AHP - Fuzzy TOPSIS	Plant choice for phytoremediation of petroleum-contaminated soils in shale gas and oil fields
9	İç and Yurdakul (2020)	Fuzzy AHP - Fuzzy TOPSIS	Measuring the functioning of a manufacturing firm
10	Prasad et al. (2020)	Fuzzy AHP - Fuzzy TOPSIS	Selection of coating material for magnesium alloy
11	Du et al. (2020)	Fuzzy AHP - Fuzzy TOPSIS	Damage appraisal of Earthen locations of the Ming Great Wall in Qinghai Province
12	Tyagi et al. (2018)	Fuzzy AHP - Fuzzy TOPSIS	Appraisal of CSR based supply chain performance system
13	Sirisawat and Kiatcharoenpol (2018)	Fuzzy AHP - Fuzzy TOPSIS	Prioritization of strategies for constraints in reverse logistics
14	Galankashi et al. (2016)	Fuzzy AHP - Fuzzy TOPSIS	Supplier choice in the automobile industry

15	Hanine et al. (2016)	Fuzzy AHP - Fuzzy TOPSIS	Choice of landfill location
16	Kusumawardani and Agintiara (2015	Fuzzy AHP - Fuzzy TOPSIS	Decision making in the HR manager recruitment procedure
17	Prakash and Barua (2015)	Fuzzy AHP - Fuzzy TOPSIS	Prioritizing the strategies of reverse logistics adoption
18	Vinodh et al. (2014)	Fuzzy AHP - Fuzzy TOPSIS	Choice of the most suitable plastic recycling process
19	Patil and Kant (2014)	Fuzzy AHP - Fuzzy TOPSIS	Prioritization of strategies of KM embracement in the Supply Chain to mitigate its inhibitors
20	Samvedi et al. (2013)	Fuzzy AHP - Fuzzy TOPSIS	Appraising risks in a supply chain by the amalgamation of Fuzzy AHP-TOPSIS
21	Aktan at Tosun (2013)	Fuzzy AHP - Fuzzy TOPSIS	Choice of automated storage and retrieval system (AS/RS)
22	Boutakhoum et al. (2017)	Fuzzy AHP - Fuzzy TOPSIS	Choice of the suitable cloud strategy to govern big data projects
23	Panchal and Kumar (2017)	Fuzzy AHP - Fuzzy TOPSIS	Performing decision-making for an electricity-producing unit in a thermal power station
24	Sindhu et al. (2017)	Fuzzy AHP - Fuzzy TOPSIS	Examination of viability report on solar station establishment

Source: *Author's composition*

3.8 Chapter Summary

In this chapter, a detailed discussion on the methodology used for accomplishing the research objectives was mentioned. The technique used for collecting data and the assessment of this data using various methods was explained. For instance, the Fuzzy AHP technique is employed to prioritize the inhibitors was argued in this chapter. Also, to assess strategies to overcome the barriers, the Fuzzy TOPSIS method is propounded and discussed. Hence, this study espouses an amalgamated Fuzzy AHP-TOPSIS model which is never done before in the maritime supply chains domain. The next chapter illustrates an application of Fuzzy AHP methodology on barriers in the maritime supply chains of containerized freight and the results gained after using this technique are discussed in detail.

Chapter 4

Understanding Maritime Supply Chains of containerized freight

Overview

This chapter aims to understand maritime supply chains (or MSCs) of containerized freight and also aims to comprehend the status of maritime supply chains in India. Further, this chapter highlights various factors that lead to the development and growth of maritime supply chains of containerized freight. Additionally, various actors and stakeholders in the maritime supply chains and their roles are drawn and discussed in detail. Moreover, this chapter illustrates an outline of how the maritime supply chains of containerized freight were developed over time in India.

4.1 Introduction

The crucial role of the integrated logistics system or better called maritime supply chain is to facilitate logistical operations e.g., transportation of raw material and manufactured commodities. The maritime supply chains ensure that the commodities must be delivered to the market in the right quantity and quality (without getting damaged) and at right time at a competitive transportation cost. Therefore, the maritime supply chains perform an indispensable role in facilitating the transportation of a variety of commodities.

In the maritime supply chains, the transportation of commodities from the point of origin to the point of destination can be arranged by combining multiple modes of transport, where multiple actors and stakeholders jointly conduct the entire logistics process under a single legal contract.

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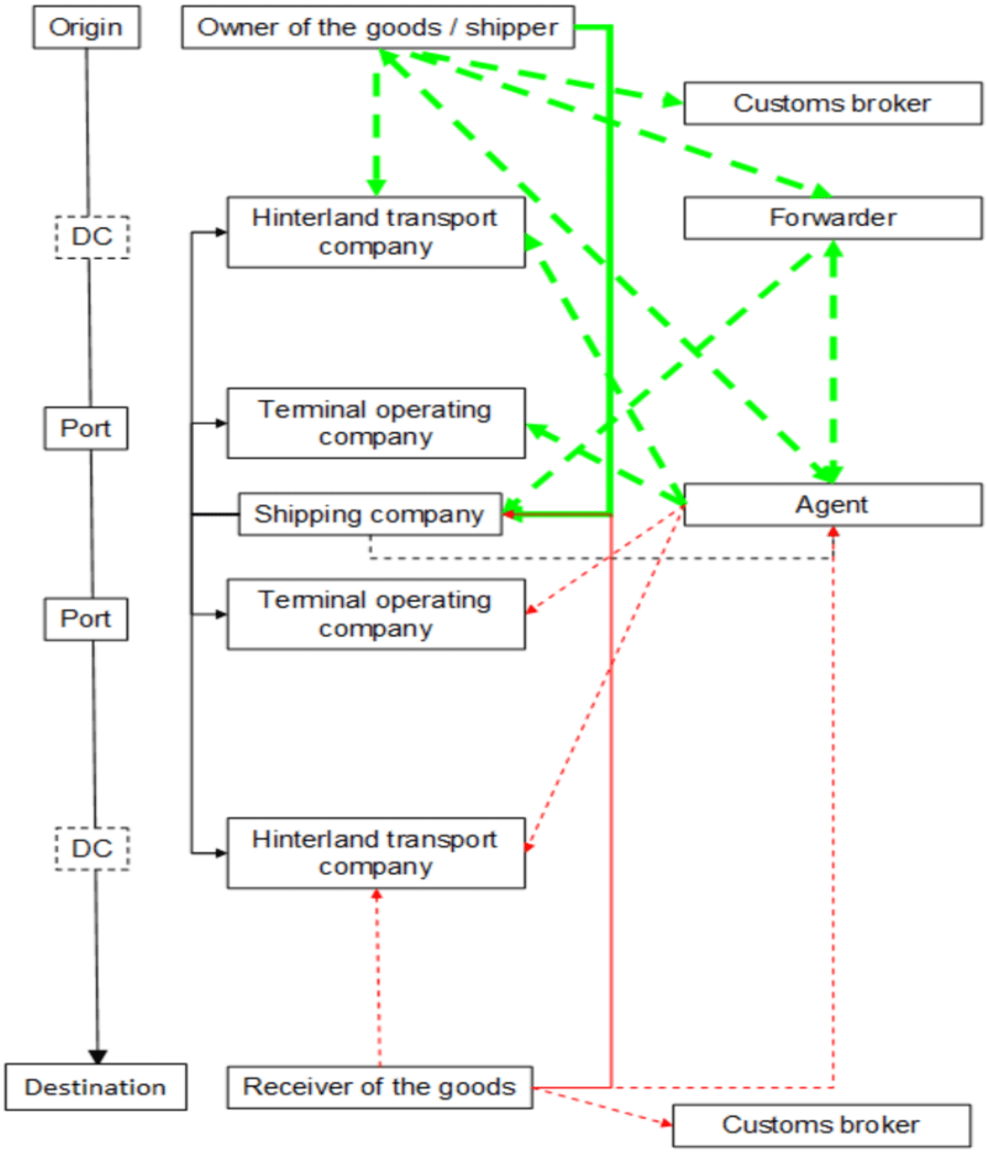
Here, the shipping line/carrier is legally responsible for the entire movement. The maritime supply chain is an efficient logistics system that facilitates the transportation of commodities in a hassle-free environment using a smaller set of streamlined documentation, well organized and controlled, a single point of contact, and a completely reliable, cost and time-saving arrangement. However, the efficient working of the maritime supply chains is highly dependent on the impact of the barriers and level of integration among actors and stakeholders. Therefore, before jump on barriers, the need is to identify and understand the role of actors and stakeholders in the maritime supply chains of containerized freight. For that reason, this chapter attempts to strengthen the understanding of various actors and stakeholders of the maritime supply chains.

4.2 Structure of a maritime supply chain (MSC)

It is necessary to realize which actor in the maritime supply chain takes which decisions. Also, in-depth knowledge is needed about which actions are taken autonomously and which are taken in the outcome of or with a view to earlier outcomes, frequently at a separate level. Previously conducted studies (e.g., Lejars et al., 2017) have illustrated clearly that some actors are extremely prominent. Some of these eminent actors are BCOs/shippers and shipping lines, whereas, freight forwarders and the forwarding agents are supporting service providers. On the other hand, seaport owners and operators are hugely dependent upon the strategies framed by these prominent actors. Despite not being the forefront actors, seaport owners and operators are also demanded to make strong commitments by financing superstructure (e.g., storage capacity, berths and terminals, breakwaters, wharves, and port logistics network), and infrastructure (e.g., modern cranes, equipment, and vehicles). Prior to jump on barriers and strategies to mitigate those barriers, It is crucial to obtain a limpid understanding of the roles and responsibilities of the actors and stakeholders, as illustrated in figure 4.1. In the figure, the dashed green lines indicate various options/ways available for moving freight through different actors of the maritime supply

chains, thus involving multiple players in the process. The Beneficial Cargo Owner (BCO), may choose to hand over the freight to forwarders, custom brokers, or agents, before submitting the freight to shipping lines. Often, the freight is also transported to the shipping lines through the hinterland transport company. Also, freight is directly given to the shipping lines for further transportation, as depicted with a bold line in figure 4.1. In the case of import, which is marked with non-bold lines, the importer decides on what way he/she wants to receive the freight. The shipping line decides in advance with the importer on the choice of route and port call, and also, who will pay what charges. Once the freight arrives port of destination, the appointed agent receives the freight and forwards it to the importer's premise. The imported freight is loaded and moved through a suitable mode of freight transport. The decision on which hinterland transport mode to choose is either taken by exporter or importer or by the shipping lines. Distribution centers (DCs) are also used in the hinterland transport network in order to relieve pressure from the transport modes. The choice of a transport mode, which includes mode and operator (for instance a container train operator), is a key decision for the BCOs, with or without the participation of a freight forwarder. The shipping lines are also the strategic actors in the entire maritime supply chain as they take a decision on port calls and hinterland transport choices. The selection of ports is based on a number of factors like availability of freight, geographical location of the ports, availability of required facilities, and their distance from the cargo hinterland. However, the current time is such that often ports have to compete with each other in order to attract shipping lines and BCOs. The two important decisions discussed here that are choice of port and hinterland mode and operator, are directly related to port selection. Contrarily, the existing hinterland transport alternatives are probably to impact the port choice decision, as evidently once a port has been chosen, one is restricted to the modes and operators.

Figure 4.1 Structure of a maritime supply chain



Source: Meersman et al. (2010)

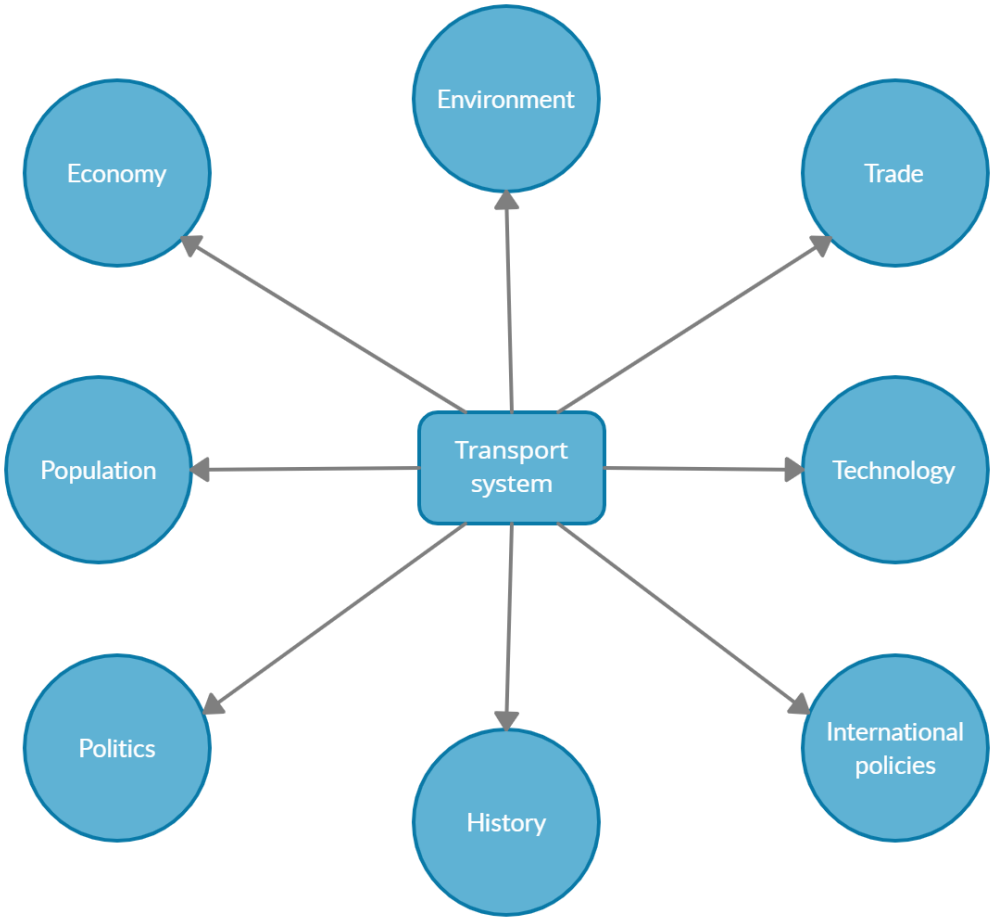
On the basis of surveys and literature study, Aronietis et al. (2010) have composed a set of factors that directly or indirectly impacting port choice decision, and the factors are; geographical location, costs, quality of port operations, the reputation of port, turnaround time, infrastructure, and availability of facilities, productivity, and efficiency, port call frequency, port information

system, hinterland connections. The above-mentioned factors are doubtlessly in order to select a port; however, their importance differs from actor to actor among maritime supply chains. Nowadays, cost minimization is an important strategy for every actor in the maritime supply chain, such as shipping lines have a larger scope than other actors for minimizing costs while keeping freight rates at such a level that they churn a good amount of profits.

4.3 Factors influencing the development and growth of the maritime supply chains

Development for the welfare of society can be brought by making appropriate changes in the social, political, and economic conditions of a country or region, as the case may be (Lipset, 1959). The results of such reforms bring quantitative and qualitative improvements in human as well as physical capital. For quite a long period of time, development-focused more on adding and upgrading physical assets, but with time focus is also given to the human capital (Benhabib and Spiegel, 1994). It is well understood that development cannot happen without giving equal importance to the physical and human capital. For example, Infrastructure is covered under physical capital, which is one of the most important factors that support economic activities (Munnell, 1992; Vandermeulen et al., 2011). The quality and quantity of transport infrastructure very much decide the level of economic development. An efficient transport infrastructure provides socio-economic benefits to society. A better transport system minimizes the cost of transporting commodities. Maritime supply chains play a vital role in refurbishing a country or region's economy (Maciulis et al., 2009) and also support other sectors like agriculture, defense, commerce, and industry, etc. The present-day transport system has evolved stage by stage from what it was in ancient and medieval times. There are many factors that have led to the development of maritime supply chains. The below figure 4.2 helps us to understand the same:

Figure 4.2 Factors influencing the development of the maritime supply chains



Source: http://www.geographynotes.com

The eight illustrated factors in the above figure have played different roles in developing maritime supply chains globally. Among these eight factors, trade, history, politics, population, and economy are the older ones compare to technology, international policies, and innovations. Trade is one such factor that was initiated thousands of years ago among various ancient settlements. Since then, ways of doing trade among various communities around the world have evolved to come to the present stage. Similarly, the population is growing with time and the need for essential commodities is increasing which is what has

become one of the main reasons for the maritime supply chains to grow rapidly. Politics and economic requirements are also two major reasons why the maritime supply chains developed over a period of time and will continue to develop in the future. All of these eight factors are interconnected, for instance, the development of population becomes necessary in order to economically develop the country.

Technology is yet another factor that is most discussed and most researched in present times to bring efficiency in the maritime supply chains. Better technology is a boon in a number of ways but it also cuts down employment opportunities for humans, and that is why, it is a challenging exercise in developing countries like BRICS nations (Almeida and Fernandes, 2008; Makki and Somwaru, 2004). Talking about the economy in the transport system, container shipping is an example where the size of ships has grown rapidly to such a level that per unit transportation cost has reduced, not just the cost but the greenhouse gasses (GHG) emission has also reduced per container (Cullinane and Khanna, 1999). Trade and politics go tandem, Venezuela is an example where the autocratic government has failed to resuscitate an oil-dependent economy and the US has imposed economic sanctions which further crippled the South American nation (Levitsky and Way, 2002). This shows how politics drives trade globally which is also mentioned by Gowa and Mansfield (1993) and Milner and Rosendorff (1997). As discussed earlier, the population is yet another factor that impacts the development of the transport system (He et al., 2005). As we know that increasing population raises the demand for more commodities to be consumed. Therefore, being a facilitator, the maritime supply chains get developed in order to cater to the rise in demand as a result of the rising population.

4.4 Development and management of actors in the maritime supply chains in India

International trade is facilitated by a number of actors and stakeholders in the maritime supply chains at the national, regional, or international level. Actors in

the maritime supply chains are either private or public-owned corporations. There exist multiple actors that facilitate trade and are linked with each other to fulfill the aim of the maritime supply chains. Over the years, many sustainable initiatives have been put into practice by various actors in the maritime supply chains of containerized freight in India. This section explains, in brief, the major actors who play a significant role in the success of the maritime supply chains.

4.4.1 Shipping lines and capacity deployment

A container-owning company is a corporation that builds and owns a maritime container and then provides it to various customers. In this case, the container owning company can be a shipping line such as; Maersk line or MSC or can be a container leasing company such as Triton Container International Limited. Container shipping lines like Maersk and MSC own a huge fleet of containers but that is not sufficient and they have to take containers on lease as well. There is hardly any shipping line that operates with just its own containers, at least none in the top 20. The shipping lines need to lease containers depending upon the demand. *A container shipping line is a firm that operates cellular container ships that carry maritime containers (owned or leased) from the loading port to the destination port. Some of the well-known container shipping lines are the Maersk line, MSC line, CMA CGM, and COSCO line, etc.* The mentioned container shipping lines are the top-performing in the world and they run various liner services among almost all the regions around the world.

Immediately after independence, India's share in international trade was insignificant. Poverty, no government support, and lack of basic infrastructure were the foremost problems (Amis and Kumar, 2000; Baud et al., 2008). However, with the end of license raj in India in 1990 (Aghion et al., 2008; Majumdar, 2004; McDowell, 1995), economic development speed up to take India to become a top growing economy in the world. The GDP growth rate increased so much so that it went over 8.5% in the year 2010. Before the 1990s, maritime was not so eminent sector but had a promising future because of the

initiation of globalization. In 1961, the Shipping Corporation of India (SCI) was founded and started its operations with 19 ships, which was a milestone for India in the maritime sector. But SCI does not have expertise in container shipping as it owns only 3 container ships, which is certainly a shortfall. All the overseas cargo to/from India is transported by foreign players and often transshipped from different hubs to Indian ports (Murshid, 2011). This is a disadvantage as foreign shipping lines utilize this opportunity to charge higher freight rates. India's container trade grew rapidly from 2.5 million TEUs (Twenty-foot equivalent unit or a 20-foot container) in the year 2000 to about 17 million TEUs in 2019 (Drewry Container Forecaster, Second quarter 2020). After the year 2000, the market share of shipping lines grew rapidly, because they could afford to operate with well-planned schedules at higher frequencies amid consistently growing ship sizes. They also have been able to attract more customers and thus more cargo volume because of strong financials and good marketing skills and thus able to earn more balanced volume to transport compared to most of the small size rivals.

The aggressiveness of container shipping companies since the year 2000 has led to vertical integration in the maritime industry (Álvarez-SanJaime et al., 2013). The giant shipping lines, such as Maersk and Mediterranean Shipping Company (MSC) have started their own agency firms that are present at most of the seaports. The shipping lines are also setting up their own forwarding and rail freight companies (Franc and Van der Horst, 2010). Also, some of the shipping lines either have some percentage of stake in Container Freight Stations (CFSs) and Inland Container Depots/Inland Clearance Depots (ICDs) or fully own them (Mwemezi and Huang, 2012). Shipping lines have established their own inland freight transport companies in an attempt to save cost and neglect the presence of third parties. Top shipping lines and Container Train Operators (CTOs) have started operating their own logistics parks in the cargo hinterlands. Renowned FMCG (Fast Moving Consumer Goods), mining, agriculture, and production companies have set up their own logistics departments rather than taking the help of third-party service providers. The involvement of multi-national companies

increases competition to the local service providers and this often leads to low prices or freight rates for that matter, offered by the companies.

The container shipping movement in India started around the 1980s and it grew since then. With an increase in cargo volume, a significant amount of traffic has shifted to non-major ports and is growing year by year. Foreign shipping lines have shown a lot of interest in calling Indian ports, especially, after India opened the doors for 100% FDI in the maritime sector. With the growth in shipping demand and cargo supply, the inland modes of transport developed over the period of time (Adolf Ng and Gujar, 2009). Pedersen (2001) says that the evolution and development of freight transport network systems offer immense benefits to the economy in which it operates. Freight transport network system is a result of logistic revolution which resulted in structural changes in last 30 years in the global transport system. Hesse and Rodrigue (2004) mentioned that the fundamental question is not about the origin or destination of the cargo but rather how the freight is moving.

Supply in container trade is the total slot capacity allocated in total vessels deployed in a number of liner services (main trade or regional services) calling ports of a particular region/country (Ducruet and Notteboom, 2012; Wang and Meng, 2012). The capacity of supply increases with an increase in vessel size, a number of services, or adding more vessels in existing liner services and vice versa. Container shipping services are now working on the just-in-time (JIT) concept because the customers expect reliable services, low costs, high security, and faster transit times (Notteboom, 2006). Talking about India, where the entire 7,500km long coastline is divided into two parts; western coast and eastern coast. Indian ports have evidenced a tremendous increase in supply capacity for a decade. The supply-demand scenario shows that the country had reached its critical level of capacity utilization of 85% in 2007-08 which eased out in the later years. It can be rightly said that the recession in 2008-09 was actually a blessing in disguise for the Indian ports which would have simply crumbled under the pressure of container traffic growth if the traffic had grown at the same pace.

Although South Asia as a region will continue to grow in the years to come at a slower pace says Drewry (Container Forecaster report, 2017). Capacity utilization declined between 2013 to 2016, but post mid of 2016, trade again picked up, and by 4Q2016 the capacity utilization level of container ports in India was 75%. The capacity share of lower east coast ports has increased significantly from 20% in 2012 to 30% in 2016, primarily due to the development of container terminals at Krishnapatnam and Kattupalli. The capacity share of the Greater Mumbai region has declined over the same period. For central east coast ports, the capacity share has remained constant, to the level of 2%. Adani Ports is the largest private container port developer and operator with eight ports and terminals in total, out of which, Adani Mundra, Adani Hazira, and Adani Kattupalli are operational and active ports in handling containerized cargo. Adani Vizhinjam port is under construction, which is being built to attract India's gateway traffic presently handled by Colombo port in Sri Lanka. Port infrastructure has to go tandem with the development in shipping supply (Like the increase in the size of ships or type of ships), both ports and liner services are interdependent (Panayides and Song, 2013). Even Notteboom and Rodrigue (2008) talked about the integration of ports and liner shipping networks in order to reap the full benefits of containerization.

The number of mainline services calling Indian ports has increased from 29 in 2Q2014 to 40 in 2Q2017. With such a remarkable development in container trade. The average vessel size calling Indian ports has surged from 4,500 Teus in 2014 to 6,000 Teus in 2017. There is a noticeable change in the maximum size of vessels calling Indian ports which was 6,802 TEUs in 2014 and have increased to 13,000 Teus in 2017. Jawaharlal Nehru Port Trust (better known as JNPT) on the western coast holds the record of handling 26 mainline services as of 2Q2017 followed by Adani Mundra where 23 mainline services are calling at the same point of time. Ports like APM Terminals Pipavav, Hazira, Kattupalli, and Krishnapatnam are called by 6, 5, 2, and 2 mainline services, respectively. However, Chennai port once being the largest container handling port on the east coast is losing its charm because it is located right in the center of Chennai city

which leaves no room for expansion, and therefore, congestion on city roads disturbs the entire supply chain. The Chennai-bound traffic is opting for alternatives like Krishnapatnam and Kattupalli like young ports which seem to have a good future. The container traffic in India has evidenced more or less a firm growth pattern for the past two decades. The total traffic has increased from 9.8 million TEUs in the financial year 2012 to 13 million TEUs in the financial year 2016 and is expected to cross 14.5 million TEUs in the financial year 2017. Over the last five years, container traffic has grown at a CAGR (Compound Annual Growth Rate) of 6%. The major ports in India accounted for almost 99% of the container traffic in early 2000. However, the situation changed with the influx of minor ports. As a result, the container traffic in minor ports in India has increased considerably over the past five years. It accounts for almost 47% of the total container traffic handled in the year 2016-17. In conclusion to the supply development of India, it can be said that with boost up in industrialization and exports from India, will certainly bring good days for container shipping and more and more liner shipping operators will be investing. Also, containerization of bulk commodities will give a forward push to the Indian container trade.

Table 4.1 This table illustrates shipping lines with mentioned capacity calling Indian ports

Operator	Number of liner services	Total Capacity (In TEUs)	Average Ship capacity (In TEUs)	Maximum Ship (In TEUs)
CMA CGM	14	604,916	6,049	9,200
Hapag-Lloyd	7	355,375	6,705	9,162
Maersk	7	353,745	6,317	10,000
MSC	4	289,269	9,040	13,102
COSCON	8	215,465	4,897	5,908
NYK	6	153,446	5,115	7,455
OOCL	4	144,861	6,585	9,200
Wan Hai	6	137,186	4,573	5,900

PIL	4	129,576	4,799	5,908
Evergreen	5	125,736	4,836	6,000

Source: Drewry Maritime Research Database (Route Capacity Database)

4.4.2 Container ports and port development strategies by the Indian government

The concept of the seaport is not new because a lot many seaport-like structures have been excavated near pre-historic settlement sites. This clearly indicates that whenever ancient civilizations engaged in trade, they developed seaports, and therefore, maritime trade flourished since that era. Container trade is the newest concept of moving freight and was developed in the late 1960s. In India, there are 13 major and around 200 non-major seaports, however, not all of them handle containerized freight. Container seaports are established only to handle containerized freight of all kinds. *A Container port or a container terminal is a combination of manpower, infrastructure, and superstructure that helps shipping containers to change modes of transport in order to reach their final destination*. Imported cargo at the container seaports is transported to the importer's premise using various modes of land transport, and also sometimes, the imported cargo is required to be transshipped to the nearer seaports and from there it is transported further.

After the end of the 2008 crisis, container shipping figures started to improve. India's consumption also acted as a catalyst in generating trade demand. However, the global meltdown between 2015 and 2017 softened the overall demand, resulted in declined export and import volume. The year 2015 proved to be a choppy year as total exports and import volume took the beating and fell sharply by 17% compared to the previous year. These circumstances put India's medium-term outlook in peril. However, container traffic at Indian ports started picking up after 2017. In the last 10 years, container traffic has grown at a CAGR of 10%. Because of such a lucrative growth rate and future potential, India has been able to attract a good volume of foreign investments. The private sector has

emerged as a major player, addressing the issues related to infrastructural bottlenecks. But despite disruptive times, in 2019, India's total throughput achieved almost a 17million Teus mark, which is the highest ever as of now.

To attract investments, India's central government has allowed 100% Foreign Direct Investment (FDI) in the shipping sector. It is also reviewing the MCA (Model Concession Agreement) utilized for the purpose of tendering port projects to the private sector. The reformed MCA aims to embrace provisions, for example; substitution of the minimum guaranteed cargo (MGC) requirement with minimum guaranteed revenue (MGR) and exit policy is also clearly drawn which will allow the private operator to exit six years after the start of commercial operations. Currently, the trend is shifting toward the use of bigger vessels, and therefore, existing cranes should be replaced with bigger and modern ones so that the turnaround time for those vessels can be shortened (Cullinane and Khanna, 2000). Modern ports will definitely help in speed export/import operations in the near future. Despite all the growth in the port sector over the years, the presence of certain barriers like duties and taxes have impeded the flow of FDI into the maritime sector. However, the road is bumpy for international players in India, for instance, global container port operators such as DP World, APMT, and PSA International are on the back foot after being asked by tariff regulatory to cut rates. This will certainly impact their profit earnings and future foreign investments in India's maritime sector.

4.4.2a Major versus non-major ports

For a decade, the growth of non-major or intermediate ports is a result of evolving Public-Private Partnership (PPP). Better facilities at non-major ports have snatched container traffic from major ports as the top-performing major ports are operating at high-capacity utilization. Non-major ports have a significant contribution towards the growth of container trade to/from India; these ports are emerging massively in throughput with a CAGR close to 30% in the past 10 years. However, the difference is huge as compared to growth in major ports.

Growth potential combined with a favorable investment climate has motivated or inspired domestic and foreign private firms to gain access to the Indian ports sector. Adding to the development of maritime infrastructure, the private sector has immensely taken part in developing hinterland connections, such as transporting containerized cargo through rail. The growth for non-major ports like Hazira and Kattupali in 2015 versus 2014 was 119 % and 200%, respectively. Indian ports have struggled to maintain efficiency but private players have invested significantly towards increasing the performance of the ports. Adani Mundra port is an example among private ports which aimed to develop itself as a major gateway hub for the cargo flowing from the North and North Western region in the country.

Presently, more than about 70% of the country's container traffic is handled by ports on the western coast. However, Opportunities for east coast ports are increasing due to India's 'Look East policy and China's evolution as India's lead trading partner. Also, the overutilization in the west coast ports provides development and expansion opportunities to ports on the Eastern coast. Container traffic handled by east coast ports of India has grown from 1.4 million TEU in 2005 to 3.15 million TEU in 2015, with a CAGR of 8%. In 2010, the Government of India came up with a 10- year action plan – the National Maritime Development Programme (NMDP) – to develop the port and maritime sector of the country. The government planned to invest $14.75 billion over a period of 10 years, which constituted $8.21 billion for enhancing the capacity of major ports with the remainder being used to develop hinterland connectivity and inland waterways. So far, the work done in this context is at a very low pace with no satisfactory results. After the change in central government in the year 2014, NDA (National Democratic Alliance) came into power. The new government felt the need for change in the strategic maritime program as they analysed that the previous governments encouraged private investment in a big way, as a result of this, the private ports were snatching the throughput handled by major ports, as discussed earlier. A study performed in collaboration by a well know auditing and

consulting firm named Ernst Young (EY) and Andhra Pradesh Chambers of Commerce and Industry (APCCIF) concluded that in coming times, the non-major ports will be dominating in handling cargo (especially containerized cargo). Conclusively the NMDP couldn't yield results that were anticipated during its formation, and therefore, the government of India showed ambition to replace NMDP with the more effective Maritime Agenda 2010-2020.

On 31 July 2015, the current central government launched its ambitious Sagarmala (ocean necklace) project aiming to uplift the maritime sector especially container trade, and establishment of port-led direct and indirect development. The primary objective of Sagarmala is to develop ports and terminals of the country and enhance the efficiency of the transport network to improve hinterland connectivity, establish logistics hubs; facilitating the environment to set up industries and manufacturing units in order to improve the export and import trade. The so-called "Make in India" megaproject will connect market places in India with ports and further with global markets, this will boost India's trade with other countries. There is no point in talking about increasing production under "*Make in India*" until we have strong maritime supply chain facilities. All this will be facilitated by Sagarmala as it will emphasize more on improving the basic infrastructure so that cargo can be evacuated and transported quickly, efficiently, and cost-effectively to and from ports by setting up Special Purpose Vehicles to install efficient rail and road evacuation systems at major ports. This project aims to develop the undeveloped regions of the country such as seven sister states in the North-East by encouraging Public-Private Partnership (PPP) models to inject investment to develop the maritime supply chain sector in the region. The target is exporting worth $900 billion by 2020 under the *Sagarmala* project. Under the *Sagarmala*, port mechanization and port modernization are also planned and are already implemented to some extent. To make *Sagarmala* a huge success following are some committees formed;

- National Sagarmala Apex committee.

- Sagarmala Development Committee (SDC).
- Sagarmala State Committee (SSC).
- Sagarmala Coordination and Steering Committee (SCSC).

4.4.3 Freight forwarders and the forwarding industry

Towards the end of the 1980s, the concept of containerization was quite liked in developing and developed countries. This was the time when multinational freight forwarding companies, regional freight forwarders or also called non-vessel operating common carrier (NVOCC) came into existence, and they initiated delivering cargo to the customer's premises by issuing a document called 'House Bill of Lading'. *A freight forwarder is a registered company that arranges transportation of cargo for individual shippers or corporations from point of origin, which can be exporter's/exporting firm's premise or an ICD to the importer's/importing firm's premise.* Some of the renowned freight forwarders in the world are; DHL Supply Chain and Global Forwarding, Kuehne + Nagel, DB Schenker, DSV, Sinotrans, Nippon Express, Hellmann Worldwide Logistics, CEVA Logistics, UPS Supply Chain Solutions, and Expeditors, etc. However, nowadays, freight forwarders are providing a full range of services which are; booking of containers, tracking of in-transit cargo, preparation of import/export documents, arranging warehouse services, negotiating freight rates on behalf of importers/exporters, custom clearance documentation, and cargo insurance. A freight forwarder does not move cargo by itself but works as an intermediary between shippers and transport companies. A freight forwarder is a prominent actor in the maritime supply chains of containerized freight.

There are many freight forwarders in the world that own a fleet of trucks and also started taking slots on freight trains. In India, a good number of freight forwarders have also taken the license of Custom House Agents (CHAs), and therefore, this provides customers with forwarding and custom clearance services under one roof. However, due to a shortage of funds and international collaborations, only a handful of companies are fully-fledged freight forwarders. Freight forwarders

work for liner shipping companies as they bring their clients' cargo to transport (Tongzon, 2009; Krajewska and Kopfer, 2006). The primary role of freight forwarders is to ease up the pressure from liner shipping companies and make sure the way is smooth for freight right from the seller's premises to the buyer's location. Although in a developing country like India where the transport infrastructure is not so strong, the freight forwarders have to deal with congestion on roads and railways, limited resources, fewer safety measures followed, and long delays at times (Sánchez et al., 2003).

Federation of Freight Forwarder's Associations in India (FFFAI) is an independent association and the solitary representative of the 28 member associations from India which represents 6,500 customs brokers (employing more than 110,000 people) (fffai.org). The primary objectives of the FFFAI are promoting its interests, coordinating member CHAs, involvement in conferences, help members with their problems, maintaining quality standards of the services, and evolving a code of ethics for CHAs.

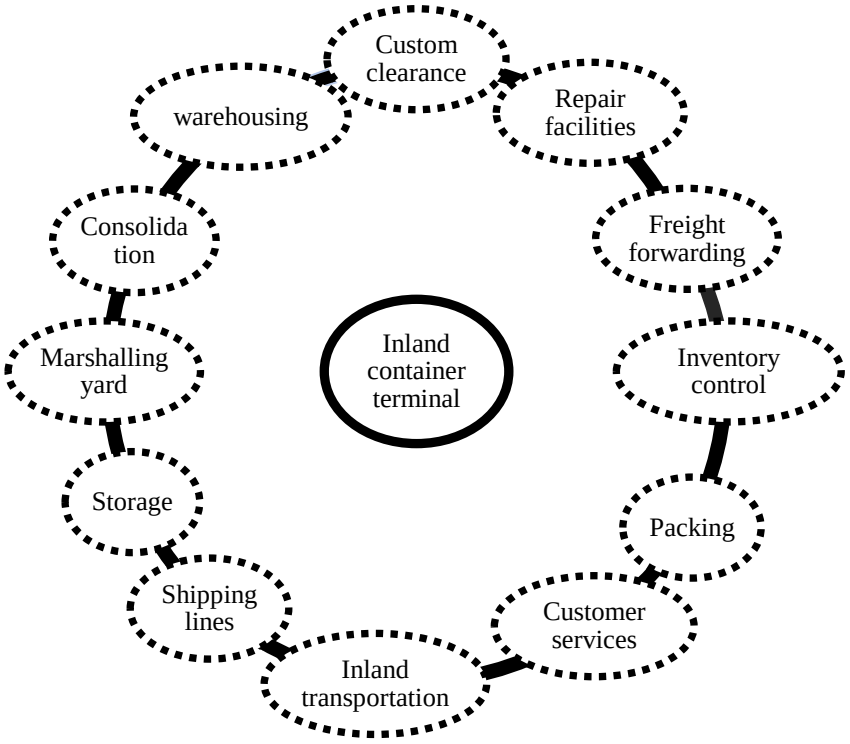
4.4.4 Inland Container Depot (ICD) and Container Freight Station (CFS)

Inland transportation has undergone a conceptual transformation that includes technological innovations, organizational, process, and numerous structural changes. One such development seen in the maritime supply chain domain over the years is the concept of inland container port or also called dry port (Banomyong and Beresford, 2001). Inland ports have affected trade flows, basically, they have added more capacity to the ports and are connected with seaports through railways or roadways. Container Freight Station (CFS) is almost similar to an ICD, having situated either at the port or in the vicinity of the port and connected to port through roadways, is the only nature which differs a CFS from ICD. Dry ports are least talked about in the maritime sector, yet a handful of researchers have attempted to study their development and future prospects. Having a huge landmass, where production arrangements are put up in deep hinterland, hence the choice of dry port makes a huge difference in logistics

network says Heaver (2002). Despite having a good network of dry ports and transport hubs, the wrong/right choice of shippers impacts the complete supply chain system which will further have an impact on operations (Hayuth and Fleming, 1994). Western or developed countries have undergone a number of analytical studies in order to increase efficiency in the supply chain but in developing countries like India, only descriptive studies are done.

There is a wide range of functions of an inland container port is identified such as cargo sorting, packing, stuffing, and de-stuffing center (Rodrigue et al., 2010). The presence of customs makes an inland port a point of customs clearance. It can also serve the purpose of warehouse, storage yard, or repairing point for damaged containers. Inland ports are mostly located close to an industrial corridor or Special Economic Zones (SEZs) and connected to seaports through roadways and railways (Wiegmans et al., 2015). As per the Ministry of Commerce (Government of India), there are around 300 dry ports in India that are either functional or under implementation phase at present. A diagram of functions of an Inland container terminal suggested by Hayut (1980) is drawn below;

Figure 4.3 This diagram illustrates the functions of an inland container depot



Source: Hayut (1980)

4.5 Development and management of hinterland transport network in India

Three major hinterlands in India are Northwest India (Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Punjab, Western Uttar Pradesh, Delhi/NCR, Haryana, Rajasthan, and Western Madhya Pradesh), Western India (Includes Gujarat and Maharashtra), and Southern clusters (Tamil Nadu and Karnataka) – account for roughly 90% of container volumes. Out of three major hinterlands, the Northwest hinterland is situated farthest from the coastline and generates around 35-40% of total throughput, followed by the Western cluster generating 23-28% of the cargo. The Gujarat and Maharashtra coastline comprises ports like Mundra, Pipavav, Kandla, and Jawaharlal Nehru Port (JNPT), respectively, that handles approximately 70% of India's EXIM traffic (as discussed earlier). While on the East coast Chennai port handles about 14%. Because of infrastructural barriers,

diversion from International maritime trade routes, and few other factors, about 78% of the container traffic from the east coast ports is moved through transshipment facilities via ports like Colombo, Singapore, and Jebel Ali. One another but an important factor for the slow movement of cargo is that the average distance between hinterland and ports in India is 700-800 km compared to 150-300 km in China. Even though India offers a lesser cost for transporting per unit cargo for a distance of one km but longer distances between hinterland and ports lead to higher costs for Inland transportation of a container in India to that of China. The inland networks are developing and regions like North-East India still need to be connected fully so that can also take part actively in trade-related activities.

4.5.1 Railways and Roadways

The railway is one of the prime modes of transporting freight from the hinterland to ports and vice-versa. There is a number of ICDs/CFSs in the country which are connected to ports through rail and roadways. But in the past decade, a surge in rail haulage, unreliable timetables of freight rakes, poor last-mile connectivity, and no technology change in railways has become a big factor for facilitating a shift towards roads results in raising its share. The running of passenger and freight trains on the same tracks has made the railways unviable for most of the transportation routes. Although, the present government has put its vision into a mission to increase the share of railways in the movement of containerized freight, cut logistics cost which is around 16% of the GDP, which they want to bring less than 10%. As anticipated, Increase the modal share of railways from the current 18% to 25% will save India $1 billion in logistics cost every year. The situation is such that it takes about 33 days to export a container from India on some international routes, while just 25 days from China. At present, rail freight in India is feasible for exporters and importers only when the distance between seaport and shippers' premises is about 1,000-1,300 km or above. With this, the Northwest hinterland which is the primary hinterland for containerized cargo, rail freight becomes a vital mode of transportation. However, the difference in cost of rail and

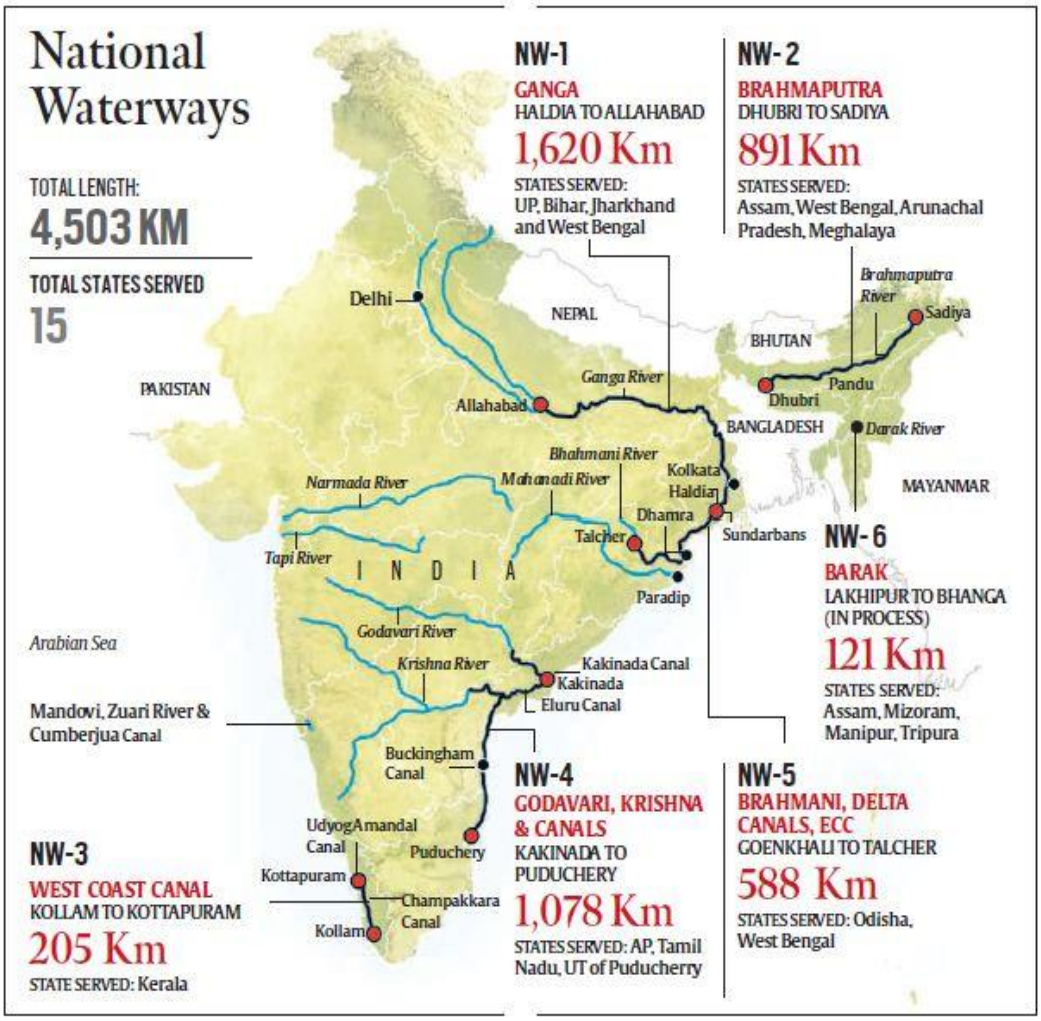
road remains much or less the same even beyond a distance of 1,000-1,300 km. As a result, only about 38% of the total volume from this region is transported by rail.

4.5.2 Inland Waterways (IWs)

Apart from rail and roadways, India has a substantial network of around 14,500 km of inland water bodies, consisting of rivers, lakes, canals, and backwaters, etc., among others. The six inland national waterways can potentially provide reliable, sustainable, and cheaper connectivity across rural, towns and cities. The inland national waterways of India are listed below:

- National Waterway 1 (NW1) from Haldia to Allahabad on Ganges-Bhagirathi-Hooghly river System
- National Waterway 2 (NW2) from Dhubri to Sadiya stretch of Brahmaputra River
- National Waterway 3 (NW3) from Kollam to Kottapuram on Champakara and Udyogamandal Canal
- National Waterway 4 (NW4) from Kakinada to Puducherry
- National Waterway 5 (NW5) from Goenkhali to Talcher on Brahmani River
- National Waterway 6 (NW6) from Lakhipur to Bhanga on Barak River (Proposed)

Figure 4.4 Inland waterways (IWs) network in India



Source: https://sandrp.in/2016/02/19/digging-our-rivers-graves/

Although these waterways have not yet been developed completely for commercial application, they provide tremendous scope for economic growth and trade facilitation. For instance, National Waterway 2 of 890 km from Sadia to Dhubri (on the Brahmaputra River) is just one meter deep in some areas. The area can be dredged and used for transporting raw material for construction projects since rail connectivity is poor in the region, also transporting packed tea from Assam to nearer seaports. The government could look into the network of Europe

that connects hundreds of cities and industrial regions through 37,000 km of waterways. On top of the six Inland National Waterways, the union government has decided to declare 101 inland waterways as national waterways for facilitating maritime transport to inland locations.

4.6 Barriers in the maritime supply chains of containerized freight

With globalization, international trade is increasing rapidly, and in all this, the maritime supply chains are playing an indispensable role in transporting containerized freight from various origins to the destinations in less time and cost. This creates value among various actors like shipping lines, freights forwarders, shippers and manufacturers. Lai et al. (2019) have explained very well how various tasks/actions in the maritime and inland transportation of containerized freight joints together to be called Maritime Supply Chains (MSCs). A maritime supply chain is defined as integration among different activities which are performed by various actors such as; shipping lines, port terminal operators, freight forwarders, and land-based logistics system. Maritime supply chains consist of series of activities and a number of actors; therefore, it needs proper planning, systematic coordination, and precise execution in transporting containerized freight from origin-to-destination (Lam, 2015). The concept of the maritime supply chain (or MSC) is gaining momentum due to growing concerns like business sustainability, intense global competition, costs, and profitability issues. Lam and Bai (2016) and Vilko et al. (2019) suggested that actors in the modern-day, maritime supply chains are interdependent and in this aggressive competitive environment they have to stay ahead in fulfilling the requirements of the shippers, which often increases the vulnerability of the maritime supply chains. If the flow of cargo is affected by any type of barrier, then the performance of the entire maritime supply chain will be imperiled, in terms of profitability, productivity, costs, and efficiency (Lam and Bai, 2016). Not just this, the presence of barriers in the Maritime supply chains inhibits technology, knowledge, process, and managerial upgrade (Luthra et al., 2016). The existence

of barriers makes the sector unattractive for foreign investors e.g., India has lost the confidence of foreign players despite potential in the maritime supply chain sector. Considering India, Venkatesh et al. (2017) and Kamble et al. (2019) pointed out barriers in the maritime domain, whereas, Mudgal et al. (2010) and Roy et al. (2016) explained how barriers are hindering the growth and development of the freight transport industry in India. So far, some studies exist on barriers in the maritime and inland transportation of freight, for instance, Yuen and Thai (2017), Chen et al. (2019), and Zhang and Lam (2019) but don't specifically address the barriers in the entire maritime supply chains of containerized freight in India and that became an inspiration to conduct this study.

The intention of current research is to discern and appraise barriers followed by identification and ranking the strategies to overcome these barriers. Ranking of these strategies is necessary so that actors in the maritime supply chains can execute them (based on the priority order) to overcome the barriers causing inefficiencies and unproductiveness in the maritime supply chains. Strategies applied to lessen or neutralize the impact of barriers will help the actors to achieve business success in terms of monetary profit and increased cliental etc. This research is persuaded by a noteworthy issue detected in the industry: despite huge potential, maritime supply chains of containerized freight have confronted numerous man-made and natural barriers (internal and external both) to its growth and development. Also, no integrated study is conducted till now that not just identifies barriers but also develops strategies to neutralize the impact of these barriers, and this is how current research aims to fill this research gap. Barriers in the maritime logistics sector are not a problem of a specific region but even the developed continents like Europe are troubled studied by Barnett et al. (2006) and Grossmann et al. (2007). The success of maritime logistics is hindered in North America as well (Perakis and Denisis, 2008 and Brooks and Frost, 2004). Adding on, these sorts of studies have contributed immensely towards the development of maritime supply chains in the Western economies. These studies contribute a deep understanding of barriers in the maritime logistics domain but none of them

identifies barriers in the maritime supply chains in context to India. Evidently, there is a notable gap in the existing literature as available studies do not address the problem of barriers specifically in the maritime supply chains of containerized freight in India and also no barriers and solution study has implemented methodological framework, which is why, this study is so valid, unique, urgent and essential to perform.

4.7 Chapter summary

This chapter has drawn attention to the development of the maritime supply chains of containerized freight in India. Also, a brief discussion on actors and stakeholders with emphasis on containerized freight is done. Along with various factors affecting the development of maritime supply chains, this chapter also discussed the current status of maritime supply chains. The next chapter identifies and evaluates the barriers in the maritime supply chains of containerized freight.

Chapter 5

Evaluation of barriers in the maritime supply chains of containerized freight

Overview

This chapter aims to cover the identification, finalization, and prioritization of the barriers in the maritime supply chains (or MSCs) of containerized freight in India. The categories and sub-categories of the barriers are discerned by conducting both primary and secondary research. Existing literature is reviewed thoroughly and domain experts are interviewed in order to understand barriers and their impact on the maritime supply chains. Additionally, how these barriers interact with each other is also comprehended. Thereafter, the Fuzzy Analytic Hierarchy Process (or FAHP) method is espoused and the steps are elucidated to exhibit how it leads to calculating the final ranks of the critical barriers.

5.1 Introduction

The concept of maritime supply chains is evolving with an increase in containerized freight traffic in India. For instance, Indian ports are all set to handle 18 million TEUs of containerized freight in 2020, which is 50% higher than what ports handled in 2015. To support such rapid growth, we need efficient and productive maritime supply chains. Although, the government is working aggressively towards the development of ports and inland freight transport systems the presence of critical barriers has led to obstructions in the development and management of the maritime supply chains.

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Actors and stakeholders (including the government) in the maritime supply chain sector need to be aware of those key barriers to ensure that they do not impact their business and the entire maritime supply chain sector as well. In order to comprehend the nature and impact of all the possible barriers, it is important to discern them by performing primary and secondary research. The next stage for actors and stakeholders would be to know the criticality level of each category and sub-category of the barrier. Once the key barriers are understood, the next step is to overcome/subjugate the impact of these barriers by identifying and implementing relevant strategies – which is demonstrated in chapter 6. The current chapter is based on the first objective which is mentioned below;

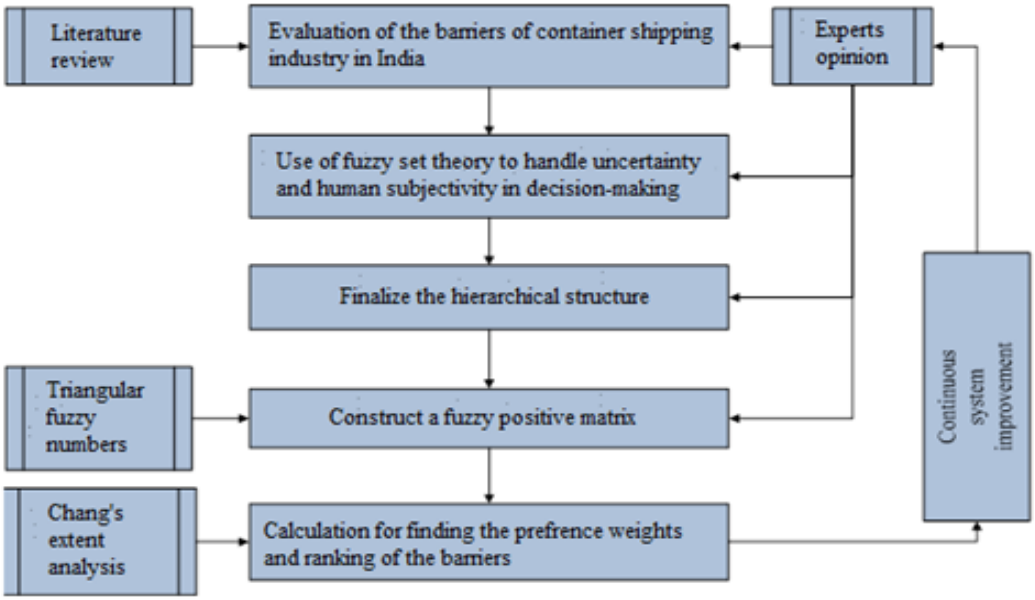
Objective 1: To discern and evaluate barriers that impact the maritime supply chains of containerized freight in India.

In order to achieve the above objective, a model for discerning and prioritizing critical barriers impacting the smooth working of the maritime supply chains is developed. The categories and sub-categories of the inhibitors are ranked on the basis of how critical they are. Also, to identify these categories and sub-categories of the inhibitors, a wide range of relevant domain experts are chosen and taken feedback from.

Ranking of the barriers is done by employing FAHP or Fuzzy Analytic Hierarchy Process methodology. This method falls under multi-criteria decision making (MCDM) or multiple-criteria decision analysis (MCDA), is a sub-area of operations research that clearly assesses diversified conflicting criteria in decision making, which helps in calculating the preference weights and then ranks of the categories and sub-categories of the constraints. This can be accomplished through pairwise comparison taking into consideration both qualitative and quantitative characteristics. To calculate the ranking, the Fuzzy AHP method is preferred, as it does not permit unreliability and fuzziness while taking decision, and is more appropriate in practical applications.

5.2 Proposed Framework

Figure 5.1 Proposed framework



Source: Author's composition

5.3 Identification of barriers in the maritime supply chains of containerized freight

The categories and sub-categories of the barriers, which influence/impact the operations and management of the maritime supply chains have been gathered from existing studies and relevant feedback from domain experts. The list of categories and sub-categories of barriers are illustrated in Table 5.1. The discerned barriers are classified into six types; Economic Barriers (ECBs), Infrastructural Barriers (IFBs), Legal Barriers (LGBs), Technological Barriers (TEBs), Administrative and Political Barriers (ADPBs), and Organizational Barriers (OGBs). Each of these above-mentioned types of constraints has a list of sub-categories which are briefly argued below:

5.3.1 Economic Barriers (ECBs)

Some of the prominent economic barriers are stringent acts causing entry barriers, costs affiliated with the wider regulatory framework, huge capital required for establishing and expanding the business, and inflated tonnage tax (Prahalathan and Vijay, 2010 and Van Der Horst and Langen, 2008). A study carried out by Yuen and Thai (2017) is the only possible research exist which talks specifically about barriers in integration among various activities in the maritime supply chain sector. Similarly, Milios et al. (2019) mentioned how economic affairs impact the maritime sector in the Scandinavian region. Port tariffs in India are uncompetitive and are well higher than what rival ports are charging found Masood et al. (2016). In fact, Song (2002) winded up by saying that ports have to compete with rivals in the region and that's how they gain a competitive edge over them. Moving on, Indian railways (IR) pursues a policy of subsidizing passenger tariff and continuously soaring freight tariff – a move that has resulted in a reduction of freight transportation through rail (Grossmann et al., 2007; Ramachandran et al., 2015 and Van Der Horst and Langen, 2008). Some more studies performed on economic barriers are reviewed such as; Garg and Kashav (2019), Meherishi et al. (2019), Konstantinus et al. (2019), Zhang and Lam (2019), Venkatesh et al. (2017), and Luthra et al. (2017). Sub-categories of economic barriers are listed in detail in table 5.1.

5.3.2 Infrastructural Barriers (IFBs)

The foremost inhibitors and the most complex in nature are infrastructural barriers. A well-developed infrastructure in the maritime supply chains is a decisive factor in their overall performance (Christodoulou and Kappelin, 2020). Outdated infrastructure with obsolete mechanical handling facilities results in delays at ports creates congestion and increases turnaround time. The old fleet is yet another inhibitor in addition to poor infrastructure integration and management. Prahalathan and Vijay, 2010; Baindur and Viegas, 2011; Chen and Yu, 2016; Langen and Chouly, 2004; Fouda, 2012 and Tongzon and Lee, 2015). Similarly, Razzaque (1997) noticed substandard logistics infrastructure as the

foremost contributors to the infrastructural barriers. Craptastic road safety systems of the National Highways have plagued entire road transport systems (Masood et. al., 2016). Also, the draft at the majority of Indian ports is shallow and cannot accommodate bigger ships, dry port facilities for the movement of containers are deficient and the freight rail amenities are inadequate. Moreover, most of the freight rail terminals available for freight handling activities are outdated (Wilmsmeier et al., 2011; Ramachandran et al., 2015). Zhang and Lam (2019) debated on the inhibitors impeding the embracing of digital infrastructure in maritime organizations. Chen et al. (2019) applied the DEMATEL approach to model barriers (including infrastructural) inhibiting green port strategy. Likewise, Venkatesh et al. (2017) and Garg and Kashav (2019) conducted in-depth arguments on the infrastructural barriers. Some of the prominent and recently performed studies talks about infrastructural barriers in the maritime supply chain domain reviewed in-depth are; Khan et al. (2019), Angelstam et al. (2017), Iacovidou and Purnell (2016), Jia et al. (2018), Majumdar and Sinha (2019), Govindan and Hasanagic (2018), Govindan and Bouzon (2018) and Owusu et al. (2020). Sub-categories of infrastructural barriers are listed in detail in table 5.1.

5.3.3 Legal Barriers (LGBs)

Legal barriers are equally important as other themes of barriers, and that is why Banomyong (2005) explained the significance of legalities in the maritime domain. There is a number of well-disciplined stakeholders in the maritime supply chain sector but still, there is room for legal barriers/disputes to arise (Chan et al., 2018). As mentioned by Ringsberg and Cole (2020), actors have legal obligations on them while serving the clients. Likewise, Karlis (2018) argued on legal barriers in the maritime domain. A type of legal barrier is high tariff charged by ports which may defunct port owner/operators' business says de Sousa et al. (2021). Some ingredients in the port tariff are charges related to hiring berths, pilotage service charges, charges related to cargo handling, and some other assorted charges, which are when high then the port service users look for alternatives (Bandara and Nguyen, 2016; Gumede and Chasomeris, 2018 and Prahalathan and Vijay, 2010).

Chen et al. (2019) talked about legal issues related to the payment of taxes and invoices against berthed ships. In developing countries, transporting freight through roads has always been a matter of concern as the trailers carrying containers are often in penurious condition, egregiously loaded than allowed, exceeding economic life thus polluting the environment and prone to accidents (Engström, 2016; Behiri et al., 2018; Yu et al., 2017; Joanna and Monika, 2016). Despite interest and capability, many countries do not permit high-sea carriers (foreign-owned shipping lines) to transport domestic freight and it certainly hampers logistics connectivity (Venkatesh et al., 2017; Baik and Park, 2002). Yet another legal barrier inhibiting the maritime supply chains is mentioned by Borchert at al. (2013) which is imposed limits on licenses, corruption, and discrimination while allocating the resources. Because of all the above Ansong et al. (2017) advocated having a proper legal framework so that issues can be resolved in their amateur stage only. Some more studies on legal barriers in context to maritime supply chains reviewed in-depth are; Majumdar and Sinha (2019), Hofmann et al. (2018), Kembro et al. (2017), Ikram et al. (2020), Beltagui et al. (2020), Delmonico et al. (2018), Luthra and Mangla (2018) and Gupta et al. (2020). Sub-categories of legal barriers are listed in detail in table 5.1.

5.3.4 Technological Barriers (TEBs)

Technological barriers are a modern-day problem for many sectors especially for actors in the maritime supply chains. Not going tandem with technological changes may lead to the extinction of business or turns a firm unproductive and non-profitable. For instance, Zhang and Lam (2019) enlightened on how barriers inhibiting the adoption process of big data analytics. Zeng et al. (2020) inadequate technological integration and lack of technological readiness may lead an actor in the maritime supply chain to extinct. This research discerned technological barriers, for instance, scarcity of modern-day freight handling equipments at ports, inadequate technological infrastructure, and scant security systems at ports (Prahalathan and Vijay, 2010; Chandra and Jain, 2007; Chandrasekaran and Kumar, 2005). Razzaque (1996), Chen et al. (2015), Büyüközka and Göçer

(2018), and MacCarthy et al. (2016) said that the foremost reason for modest growth is the sluggish implementation of digitalization in the maritime supply chains. Merchan et al. (2019), Liang et al. (2016), Visser (2018), and Burl (2019) stated that obsolete technology is no doubt the foremost reason for inhibiting growth and development in freight transport through rail and roads. Similarly, technology in the inland waterways has moved sluggishly (Prussi et al., 2019; ImranUddin et al., 2017; Peeters et al., 2020; Barnes, 2019). Take an example of Asian countries where the container-carrying trailers travel at an average speed of 40-50 kmph, which is quite lesser than in Europe (Masood et al., 2016). Post-independence, nothing significant was added to the existing freight rail technology and the basic problems remained the same to the present day (Ramachandran et al., 2015). Some more noteworthy studies performed on technological barriers are; Kumar and Kansara (2018), Kouhizadeh et al. (2021), Gupta et al. (2020), Kamilaris et al. (2019), Raj et al. (2020), and Wang et al. (2016). Sub-categories of technological barriers are listed in detail in table 5.1.

5.3.5 Administrative and Political Barriers (ADPBs)

Some of the prominent ADPBs are recurrent changes of the government of a country, often leading to government officials not grasping the economic situation of the country, mainly the reform needs in multiple sectors. Shi et al. (2019) pointed out lack of administrative measures as one of the foremost barriers under ADPBs. Likewise, Shah and Ikram (2019) ranked political barriers as censorious among all. A recent study performed by Jiang et al. (2017) mentioned that maritime supply chains are inhibited because political uncertainties are rising. Many of the policymakers and strategists in government are either from civil services or defense forces who follow the orthodox way of controlling and managing work and this holds back the growth and development of maritime supply chains. This is one major reason why Ministry of Shipping-owned projects have tasted little success says Venkatesh et al. (2017). However, the situation is totally different in Europe and other developed economies where government-owned projects are efficient (Milios et al., 2019). Political uncertainty, absence of

stability in government policies, and resource constraints in the country have been sorted as common issues, which is learned from the Maritime Silk Road Initiative (Blanchard, 2017; Blanchard, 2018; Razzaque, 1996). Hastig and Sodhi (2020) and Chan et al. (2019) also talked about political instability as a hurdle in accomplishing maritime supply chain-related projects. Pakistan alleges the Indian government of promoting terrorism, an allegation that could tarnish India's image in the international market in addition to creating an anti-trade environment (Masood et. al., 2016). Some more noteworthy barriers related to political and administrative set up are regulatory complexities, corruption, lack of eagerness and understanding, unavoidable delays in customs procedure and licensing impact the entire maritime supply chain domain considerably (Stough, 2005). Sub-categories of administrative and political barriers are listed in detail in table 5.1.

5.3.6 Organizational Barriers (OGBs)

In growing countries like India, there is a scarcity of qualified managerial personnel and skilled labor which inhibits the growth and development of maritime supply chains (Ferreira et al., 2018; Duin and Thoben, 2019; Yuen and Thai, 2017; Razzaque, 1996). The major barrier among actors in the maritime supply chain (especially seaports) is the lack of formal organizational structure. In case the organizational structure exists then it is imperfectly expounded (Notteboom, 2007 and Thomas, 1994). At present, the overall organizational structure of the actors in the maritime supply chains must be amended and a proper channel of communication among stakeholders and actors must be established (Verhoeven, 2009; Wang and Slack, 2006; and Tongzon and Lee, 2015). Also, Suarez-Aleman and Hernandez (2014) advocated fulfilment of organizational demands for improving maritime supply chains. Sub-categories of organizational barriers are listed in detail in table 5.1.

5.4 Categories and sub-categories of barriers in the maritime supply chains of containerized freight

Table 5.1 This table illustrates discerned categories and sub-categories of the barriers.

Category	Category code	Sub-category	References
Economic Barriers (ECBs)	ECB1	Lack of FDIs and other investments in the maritime supply chain sector	Pittman et al. (2020), Kurosaki and Singh (2016), Park et al. (2016), Carrara and Longden (2017) and Ruan et al. (2019)
	ECB2	Barriers to entry and expansion in the maritime supply chain business	
	ECB3	High and frequent increments in rail haulage charges	
	ECB4	Higher hinterland transport cost	
	ECB5	High port tariffs compared to rivals	
	ECB6	Slow growth of cargo generating sectors	
Infrastructural Barriers (IFBs)	IFB1	Insufficient area at seaports	Dawda et al. (2019), Kumar et al. (2020), Repetto et al. (2017), Kumar and Anbanandam (2020) and Dadsena et al. (2019)
	IFB2	Lack of infrastructural integration (in context to the maritime supply chains) with neighboring countries and regions	
	IFB3	Lack of availability and quality of road infrastructure for freight transportation	
	IFB4	Lack of availability and quality of inland waterways infrastructure	
	IFB5	Lack of availability and quality of rail infrastructure for freight transportation	
	IFB6	Poor quality infrastructure of warehouses and cargo storage yards' in the hinterland	
	IFB7	Lack of availability and quality of the maritime supply chain infrastructure in the North East region of India	
	IFB8	Lack of availability and quality of port-to-port freight transportation infrastructure	
	IFB9	Lack of land-side and water-front infrastructure at ports	
	IFB10	Lack of availability and quality of ICD/CFS infrastructure	
	IFB11	Lack of dedicated transshipment and feeder port infrastructure	

Technological Barriers (TEBs)	TEB1	Obsolete freight rail technology	Yadav et al. (2020), Kumar and Kansara (2018), Chauhan et al. (2021), Singh et al. (2019), Rajput and Singh (2019), Masood et al. (2016) and Moktadir et al. (2019)
	TEB2	Lack of seaport modernization in terms of technology	
	TEB3	Slow pace of digitization/Computerization in the maritime supply chains	
	TEB4	Poor technology in the inland waterways network	
	TEB5	Insufficient and outdated technology in the warehouses, ICDs/CFSs and other container depots.	
	TEB6	Poor technology road trailers lead to slow speed and inefficiency	
Administrative and Political Barriers (ADPBs)	ADPB1	Terrorism	Praharaj et al. (2018), Kumar et al. (2015), Rauer and Kaufmann (2015), Farooque et al. (2019), Waterman (2017) and Bienhaus and Haddud (2018)
	ADPB2	Disagreement between central and state government on the maritime supply chain projects	
	ADPB3	No relevant government policies to cover each activity in the maritime supply chain	
	ADPB4	Conflicts with neighboring countries impede growth of the maritime supply chain network	
	ADPB5	Abuse of bureaucratic powers	
	ADPB6	Lack of administrative and political knowledge	
	ADPB7	Unstable government state or central government	
	ADPB8	Corruption	
	ADPB9	Lack of passion to develop the maritime supply chains among actors, governments and bureaucrats	
Legal Barriers (LGBs)	LGB1	Lack of transparency in the entire legal process	Kumar and Anbanandam (2020), Venkatesh et al. (2017), Majumdar and Sinha (2019), Malik and Tiwari (2017) and Masood et al. (2016)
	LGB2	Unsupportive laws, regulations and government policies for the actors in the maritime supply chains	
	LGB3	Discrimination and delay in approvals and allocation of projects and resources	
	LGB4	Lengthy legal process in India	
	LGB5	Seaport operators charged with fines/penalties for various reasons is demotivating private investments	
	LGB6	Corruption and bribery culture right from document approvals to getting mega port projects	
	LGB7	No strict freight transport pollution related laws and regulations, impact on air and water quality because of the maritime supply chains activities	

Organizational Barriers (OGBs)	OGB1	Lack of safety measures followed in the maritime supply chains	Kumar and Anbanandam (2020), Venkatesh et al. (2017), Kamble et al. (2019), Suarez-Aleman and Hernandez, (2014) and Tongzon and Lee (2015)
	OGB2	Lack of qualified managerial personnel	
	OGB3	Labor strikes and unskilled labor	
	OGB4	Lack of managerial and operational integration in the maritime supply chains	
	OGB5	Unavailability of labor due to migration (as a result of pandemics, low wages/salaries, poor facilities etc.)	
	OGB6	Lack of dialogue among actors in the maritime supply chains	
	OGB7	Lack of formal organizational structure	

Source: Author's composition

5.4.1 Stage 1 - Application of Fuzzy AHP Methodology

The AHP procedure was instigated by Satty (1980), is an empirical arrangement of decision making where there is multi-criteria. The practice of AHP has some complications as it is often employed in friable circumstances, the measurement scale is not balanced, its subjective character and impreciseness. This entails a Fuzzy situation to respond to the issues (Prakash & Barua, 2015; 2017).

In the FAHP set-up, there exists error and poor lucidity in determining linguistic variables. This unpredictability can be subjugated through Fuzzy methodology. In fact, the so-called fuzzy triangular numerals (TFNs) are recurrently utilized (refer Table 5.2).

Table 5.2 Matrix of TFNs

Linguistic variables	Assigned TFN
Equally	(1, 1, 1)
Very Lower	(1, 2, 3)
Lower	(2, 3, 4)
Medium	(3, 4, 5)
Higher	(4, 5, 6)
Very Higher	(5, 6, 7)
Excellent	(7, 8, 9)

Source: Garg and Kashav (2019)

Chang (1992) method:

Definition 1 If $\tilde{N}_1 = (p_1, q_1, r_1)$ and $\tilde{N}_2 = (p_2, q_2, r_2)$ are representing two TFNs then algebraic operations can be stated as follows-

$\tilde{N}_1 \oplus \tilde{N}_2 = (p_1, q_1, r_1) \oplus (p_2, q_2, r_2) = (p_1 + p_2,\ q_1 + q_2, r_1 + r_2)$ ..... (1.1)

$\tilde{N}_1 \ominus \tilde{N}_2 = (p_1, q_1, r_1) \ominus (p_2, q_2, r_2) = (p_1 - p_2,\ q_1 - q_2, r_1 - r_2)$ ..... (1.2)

$\tilde{N}_1 \otimes \tilde{N}_2 = (p_1, q_1, r_1) \otimes (p_2, q_2, r_2) = (p_1 p_2,\ q_1 q_2, r_1 r_2)$ ..... (1.3)

$\tilde{N}_1 \oslash \tilde{N}_2 = (p_1, q_1, r_1) \oslash (p_2, q_2, r_2) = (p_1/p_2,\ q_1/q_2, r_1/r_2)$ ..... (1.4)

$\alpha \otimes \tilde{N}_1 = (\alpha p_1, \alpha q_1, \alpha r_1)$ where $\alpha > 0$ ..... (1.5)

$\tilde{N}_1^{-1} = (p_1, q_1, r_1)^{-1} = \left(\frac{1}{r_1}, \frac{1}{q_1}, \frac{1}{p_1}\right)$ ..... (1.6)

To apply the Fuzzy analytical hierarchical process according to the method of Chang's (1992) extent analysis used. Steps are given below-

$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3 \ldots \ldots, M_{g_i}^m$ Where g_i is the goal set (i = 1, 2, 3, 4, 5 .....n) and all the $M_{g_i}^j$ (j = 1, 2, 3, 4, 5 ....., m) are TFNs given in Table 5.2.

Step 1: Determine S_i (Fuzzy synthetic extent value) w.r.to the i^{th} criterion

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \quad \ldots\ldots\ldots\ldots (1.7)$$

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} p_{ij}, \sum_{j=1}^{m} q_{ij}, \sum_{j=1}^{m} r_{ij}\right)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} r_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} q_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{ij}}\right)$$

Where p is the lower limit value, q is the most promising value and r is the upper limit value.

Step 2: The degree of possibility of

$S_2 = (p_2, q_2, r_2) \geq S_1 = (p_1, q_1, r_1)$ is defined as below

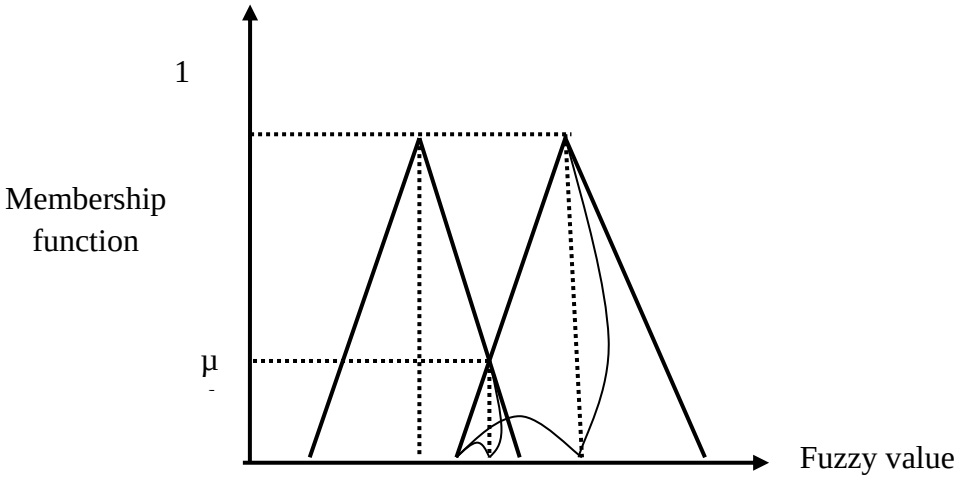
$V(S_2 \geq S_1) = \sup_{y \geq x} [\min(\mu_{S_1}(x), \mu_{S_2}(y))]$

and x and y are membership values and can be written as given in equation 1.8 below:

$$V(S_2 \geq S_1) = \begin{cases} 1 & \text{if } b_2 \geq b_1 \\ 0 & \text{if } a_1 \geq c_2 \\ \dfrac{p_1 - r_2}{(q_2 - r_2) - (q_1 - p_1)} = \mu d, & \text{otherwise} \end{cases} \quad \ldots\ldots\ldots (1.8)$$

Where μd is the maximum membership point μ_{S_1} and μ_{S_2} (refer Figure 5.2)

Figure 5.2 Fuzzy numbers' intersection



Source: Author's composition

To compare S1 and S2 we need both V(S1 ≥ S2) and V(S2 ≥ S1).

Step 3: The degree of possibility for a convex Fuzzy number S to be greater than k convex Fuzzy numbers Si (i= 1,2,.....,k) can be defined by

V (S≥S1,S2,.....,Sk)

= V [(S≥S1) and (S≥S2) and .....and (S≥Sk)]

= minV (S≥Si), i= 1,2,.....,k

Assume that d′(Ai) = min V(Si≥ Sk) ……...(1.9)

For k = 1, 2, …, n, k ≠ i, Than the weight vectors are given in equation 1.10 as,

W'= (d'(A1), d'(A2),.....,d'(Am))T ……..….(1.10)

Step 4: Finally, normalized weight vectors are known in equation 1.11 as,

W= (d (A1), d (A2),.....,d (Am))T …… (1.11)

5.4.2 Stage 2 - Determination of barriers' weights

The decision team has assigned a rating to the specific barriers' categories and their sub-categories. An expert panel has allocated the Fuzzy score to each approach using the scale given in table 5.2 as highlighted in table 5.3. The Fuzzy score matrix of the specific barriers group and their sub-groups, along with weight value, are highlighted in table 5.4-5.9. In order to obtain priority weights, Chang's extent analysis is exercised in the research methodology. The results of the specific barriers group and their sub-groups are offered in table 5.10.

Table 5.3 Ranking of the barriers

	ECB	IFB	LGB	TEB	ADPB	OGB	Weights	Rank
ECB	(1, 1, 1)	(2, 3, 4)	(3, 4, 5)	(0.33, 0.5, 1)	(0.2, 0.25,0.33)	(0.25, 0.33, 05)	0.1620	4
IFB	(0.25, 0.33, 05)	(1, 1, 1)	(0.33, 0.5, 1)	(2, 3, 4)	(2, 3, 4)	(3, 4, 5)	0.2053	1
TEB	(1, 2, 3)	(0.25, 0.33, 05)	(0.33, 0.5, 1)	(1, 1, 1)	(0.25, 0.33, 05)	(3, 4, 5)	0.1758	3
ADPB	(3, 4, 5)	(0.25, 0.33, 05)	(0.2, 0.25, 0.33)	(2, 3, 4)	(1, 1, 1)	(1, 2, 3)	0.1464	5
LGB	(0.2, 0.25, 0.33)	(1, 2, 3)	(1, 1, 1)	(1, 2, 3)	(3, 4, 5)	(0.33, 0.5, 1)	0.1875	2
OGB	(2, 3, 4)	(0.2, 0.25, 0.33)	(1, 2, 3)	(0.2, 0.25, 0.33)	(0.33, 0.5, 1)	(1, 1, 1)	0.1230	6

Source: Author's composition

Table 5.4 Economic barriers' ranking

Barriers	Preference weights	Ranking
ECB1	0.1506	5
ECB2	0.2145	1
ECB3	0.1727	2
ECB4	0.1628	3
ECB5	0.1522	4
ECB6	0.1472	6

Source: Author's composition

Table 5.5 Infrastructural barriers' ranking

Barriers	Preference weights	Ranking
IFB1	0.0762	11
IFB2	0.0780	10
IFB3	0.0920	5
IFB4	0.0849	6
IFB5	0.0969	3
IFB6	0.0834	8
IFB7	0.0818	9
IFB8	0.0969	4
IFB9	0.1021	2
IFB10	0.0849	7
IFB11	0.1230	1

Source: Author's composition

Table 5.6 Technological barriers' ranking

Barriers	Preference weights	Ranking
TEB1	0.1620	4
TEB2	0.2053	1
TEB3	0.1758	3
TEB4	0.1464	5
TEB5	0.1875	2
TEB6	0.1230	6

Source: Author's composition

Table 5.7 Administrative and policy barriers' ranking

Barriers	Preference weights	Ranking
ADPB1	0.0933	9
ADPB2	0.1034	7
ADPB3	0.1143	3
ADPB4	0.1237	2
ADPB5	0.1136	4
ADPB6	0.1068	6
ADPB7	0.1005	8
ADPB8	0.1360	1
ADPB9	0.1085	5

Source: Author's composition

Table 5.8 Legal barriers' ranking

Barriers	Preference weights	Ranking
LGB1	0.1564	2
LGB2	0.2104	1
LGB3	0.1335	5
LGB4	0.1247	6
LGB5	0.1470	3
LGB6	0.1454	4
LGB7	0.0826	7

Source: Author's composition

Table 5.9 Organizational barriers' ranking

Barriers	Preference weights	Ranking
OGB1	0.1567	2
OGB2	0.1919	1
OGB3	0.1347	5
OGB4	0.1269	6
OGB5	0.1475	4
OGB6	0.0873	7
OGB7	0.1551	3

Source: Author's composition

Table 5.10 Barriers' global ranking

Specific	Weights	Rank	Sub-barriers	Weights	Ranking	Global weights	Global ranking
ECBs	0.162	4	ECB1	0.1506	5	0.0244	16
			ECB2	0.2145	1	0.0347	3
			ECB3	0.1727	2	0.028	8
			ECB4	0.1628	3	0.0264	11
			ECB5	0.1522	4	0.0247	15
			ECB6	0.1472	6	0.0238	17
IFBs	0.2053	1	IFB1	0.0762	11	0.0156	39
			IFB2	0.078	10	0.016	37
			IFB3	0.092	5	0.0189	27
			IFB4	0.0849	6	0.0174	30
			IFB5	0.0969	3	0.0199	23
			IFB6	0.0834	8	0.0171	32
			IFB7	0.0818	9	0.0168	33
			IFB8	0.0969	4	0.0199	24
			IFB9	0.1021	2	0.021	21
			IFB10	0.0849	7	0.0174	31
			IFB11	0.123	1	0.0252	13
TEBs	0.1758	3	TEB1	0.162	4	0.0285	7
			TEB2	0.2053	1	0.0361	2
			TEB3	0.1758	3	0.0309	5
			TEB4	0.1464	5	0.0257	12
			TEB5	0.1875	2	0.033	4
			TEB6	0.123	6	0.0216	20
ADPBs	0.1464	5	ADPB1	0.0933	9	0.0137	45
			ADPB2	0.1034	7	0.0151	43
			ADPB3	0.1143	3	0.0167	34
			ADPB4	0.1237	2	0.0181	29
			ADPB5	0.1136	4	0.0166	35
			ADPB6	0.1068	6	0.0156	40
			ADPB7	0.1005	8	0.0147	44
			ADPB8	0.136	1	0.0199	22
			ADPB9	0.1085	5	0.0159	38
LGBs	0.1875	2	LGB1	0.1564	2	0.0293	6
			LGB2	0.2104	1	0.0394	1
			LGB3	0.1335	5	0.025	14
			LGB4	0.1247	6	0.0234	19
			LGB5	0.147	3	0.0276	9
			LGB6	0.1454	4	0.0273	10
			LGB7	0.0826	7	0.0155	42
OGBs	0.123	6	OGB1	0.1567	2	0.0193	25
			OGB2	0.1919	1	0.0236	18
			OGB3	0.1347	5	0.0166	36
			OGB4	0.1269	6	0.0156	41
			OGB5	0.1475	4	0.0181	28
			OGB6	0.0873	7	0.0107	46
			OGB7	0.1551	3	0.0191	26

Source: Author's composition

5.5 Analysis of results and discussions

The results in this study are derived by utilizing the Fuzzy AHP method under Fuzzy environment are demonstrated in Table 5.10. The final outcome constructs below arguments:

5.5.1 Rank of the Categories

The presence of critical barriers led to a number of business problems that are faced by the actors and stakeholders, for instance, shippers alone are losing $400 million every year. Therefore, to discern these barriers, this study took the help of the Delphi survey and available literature so that the categories and sub-categories of barriers can be unearthed. Thereafter, the Fuzzy AHP method was applied to those categories and sub-categories. The results specify that the infrastructural barriers (IFBs) category is critical most and the foremost reason in crippling of maritime supply chains of containerized freight. In terms of criticality, infrastructural barriers (IFBs) are followed by Legal Barriers (LGBs), Technological Barriers (TEBs), Economic Barriers (ECBs), Administrative and Political Barriers (ADPBs), and Organizational Barriers (OGBs).

Infrastructural barriers or IFBs are the critical most inhibitors in nature when it comes to smooth operations and management of the maritime supply chains of the containerized freight. In fact, most of the domain experts advocated the fact that IFBs should be given the first rank as there is a lack and absence of infrastructural facilities related to the maritime supply chains.

Legal Barriers (LGBs) and technological barriers (TEBs) are the next most significant barriers that inhibit the smooth working of the maritime supply chains by problems like unsupportive government policies, laws, and regulations, corruption, bribery, poor quality of equipments and cranes, and poor technology in the ICDs/CFSs. Economic barriers (ECBs) gained a fourth place and the broader economy and trade-related issues that hinder the smooth working of the maritime supply chains. Administrative and political barriers (ADPBs) and

organizational barriers (OGBs) possess the least influence on the maritime supply chains of containerized freight.

5.5.2 Rank of Individual factors in each category

The section discusses the ranks obtained by individual categories and sub-categories under them, which is as follows;

5.5.2a Infrastructural Barriers (IFBs)

The empirical analysis concludes infrastructural barriers to be the most severe/critical in maritime supply chains of containerized freight. IFBs are also argued by some profound studies like Chaudhary et al. (2017), Katiyar et al. (2017), Rahman et al. (2020), and Kamble et al. (2019). Under IFBs, there are 11 sub-criteria which are ranked as IFB11>IFB9>IFB5>IFB8>IFB3>IFB4>IFB10>IFB6>IFB7>IFB2>IFB1, where, IFB11 which is "Lack of dedicated transshipment and feeder port infrastructure" has obtained a preference weight of 0.1230 within the pool of 11 sub-categories of infrastructural barriers. Similarly, IFB11 obtained a preference weight of 0.0252 among 46 sub-categories of the barriers and ranked 13th most critical sub-category of the barriers. This indicates that IFB11 is the most critical and thus ranked one among IFBs. Contrary to IFB11, IFB1 which is "Insufficient area at seaports" has scored a preference weight of 0.0762 among IFBs, and therefore, it is the least critical in nature and has been ranked 11th, refer Table 5.10. Also, IFB1 obtained a preference weight of 0.0156 among 46 sub-categories of the barriers and ranked 39th most critical sub-category of the barriers. The prominence of IFB11 was also explained by one of the domain experts in the Delphi survey panel;

The problem of lack of transshipment hub and feeder port in India is widely realized and not new among domain experts, however, the government has failed to understand its importance. The establishment of a dedicated transshipment hub will not only save the immense cost of shippers but also will provide business to many actors in maritime supply chains. Also, having a dedicated transshipment hub will speed up the flow of cargo in maritime supply chains and will be highly

helpful in implementing the concept of JIT (Just in time). With the development of a transshipment hub port, socioeconomic development of coastal areas and communities will also boost. Therefore, the need of the hour is to develop a transshipment hub and feeder port in India.

In a study performed by Kavirathna et al. (2018), the transshipment hub seaport competitiveness of Port of Colombo was assessed and compared with transshipment hub ports in the Southeast Asia region. Port of Colombo is the most preferred transshipment hub port in the Southeast Asia region and which is why India-bound cargo is also offloaded at Port of Colombo and then further transhipped to Indian ports. Drewry Maritime Research estimates that 75% of transshipment cargo at Colombo is India bound. This means around 3.5 million TEUs of India's containerized cargo is handled by the Colombo port. The extra added cost is $80-100, or Rs 5,000-6,500, per TEU, and this wouldn't be paid if the container traffic is handled by Indian ports. An estimated $330 million of the extra cost paid by shippers in 2017-18. This can also be treated as an opportunity cost not earned by the Indian container ports and terminals. Not just this, Colombo accounts major chunk of India's transshipment volume which is 48%, whereas Singapore handles 22% and Malaysia's Port Klang 10% of India's international cargo, as per Drewry maritime research.

Going further, IFB9 which is 'Poor land-side and water-front infrastructure at ports' scored the second rank with a preference weight of 0.1021 among IFBs. Also, IFB1 obtained a preference weight of 0.0210 among 46 sub-categories of the barriers and ranked 21st most critical sub-category of the barriers. The ranking of IFB9 can be understood from the fact that many of the major seaports are underperforming and the foremost reason for this is inadequate and obsolete seaport infrastructure. For instance, land and waterfront infrastructure at seaports and equipments are outdated, incapable of continuous dredging operations, obsolete navigational aids and IT systems, outdated pilot and tug boats, and insufficient container yards are just some of the infrastructure-related issues which are faced by container seaports in India. Because of the above-mentioned

problems, foreign investors are hesitant about investing in the region. Thereafter, IFB5 which is 'Poor freight rail infrastructure' gained the third rank by scoring a preference weight of 0.0969 among IFBs. Also, IFB1 obtained a preference weight of 0.0199 among 46 sub-categories of the barriers and ranked 23rd most critical sub-category of the barriers. Why IFB5 ranked third because there are so many shortfalls if we look thoroughly at our freight rail network and, which is why the share of container traffic transported by railways to/from seaports has fallen drastically over years. Lack of dedicated tracks for freight railways, inadequate technology, lack of connectivity especially in the Northeast India region, and lack of foreign investment are some of the major reasons why freight rail infrastructure remained in a poor state. The essence of IFB9 and IFB5 is well argued by Hossain et al. (2020), Durán et al. (2018), and Wilmsmeier and Monios (2016). Likewise, IFB8 which is "Lack of availability and quality of port-to-port freight transportation infrastructure" has secured the fourth rank among IFBs by scoring a preference weight of 0.0969 in the pool of IFBs. Also, IFB8 obtained a preference weight of 0.0199 among 46 sub-categories of the barriers and this makes it the 24th most critical sub-category globally. Likewise, IFB3 which is "Lack of availability and quality of road infrastructure for freight transportation", IFB4 which is "Lack of availability and quality of inland waterways infrastructure", IFB10 which is "Lack of availability and quality of ICD/CFS infrastructure", IFB6 which is "Poor quality infrastructure of warehouses and cargo storage yards' in the hinterland", IFB7 which is "Lack of availability and quality of maritime supply chain infrastructure in the North East region of India" and IFB2 which is "Lack of infrastructural integration (in context to maritime supply chains) with neighboring countries and regions" obtained preference weights of 0.0920, 0.0849, 0.0849, 0.0834, 0.0818 and 0.0780 among IFBs and stood at fifth, sixth, seventh, eighth, ninth and tenth rank, respectively. Also, among 46 sub-categories of barriers, IFB3, IFB4, IFB10, IFB6, IFB7, and IFB2 obtained preference weights of 0.0189, 0.0174, 0.0174, 0.0171, 0.0168 and 0.0160 gained 27th, 30th, 31st, 32nd, 33^{rd,} and 37th rank, respectively.

5.5.2b Legal Barriers (LGBs)

Legal barriers (or LGBs) gained the second rank with a preference weight of 0.1875 among categories of the barriers. With this, LGBs are the second most critical/severe in nature after IFBs, which was also discussed by Majumdar and Sinha (2019) and Chaudhary et al. (2017) in the past. Under LGBs, there are seven sub-categories which are ranked as LGB2>LGB1>LGB5>LGB6>LGB3>LGB4>LGB7 (refer Table 5.10). Here, LGB2 which is "Unsupportive government policies, laws and regulations for the actors in the maritime supply chains" has gained a preference weight of 0.2104 among sub-categories of legal barriers (LGBs). This indicates LGB2 to be the most critical and therefore has gained the first rank. Also, LGB2 obtained a preference weight of 0.0394 among 46 sub-categories of the barriers, and with this, LGB2 has gained the first rank globally. Government policies and laws related to the maritime supply chain sector haven't been very friendly to foreign investors in India. A lot many times port operators are penalized by the government for unfair practices, however, this demotivates foreign investments. Yet another example is the high haulage tariff charged by Indian Railways which is a hurdle for private train operators in India and for this they have been protesting for a long. The prominence of LGB2 was also explained by one of the domain experts in the Delphi survey panel;

Government policies and laws have been unsupportive when it comes to the maritime supply chain sector. India must consider an example of countries like Singapore and Panama where the economic development of the countries is totally dependent on the maritime business. No doubt, India is strategically located on a prominent Far East and Europe trade lane and if the government shows required relevant interest towards sector's growth, the sector can contribute immensely towards the socio-economic development of the country.

Further, LGB1 which is "Lack of transparency in the entire legal process" gained a preference weight of 0.2104 among LGBs and scored the second rank among this pool. Also, LGB1 obtained a preference weight of 0.0293 among 46 sub-categories

of the barriers, and with this, LGB1 has gained the sixth rank globally. Lack of transparency has always been a problem in a developing country like India, and because of this, unfair practices have become very common. If there is a lack of transparency in the system then there is a high possibility of corruption and illegalities. Moving on, LGB5 which is "Seaport operators charged with fines/penalties for various reasons is demotivating private investments" gained a preference weight of 0.1470 among LGBs and scored the third rank among LGBs. Also, LGB5 obtained a preference weight of 0.0276 among 46 sub-categories of the barriers, and with this, LGB5 has gained the third rank globally. Similarly, LGB6 which is "Corruption and bribery culture right from document approvals to getting mega port projects", LGB3 which is "Discrimination and delay in approvals and allocation of projects and resources" and LGB4 which is "Lengthy legal process in India" secured preference weights of 0.1454, 0.1335 and 0.1247 among LGBs and stood at fourth, fifth and sixth rank, respectively. Also, among 46 sub-categories of barriers, LGB6, LGB3, and LGB4 obtained preference weights of 0.0273, 0.0250, and 0.0234 and gained 10^{th}, $14^{th,}$ and 19^{th} rank respectively. LGB7 which is 'No strict freight transport pollution-related laws and regulations, impact on air and water quality because of maritime supply chain activities' obtained a preference weight of 0.0826 and acquired the seventh rank. This means LGB7 is the least critical among sub-criteria of LGBs. Also, LGB7 obtained a preference weight of 0.0155 among 46 sub-categories of the barriers., and with this, it has gained 42^{nd} rank globally. There have been cases in the under-developed or developing economies where governments have not been much supportive or friendly towards actors in the maritime supply chains (Bavinck et al., 2017; Sorour and Abdul-Mageed, 2016).

5.5.2c Technological Barriers (TEBs)

With a preference weight of 0.1758, this study concluded Technological Barriers (TEBs) to be the third most critical/severe in nature which has six sub-categories under it. In fact, Chen et al. (2019), Zhang and Lam (2019) and Radwan et al. (2019) talked about how technology-related barriers obstructed the smooth flow of containerized freight in maritime supply chains. Under TEBs, there are six sub-

categories which are ranked as TEB2>TEB5>TEB3>TEB1>TEB4>TEB6 (refer Table 5.10). Here, TEB2 i.e., "Poor quality of equipments and cranes at ports" obtained a preference weight of 0.2053 among the pool of six technological barriers and thus scored rank one, which makes it the most critical sub-category of technological barriers. Also, TEB2 obtained a preference weight of 0.0361 among 46 sub-categories of the barriers and this makes it the 2nd most critical sub-category globally. Indian ports especially container ports lack technological advancements and this is a prominent constraint when compared with most modern container ports located globally. One big reason why Indian ports cannot compete with Port of Colombo is because of old and obsolete equipments and cranes at Indian ports which are highly inefficient and unproductive. Poor cranes adversely affect the loading/unloading rates and turnaround time of the vessels. Not just the efficiency and productivity but because of old and obsolete cranes, the safety of the dock labor and berthed vessels is also in peril, if anything wrong happens. The poor condition of equipments and cranes is also because of the lack of interest shown by the government towards the development of container ports in India. The prominence of TEB2 was also explained by one of the domain experts in the Delphi survey panel;

A report presented by Comptroller and Auditor General (CAG) in 2010, mentioned briefly Indian ports especially major ports compelled to use old and obsolete equipments which are decreasing productivity, efficiency, turnaround and also compromising with safety of dock labor. Poor quality of equipments and cranes at ports was one of the foremost reasons why containerized cargo volumes have shifted from major to non-major ports over years.

Moving on, TEB5 i.e., "Insufficient and outdated technology in the warehouses, ICDs/CFSs and other container depots" received a preference weight of 0.1875 among the pool of six technological barriers and therefore scored the second rank. Also, TEB5 obtained a preference weight of 0.0330 among 46 sub-categories of the barriers and this makes it the fourth-most critical sub-category globally. Technology is adopted to solve multiple problems in warehouses, ICDs/CFSs, and other container depots, however, if required technology is not installed or obsolete

technology is replaced then the productivity of the warehouse/ICD/CFS will be decreased. Singh et al. (2019) also took an example of SMEs in the food industry in India and explained how obsolete technologies can affect any business significantly. Further, TEB3 i.e., "Slow pace of digitization/Computerization in maritime supply chains" has scored a preference weight of 0.1758 among the pool of six technological barriers and thus gained the third rank. Also, TEB3 obtained a preference weight of 0.0309 among 46 sub-categories of the barriers and this makes it the fifth most critical sub-category globally. India is a leading developing country and its maritime supply chain sector is evolving in tandem with the strengthening of the economy. Similarly, digitization and computerization are also being installed in all the sectors including maritime supply chains to boost the economy. However, the slower pace of installing digitization/computerization has already attracted a lot of issues and has increased the possibility of barriers and constraints which if ignored could prove to be destructive. Thereafter, TEB1 and TEB4 obtained preference weights of 0.1620 and 0.1464 among the pool of TEBs and are ranked fourth and fifth, respectively, among TEBs. Also, TEB1 and TEB4 gained preference weight of 0.0285 and 0.0257 among 46 sub-categories of the barriers and have scored seventh and 12th rank globally. Further, TEB6 which is "Lack of modern technology road trailers lead to slow speed and inefficiency" received the least rank among six TEBs by securing a preference weight of 0.1230. Also, TEB6 attained a preference weight of 0.0216 among 46 sub-categories of the barriers and this makes it the 20th most critical sub-category globally.

5.5.2d Economic Barriers (ECBs)

Economic Barriers (or ECBs) attained a preference weight of 0.1620 among six categories of barriers and are the fourth-most critical type of barriers. ECBs have six sub-categories of barriers which are ranked ECB2>ECB3>ECB4>ECB5>ECB1>ECB6 (refer Table 5.10), wherein, ECB2 which is "Entry and expansion barriers in the maritime supply chain businesses" possessed the first rank by securing a preference weight of 0.2145 and is most severe among economic barriers. Also, ECB2 attained a preference weight of

0.0347 among 46 sub-categories of the barriers and this makes it the 3rd most critical sub-category globally. Entry barriers are those elements that prevent the entry of corporations in the maritime supply chain sector, contrary to this, exit barriers are those elements that do not let corporations exit the sector even though they are making losses. One of the major reasons why there are entry and exit barriers in the maritime supply chain sector is because of the involvement of huge investments. It needs heavy funds to enter maritime supply chain business, and once entered, it is difficult to wind up. In this era, when competition in the maritime supply chain sector is at its peak, it becomes even more difficult to enter and exit the sector. Entry barriers are good for those for are already there in the maritime supply chain sector as the barriers do not let new corporations join the sector. On the other hand, exit barriers do not let corporations exit maritime supply chain business easily, and therefore, the existing companies would not be benefitted from this. The prominence of ECB2 was also explained by one of the domain experts in the Delphi survey panel;

In context to the maritime supply chain sector - A barrier or constraint to entry is a set of factors that impede the ability of a corporation to enter, invest and operate in maritime supply chain business. Similarly, a barrier or constraint to exit is a set of elements that inhibit a company to wind up the business and leave the maritime supply chain industry. One such factor/element that impedes entry in the maritime supply chain sector is its highly capital-intensive nature that does not easily allow firms to enter and invest in the sector. Cut-throat competition in this sector is yet another factor why firms do not enter the sector. Likewise, once entered this domain it's not easy for the corporation to leave because of huge investments in assets.

Moving on, ECB3 i.e., "High and frequent increments in rail haulage charges" scored a preference weight of 0.1727, which makes it the second most critical barrier among ECBs. Also, ECB3 attained a preference weight of 0.0280 among 46 sub-categories of the barriers and this makes it the 8th most critical sub-category globally. Haulage charge is the tariff paid by container train operators to

the Indian Railways on behalf of shippers for using its locomotives, fuel, network, and other facilities. Subsidized passenger fares compel the Indian Railways to lift haulage charges in order to maintain revenues, but high haulage charges discourage freight volumes. This has actually happened over years as because of increasing haulage charges the share of containerized freight on trains has reduced drastically, rather shifted to roadways. Container train operators have been protesting every year over high haulage charges. At the time of taking feedback on barriers from one of the domain experts working for a container train operator gave the below comment;

Container train operators are not pleased with frequent and high haulage charges announced by Indian Railways. Therefore, they are suggesting IR that haulage fee should be declared only annually, with proper announcement and the annual hike required to be restricted at 5%. High haulage charges are directly impacting the profitability of the container train operators as it stays around 60-70% of the operating cost of a CTO.

Likewise, ECB4 i.e., "Higher hinterland transport cost" gained the third rank among ECBs by scoring a preference weight of 0.1628 among ECBs. Also, ECB4 attained a preference weight of 0.0264 among 46 sub-categories of the barriers and this makes it the 11^{th} most critical sub-category globally. It is very well known that logistics cost in India is 13-14% of the GDP, which is quite higher than in the developed countries like the United States, Germany, and Japan. High hinterland transport cost is a demotivating factor for the actors in maritime supply chains and especially for foreign investments. Most importantly, high hinterland transport costs discourage micro and small enterprises that are importing and exporting products. In a similar way, ECB5 which is "High port tariffs compared to rivals" and ECB1 which is "Lack of FDIs and other investments in maritime supply chain sector" obtained preference weights of 0.1522 and 0.1506, respectively, among ECBs and scored fourth and fifth ranks, respectively, among sub-categories of ECBs. India's rival transshipment hubs of Colombo, Singapore, Jebel Ali, and Port Klang offer considerably lower port tariffs than JNPT, Adani

Mundra, and Pipavav - India's top bustling container ports. This not just demotivates actors in the maritime supply chain business but also scraps India's much-awaited plan to establish a hub transshipment port. Also, ECB5 and ECB1 attained preference weights of 0.0247 and 0.0244 among 46 sub-categories of the barriers and this makes it the 15th and 16th most critical sub-categories globally. Oppositely, ECB6 which is 'Uncompetitive port tariffs' secured the least rank among sub-categories of economic barriers.

5.5.2e Administrative and Political Barriers (ADPBs)

Administrative and Political Barriers (or ADPBs) are ranked fifth most critical/crucial barriers. Under ADPBs, nine sub-categories are identified and ranked with the Fuzzy AHP method, check Table 5.10. In the analysis, ADPB8 which is "Corruption" obtained a preference weight of 0.1360 among nine sub-categories of ADPBs and thus attained the first rank which makes it the most critical/severe sub-category. Also, ADPB8 gained a preference weight of 0.0199 among 46 sub-categories of the barriers and this makes it the 22nd most critical sub-category in the pool of 46 sub-categories. The problem of corruption is quite prevalent in the maritime supply chain sector of India. In order to intercept corruption in the maritime supply chain section, the government of India has linked up with Maritime Anti-Corruption Network (MACN). Corruption is not only restricted up to project allocations but also with vessels calling Indian ports as they face unwanted barriers/constraints or interdict demands. A number of growing countries possess export/import licensing and other regulatory needs but due to the absence of lucidity and other issues, freight transportation consumes more time, troublesome, and expensive. Reviewing these demands, mainly in 'greater risk' nations where native officers may be significantly poorly paid and where corruption is a practice, the urge to give bribes to the bureaucrats to expedite merchandise trade may be heftier. A reported by the OECD, the freight transport sector is one of the most corrupt where most bribes are given, and therefore, revisions to the Prevention of Corruption Act, 1988 mention corruption as an odious offence, and stricter prison terms are enforced for those who are

involved. The actions decided comprise penal terms being increased from six months to three years and from a highest of five years to seven years. The proposed amendment Act will also ensure a speedy trial, limited to two years, for corruption cases. The ambit of the existing Act will be enhanced to make commercial entities liable for inducement of public servants. Under the present law, only individuals are liable. The recommended revision also gives for the problem of recommendation to corporate firms to avoid officials connected with them from bribing a public servant. Confronting these problems is beneficial for the maritime sector, and for actors and stakeholders in this sector. Despite all efforts, the problem of corruption has remained widespread in the maritime supply chain sector of India, for that reason, ADPB8 has gained the first rank in the analysis. The prominence of ECB2 was also explained by one of the domain experts in the Delphi survey panel;

The influence of culture of bribery goes past higher money paid for low grade commodities to substandard grade construction of infrastructure generating less returns, beside less funds for maintenance – and this is how the impact of corruption can be felt. Renowned actors in the maritime business are involved in corruption, because they have deep pockets, they big for bigger government projects. The entire bidding is surrounded by corruption, as the officials in the government may favor certain bidders.

The customs and excise departments in the under-developed and developing nations are often involved in corruption related activities. Especially in the under-developed countries, the customs officers are often involved in crimes like blackmailing, patronage, favourtism, misuse, and cronyism. Moving on, ADPB4 i.e., 'Conflicts with neighboring countries impede the growth of the maritime supply chain network' obtained the second rank among 9 sub-categories of ADPBs with a preference weight of 0.1237. Also, ADPB4 acquired a preference weight of 0.0181 among 46 sub-categories of the barriers and this places it at 29th position among them. Alfaqiri et al (2019) follow a systematic procedure for assessing the risks in supply chains. This study considers the piracy issue in

Africa which is a significant problem hindering the smooth running of the supply chains. Further, ADPB3 i.e., 'No relevant government policies to cover each activity in the maritime supply chain' achieved the third rank among nine administrative and political barriers with a preference weight of 0.1143, and similarly, bagged 34th rank among 46 sub-categories of the barriers with a preference weight of 0.0167. Likewise, ADPB5 which is 'Abuse of bureaucratic powers' secured the fourth rank among nine ADPBs with a preference weight of 0.1136. Also, ADPB5 secured a preference weight of 0.0166 in order to stay at 35th rank among 46 sub-categories of ADPBs. Going further, ADPB9 i.e., 'Lack of passion to develop the maritime supply chains among actors, governments and bureaucrats' gained the fifth rank with a preference weight of 0.1085 within nine sub-categories of administrative and political barriers, and similarly, ADPB9 scored 38th rank with a preference weight of 0.0159 among 46 sub-categories of the barriers. The significance of the top five sub-categories of ADPBs was also explained by one of the domain experts in the Delphi survey panel;

The analysis performed on ADPBs is beneficial for decision-makers and strategists. At least the top five ranked sub-categories of administrative and political barriers should be considered the most critical and must be treated on a priority basis. For instance, ADPB4 i.e., 'Conflicts with neighboring countries impede the growth of the maritime supply chain network' is so critical for India because of bad relations between India and Pakistan. The situation is so critical that the Indian ports located close to Pakistan are always on high-security alert. Likewise, there are many other administrative and political issues which are prioritized and discussed in detail.

Thereafter, ADPB6 which is 'Lack of administrative and political knowledge', ADPB2 which is 'Disagreement between central and state government on the maritime supply chain projects', ADPB7 which is 'Unstable government state or central government' and ADPB1 which is 'Terrorism' have been ranked sixth, seventh, eighth and ninth with a preference weight of 0.1068, 0.1034, 0.1005 and 0.0933, respectively. Also, ADPB6, ADPB2, ADPB7, and ADPB1 have been

ranked 40th, 43rd, 44th, and 45th among 46 sub-categories of the barriers. The sequence in which administrative and political barriers are ranked is; ADPB8>ADPB4>ADPB3>ADPB5>ADPB9>ADPB6>ADPB2>ADPB7>ADPB 1, where ADPB8 is the most critical and ADPB1 is the least.

5.5.2f Organizational Barriers (OGBs)

Organizational Barriers (or OGBs) secured the least rank i.e., sixth rank among the categories of barriers with a preference weight of 0.1230. Among organizational barriers, OGB2 i.e., "Lack of qualified managerial personnel" gained the first rank among ADPBs with a preference weight of 0.1919 and secured 18th rank among 46 sub-categories with a preference weight of 0.0236. Research done by Lu et al. (2018) confirmed that even developed countries have a dearth of trained and skilled professionals in the maritime sector. Similarly, Baz and Laguir (2017) confirmed the lack of a qualified workforce in the maritime and logistics sector. Also, Lin and Chang (2018) and Vural et al. (2019) mentioned the scarcity of qualified manpower among logistics service providers. Additionally, Ellinger et al. (2020) wrote about the deficiency of a skilled workforce in maritime logistics networks. Not only in India but in almost whole of South Asia (developing countries), the problem of shortage of skilled workforce is quite prevalent. This directly impacts the productivity, efficiency, and profitability of the various sectors. The significance of the top organizational barrier was also explained by one of the domain experts by saying that;

There is a critical requirement for skilled manpower in India. The censorious and instant need for expertise evolution is observed to be in the road freight and warehousing parts of the supply chains. The migration of skilled professionals to high-paying countries for better remuneration is yet another reason why there is a serious scarcity of skilled manpower in India. Therefore, it is necessary to give emphasis on 'Lack of qualified managerial personnel'.

Further, OGB1 or "Lack of safety measures followed in the maritime supply chains" obtained the second rank with a preference weight of 0.1567 within the

sub-categories of organizational barriers. Also, OGB1 secured 25th rank among 46 sub-categories of the barriers with a preference weight of 0.0193. Lack of safety in the maritime and logistics sector is an unidentified issue in India. The workforce at ports often does not follow the safety measures established and enforced by the authorized authorities. Moreover, OGB7 which is "Lack of formal organizational structure" attained a preference weight of 0.1551 among seven sub-categories of organizational barriers and scored 26th rank among total 46 sub-categories with a preference weight of 0.0191. Going further, OGB5 i.e., "Unavailability of labor due to migration (as a result of pandemics, low wages/salaries, poor facilities, etc.)" secured the fourth rank with a preference weight of 0.1475 among OGBs and obtained 28th rank with a preference weight of 0.0181. Likewise, OGB3 which is "Labor strikes and unskilled labor" acquired a preference weight of 0.1347 among seven OGBs to stand at fifth rank. Additionally, OGB3 gained the 36th rank among a total of 46 sub-categories with a preference weight of 0.0166. Furthermore, OGB4 i.e., "Lack of managerial and operational integration in the maritime supply chains" stood at sixth rank with a preference weight of 0.1269 among seven organizational barriers. Also, OGB4 scored 41st rank with a preference weight of 0.0156 among a total of 46 sub-categories of barriers. Moving on, OGB6 i.e., "Lack of dialogue among actors in the maritime supply chains" achieved the least rank i.e., seventh with a preference weight of 0.0873 among seven OGBs. Likewise, OGB6 got the least rank among 46 sub-categories of barriers, which makes it the least critical in nature. The sequence in which organizational barriers are ranked is; OGB2>OGB1>OGB7>OGB5>OGB3>OGB4>OGB6 (refer Table 5.10), wherein, OGB2 which is 'Unqualified managerial personnel' is the most critical and OGB6 which is 'Lack of dialogue among actors in the maritime supply chains' is the least.

5.6 Sensitivity Analysis

To confirm the resilience of the propounded framework and appraise the ranking arrangement, sensitivity analysis was executed as demonstrated by Garg (2020) and Garg and Kashav (2019). The end results acquired in table 5.10 recommend

that out of all the inhibitors, the IFBs secured the first rank and earned the highest weightage value (0.2224), consequently, IFBs may impact the ranking of other categories as well (Vishwakarma et. al., 2019; Mahtani and Garg, 2018). To calculate the impact on barriers' ranking; a gradational change in value from 0.1 to 0.9, to the IFBs, was assessed as illustrated in Table 5.11.

The yielded results illustrate that the utmost fluctuation was in the organizational barrier (table 5.11). Additionally, because of the difference in the infrastructural barrier (IFB) weights, the specific category weights and their final ranking vary. In the sensitivity analysis, when the value of IFB is 0.1, the first rank is secured by ECB2; while, IFB1 captured the last rank. LGB2 stood at the first position in the next experiment and the least rank is acquired by OGB6 when the infrastructural barrier (IFB) value is 0.2 (refer table 5.12 and figure 5.3). Post this, IFB11 stood at the first spot in the leftover investigations and the least rank is possessed by OGB6. Consequently, it culminates that the infrastructural barrier (IFB) is censorious in the maritime supply chain development in India, and thus needs extensive recognition of policymakers. This examination also propounds that to advance the maritime supply chain, managers of these corporations require to stress the infrastructural barrier and communicate the associated problems successfully on the basis of priority.

Table 5.11 Barriers' category values with increasing infrastructural barrier

Listed barriers	Weights of the barriers									
ECBs	0.1833	0.1633	0.1588	0.1433	0.1233	0.1033	0.0833	0.0633	0.0433	0.0213
IFBs	0.1	0.2	0.2224	0.3	0.4	0.5	0.6	0.7	0.8	0.9
LGBs	0.1998	0.1798	0.1753	0.1598	0.1398	0.1198	0.0998	0.0798	0.0598	0.0298
TEBs	0.1662	0.1462	0.1417	0.1262	0.1062	0.0862	0.0662	0.0462	0.0262	0.0069
ADPBs	0.2105	0.1905	0.1860	0.1705	0.1505	0.1305	0.1105	0.0905	0.0705	0.0429
OGBs	0.1402	0.1202	0.1157	0.1002	0.0802	0.0602	0.0402	0.0202	0.0002	0.0001
Total	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

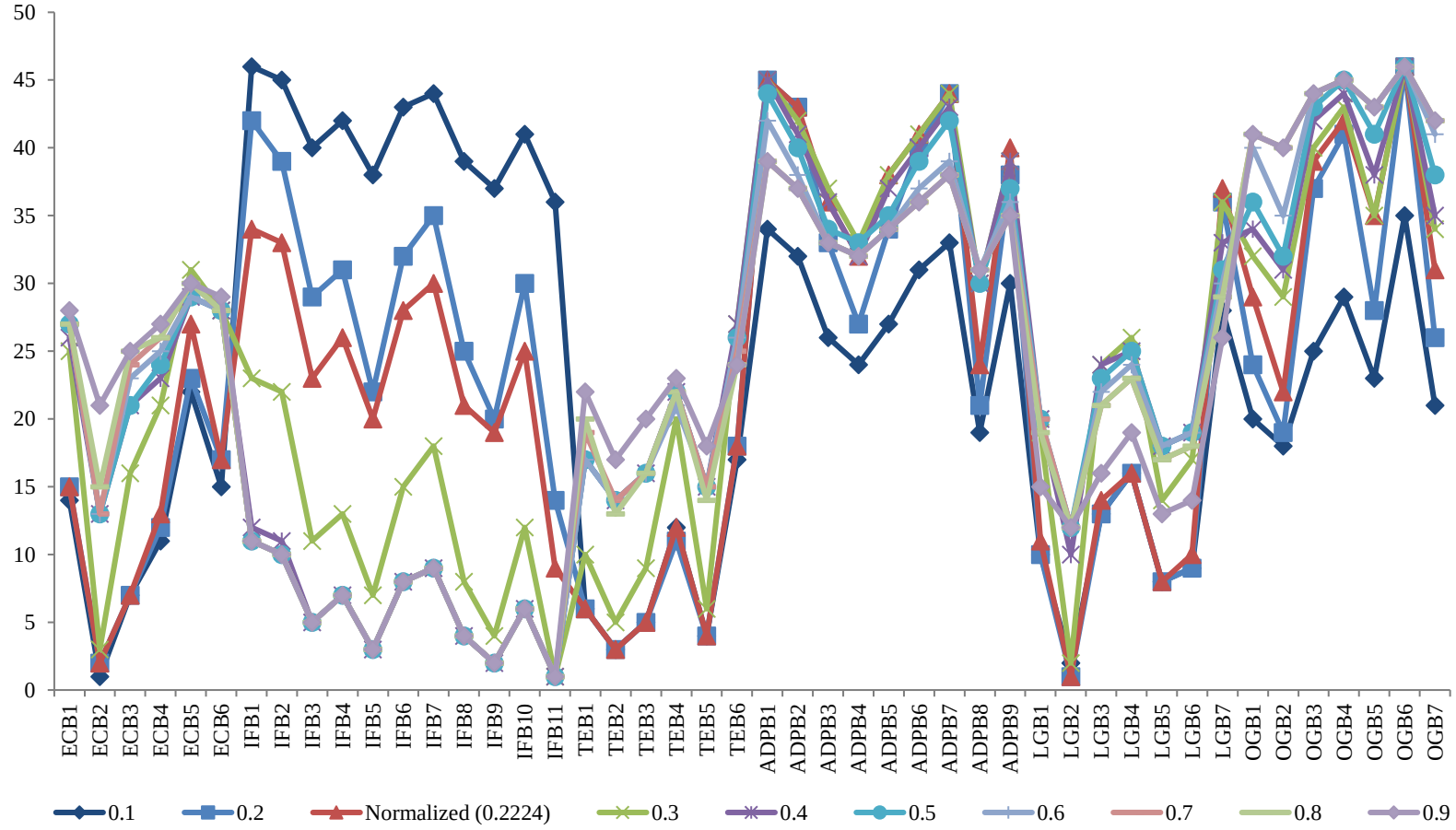
Source: Author's composition

Table 5.12 Barriers ranking when infrastructural barrier varies

Identified barriers	Ranking of the barriers when variation in the weight of infrastructural barrier									
	0.1	0.2	Normalized (0.2224)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ECB1	14	15	15	25	26	27	27	27	27	28
ECB2	1	2	2	3	13	13	13	13	15	21
ECB3	7	7	7	16	21	21	23	24	25	25
ECB4	11	12	13	21	23	24	25	26	26	27
ECB5	22	23	27	31	29	29	29	30	30	30
ECB6	15	17	17	28	28	28	28	28	28	29
IFB1	46	42	34	23	12	11	11	11	11	11
IFB2	45	39	33	22	11	10	10	10	10	10
IFB3	40	29	23	11	5	5	5	5	5	5
IFB4	42	31	26	13	7	7	7	7	7	7
IFB5	38	22	20	7	3	3	3	3	3	3
IFB6	43	32	28	15	8	8	8	8	8	8
IFB7	44	35	30	18	9	9	9	9	9	9
IFB8	39	25	21	8	4	4	4	4	4	4
IFB9	37	20	19	4	2	2	2	2	2	2
IFB10	41	30	25	12	6	6	6	6	6	6
IFB11	36	14	9	1	1	1	1	1	1	1
TEB1	6	6	6	10	17	17	17	19	20	22
TEB2	3	3	3	5	14	14	14	14	13	17
TEB3	5	5	5	9	16	16	16	16	16	20
TEB4	12	11	12	20	22	22	21	22	22	23
TEB5	4	4	4	6	15	15	15	15	14	18
TEB6	17	18	18	27	27	26	26	25	24	24
ADPB1	34	45	45	45	45	44	42	39	39	39
ADPB2	32	43	43	42	41	40	38	37	37	37
ADPB3	26	33	36	37	36	34	33	33	33	33
ADPB4	24	27	32	33	32	33	32	32	32	32
ADPB5	27	34	38	38	37	35	34	34	34	34
ADPB6	31	40	41	41	40	39	37	36	36	36
ADPB7	33	44	44	44	43	42	39	38	38	38
ADPB8	19	21	24	30	30	30	31	31	31	31
ADPB9	30	38	40	39	39	37	36	35	35	35
LGB1	10	10	11	19	20	20	20	20	19	15
LGB2	2	1	1	2	10	12	12	12	12	12
LGB3	13	13	14	24	24	23	22	21	21	16
LGB4	16	16	16	26	25	25	24	23	23	19
LGB5	8	8	8	14	18	18	18	17	17	13
LGB6	9	9	10	17	19	19	19	18	18	14
LGB7	28	36	37	36	33	31	30	29	29	26
OGB1	20	24	29	32	34	36	40	41	41	41
OGB2	18	19	22	29	31	32	35	40	40	40
OGB3	25	37	39	40	42	43	44	44	44	44
OGB4	29	41	42	43	44	45	45	45	45	45
OGB5	23	28	35	35	38	41	43	43	43	43
OGB6	35	46	46	46	46	46	46	46	46	46
OGB7	21	26	31	34	35	38	41	42	42	42

Source: Author's composition

Figure 5.3 Sensitivity analysis results



Source: Author's composition

5.7 Chapter Summary

This chapter argued the methodology and evaluated the data obtained on categories and sub-categories of barriers in the maritime supply chains of containerized freight. To calculate that ranking of the barriers, the Fuzzy AHP technique was employed. The results accomplished at each stage were illustrated clearly and in a detailed manner. The preference weights and ranks gained by each category and sub-category of the barrier were based on the level of criticality each category and sub-category possess. The next chapter is based on an evaluation of the strategies to overcome the barriers using the Fuzzy TOPSIS method.

Chapter 6

Assessment of strategies to overcome barriers in the maritime supply chains

Overview

The previous chapter i.e., chapter – 5 was based on the identification and evaluation of barriers. However, just scrutinizing the barriers is not enough. Therefore, this chapter aims to cover the identification, finalization, and prioritization of the strategies in order to overcome/subjugate the influence of barriers present in the maritime supply chains of containerized freight. As like barriers, a set of 25 strategies are discerned using primary and secondary data. Thereafter, the Fuzzy TOPSIS method is espoused and the steps are elucidated to exhibit how it calculates the final ranking of the strategies.

6.1 Introduction

The maritime supply chain is comparatively a new subject for developing countries like India, which deals with the integration perspective of various activities happening at ports and inland logistics networks. The primary motive of the maritime supply chains is to decrease time and cost in the transportation of containerized freight, and that is why it is highly necessary for developing nations like India to ensure the sound condition of the maritime supply chain facilities. However, the situation of the maritime supply chains in India is not up to the global standards and they are impeded due to the presence of severe barriers. Additionally, there is a lack of literature on the maritime supply chains, and that is why current research holds great importance. In the previous chapter, a brief analysis on barriers in the maritime supply chains is carried out, however, only assessment of the barriers is not enough and the need is to discern and rank

strategies to overcome/subjugate the impact of barriers. For that reason, the current chapter is based on objective two and three which are mentioned below;

Objective 2: To identify the strategies to overcome/subjugate barriers in the maritime supply chains of containerized freight in India.

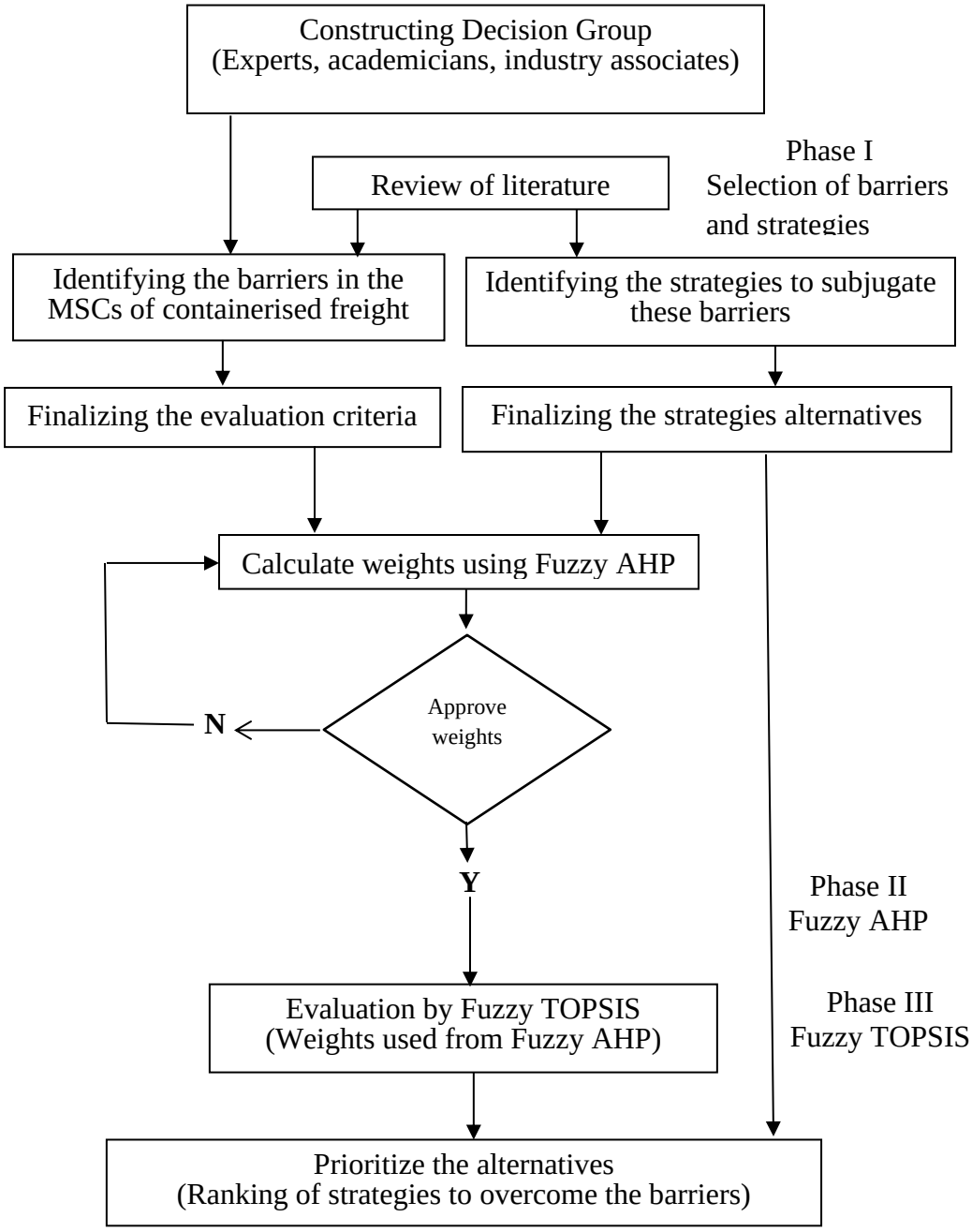
Objective 3: To develop a framework in order to overcome barriers in the maritime supply chains of containerized freight.

In order to achieve the above objectives, an integrated framework for identification and prioritization of strategies to overcome/subjugate barriers in the maritime supply chains of containerized freight is developed. To identify strategies, a wide range of relevant domain experts are chosen and relevant feedback is taken. All the identified 25 strategies are ranked on the basis of how critical and important they are in order to overcome the impacts of barriers.

Ranking of the strategies is done using Fuzzy TOPSIS or Fuzzy Technique for Order of Preference by Similarity to Ideal Solution method. Similar to the Fuzzy AHP, this technique also falls under the multi-criteria decision making (MCDM) method, which helps in calculating the preference weights and then ranks of the strategies to overcome the influence of barriers. This way current study propounds an integrated Fuzzy AHP-TOPSIS framework.

6.2 Proposed framework

Figure 6.1 Proposed overall framework for this research thesis



Source: Author's composition

6.3 Identification of strategies to overcome barriers in the maritime supply chains of containerized freight

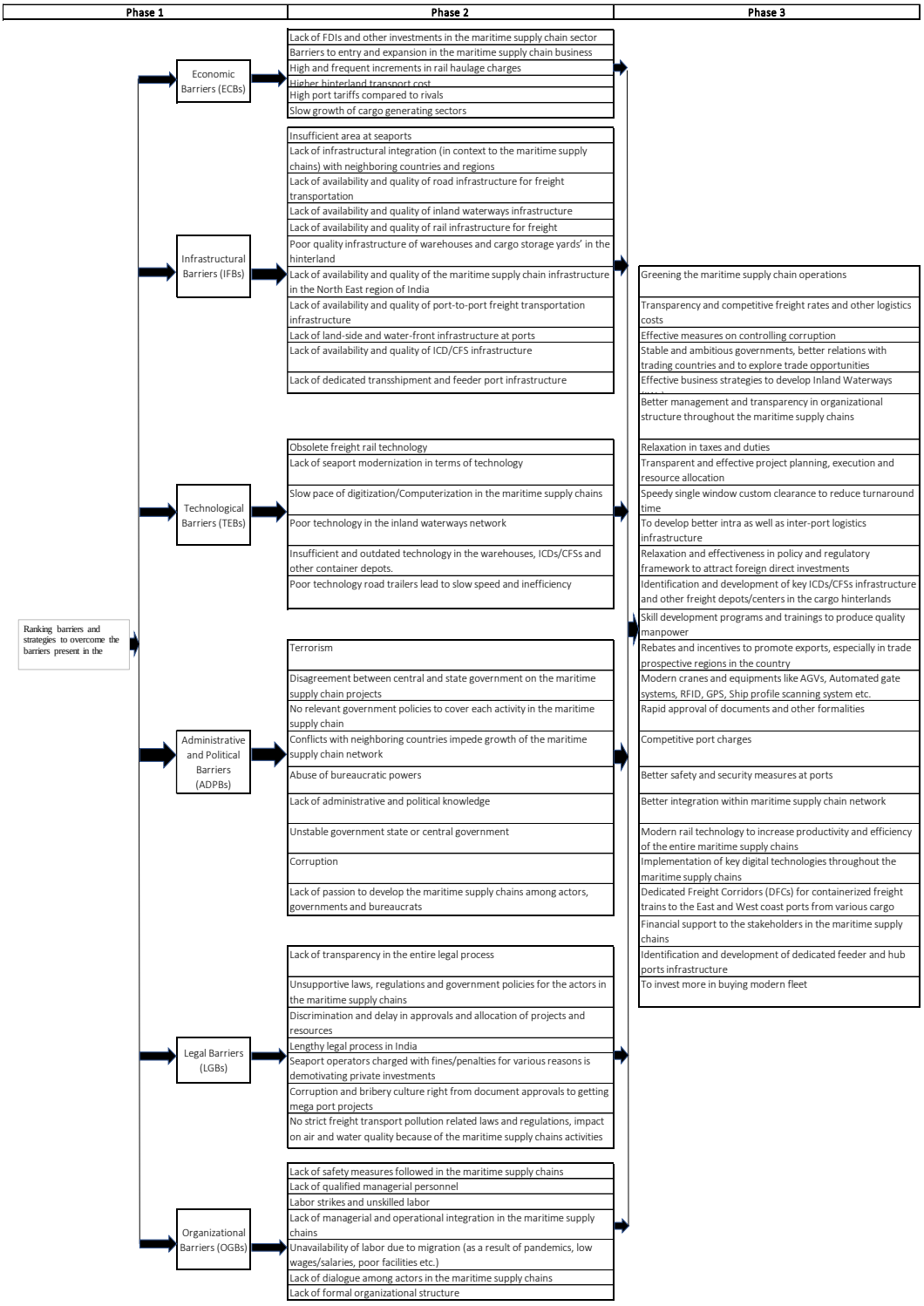
Table 6.1 This table illustrates a set of 25 strategies discerned to overcome the impact of barriers in the maritime supply chains of containerized freight.

Code	Strategies
S1	Greening the maritime supply chain operations
S2	Transparency and competitive freight rates and other logistics costs
S3	Effective measures on controlling corruption
S4	Stable and ambitious governments, better relations with trading countries and to explore trade opportunities
S5	Effective business strategies to develop Inland Waterways (IWs)
S6	Better management and transparency in organizational structure throughout the maritime supply chains
S7	Relaxation in taxes and duties
S8	Transparent and effective project planning, execution and resource allocation
S9	Speedy single window custom clearance to reduce turnaround time
S10	To develop better intra as well as inter-port logistics infrastructure
S11	Relaxation and effectiveness in policy and regulatory framework to attract foreign direct investments
S12	Identification and development of key ICDs/CFSs infrastructure and other freight depots/centers in the cargo hinterlands
S13	Skill development programs and trainings to produce quality manpower
S14	Rebates and incentives to promote exports, especially in trade prospective regions in the country
S15	Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system etc.

S16	Rapid approval of documents and other formalities
S17	Competitive port charges
S18	Better safety and security measures at ports
S19	Better integration within maritime supply chain network
S20	Modern rail technology to increase productivity and efficiency of the entire maritime supply chains
S21	Implementation of key digital technologies throughout the maritime supply chains
S22	Dedicated Freight Corridors (DFCs) for containerized freight trains to the East and West coast ports from various cargo hinterlands
S23	Financial support to the stakeholders in the maritime supply chains
S24	Identification and development of dedicated feeder and hub ports infrastructure
S25	To invest more in buying modern fleet

Source: Combined results of the studies of Garg and Kashav (2019), Jasmi and Fernando (2018), Adland et al. (2018), Yin et al. (2019), Hansen (2018), Choi (2018), Sehgal et al. (2018), Vanelslander and voorde (2018), Chen et al. (2018); Ahadi et al. (2018), Trivedi et al. (2021), Wan et al. (2019), Neutzling et al. (2018), Milios et al. (2019), Sherafati et al. (2020), Monch et al. (2018), Ivanov et al. (2017), Schepler et al. (2017), Vaghi and Lucietti (2016), Garcia-Alonso et al. (2019); Jaffee (2019), Parola et al. (2017), Ibrahim et al. (2019); Karlis and Polemis (2018), Cruz and Sarmento (2019), Raimbault (2019), Witte et al. (2017), Chen et al. (2018), Chhetri et al. (2020), Mijiyawa (2017), Rong et al. (2017), Giudice et al. (2021), Heilig et al. (2017), Vaio and Varriale (2020), Jeevan et al. (2019), Berg et al. (2017); Ding et al. (2019), Vukić et al. (2018), John et al. (2018), Bazaras and Palšaitis (2018), Palmieri et al. (2019); Lam and Bai (2016), Yuen and Thai (2017), Naweed et al. (2018), Balog et al. (2019), Büyüközkan and Göçer (2018), Hartley and Sawaya (2019), Upadhyay and Bolia (2014), Shankar et al. (2019), Lee (2008), Koilo and Grytten (2019), Kavirathna et al. (2018), Wang and Yeo (2019), Shintani et al. (2019) and Martínez-López et al. (2018).

Figure 6.2 Decision sequence for prioritizing strategies to subjugate barriers in the maritime supply chains of containerized freight.



Source: Author's composition

6.3.1: Stage 1 - Application of Fuzzy TOPSIS methodology

The process of decision-making becomes complex when it involves qualitative and quantitative variables. In such situations, the MCDM approach can be utilized to handle multiple attributes and conflicting decision system structures (Luthra et al., 2018). There are numerous MCDM tools are available among them the Fuzzy TOPSIS approach based on the distance priority method which assists in the prioritization of robust selective attributes and optimizes from multiple responses. The final ranking is obtained based on the closeness coefficient values of an individual attribute. The steps of the Fuzzy TOPSIS technique is elaborated below:

Level 1: Score is allocated to each criterion to obtain a matrix for strategies as per scale is given in table 4.

Table 6.2 Score for linguistics variable

Assessment rating	Specific TFNs
Very Poor	(1, 2, 3)
Poor	(2, 3, 4)
Average	(3, 4, 5)
High	(4, 5, 6)
Very High	(5, 6, 7)
Excellent	(6, 7, 8)

Source: Author's composition

Level 2: Calculation of cumulative Fuzzy values for the alternatives

If the fuzzy value of the Nth expert is $\breve{F}_{abN} = (l_{abN}, p_{abN}, u_{abN})$ overhere a =1,2,3,……..m, b=1,2,3……..n then the aggregated Fuzzy score $\breve{F}_{ab}$ of the strategies w.r. to specific barrier is denoted by $\breve{F}_{ab}(l_{ab}, p_{ab}, u_{ab})$, where

$$a = \min_{N}\{l_{abN}\}, \quad b = \frac{1}{N}\sum_{N=1}^{N} p_{abN}, \quad c = \max_{N}\{u_{abN}\}$$

(3.5)

Level 3: Determine normalized values

Normalized values are determined by $\breve{G}$ where:

$$\breve{G} = [p_{ij}]_{mxn} \quad \text{Where i = 1,2,3,…….m and j = 1,2,3,…….n}$$

$$\breve{x}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = \max c_{ij} \text{ (benefit criteria)}$$

(3.6)

$$\breve{x}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{ and } a_j^- = \min a_{ij} \text{ (Cost criteria)}$$

(3.7)

Level 4: Determine the Standardized weight score by applying the Eq.

$$\breve{Y} = [\breve{p}_{ij}]_{mxn} \quad \text{where } \breve{p}_{ij} = \breve{x}_{ij} \otimes w_j$$

(3.8)

Level 5: Obtain fuzzy ideal solution for positive and negative values as follows respectively:

$$Z^+ = \{\rho_1^+, \ldots\ldots, \rho_n^+\}, where\ \rho_j^+ = \{\max(\rho_{ij})\ if\ j\epsilon J; min(\rho_{ij}) if\ j\epsilon J'\},\ j = 1 \ldots\ldots n$$

(3.9)

$$Z^- = \{\rho_1^-, \ldots\ldots, \rho_n^-\}, where\ \rho_j^- = \{min(\rho_{ij})\ if\ j\epsilon J; max(\rho_{ij})\ if\ j\epsilon J'\}, j = 1 \ldots\ldots n$$

(3.10)

Level 6: Calculate Fuzzy positive values and negative values for a solution using given Eqns below-

$$\psi_i^+ = \left\{\sum_{j=1}^{n}(\rho_{ij} - \rho_{ij}^+)^2\right\}^{1/2}, \quad i = 1 \ldots\ldots\ldots\ldots m$$

$$\psi_i^- = \left\{\sum_{j=1}^{n}(\rho_{ij} - \rho_{ij}^-)^2\right\}^{1/2}, \quad i = 1 \ldots\ldots\ldots\ldots m \qquad (3.11)$$

$$CC_i = \frac{\psi_i^-}{\psi_i^- + \psi_i^+} \qquad i = 1 \ldots\ldots\ldots m. \quad C_i \epsilon (0,1)$$

(3.12)

6.3.2: Stage 2 - Prioritization of the strategies

The construction of the Fuzzy score matrix of the policy as per the assessment scale is highlighted in Table 6.2. Here, the weighted Fuzzy score matrix of one member of the decision team is given due to space restriction (refer to Table 6.3). Hereafter, a comprehensive weighted Fuzzy score matrix is obtained as highlighted in Table 6.4. Then goal optimization approach is used to determine the usual aggregate Fuzzy matrix by using equations 3.6 and 3.7. After that, a comprehensive weighted normalized Fuzzy score matrix is obtained by-product of the barriers group weights calculated through FAHP as given in table 6.5 with a normalized aggregate Fuzzy matrix which is presented in table 6.6. This work utilized Fuzzy positive vector $\widetilde{\rho_1^+} = (0, 0, 0)$ and fuzzy negative vector $\widetilde{\rho_1^+} = (1, 1, 1)$ to calculate the ideal solution. Then the distance of each strategy has been calculated by using equation 3.11 and the closeness coefficient is obtained using Equation 3.12. Hereafter, descending arrangement of CC_i values provide a final ranking of strategies (see Table 6.8). Steps have been followed as discussed in the research methodology section.

Table 6.3 Score matrix for the strategies (Specialist 1)

	EB1	EB2	EB3	…	…	OB5	OB6	OB7
S1	H	M	H	..	..	M	M	M
S2	M	H	H	..	..	VH	M	L
S3	H	VH	VH	..	..	M	H	M
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
S13	VH	H	M	..	..	L	M	M
S24	M	M	H	..	..	M	M	H
S25	VH	H	M	..	..	L	M	M

Source: Author's composition

Table 6.4 Fuzzy score matrix for the strategies (Specialist 1)

	EB1	EB2	EB3	…	…	OB5	OB6	OB7
S1	(4, 5, 6)	(3 , 4, 5)	(4, 5, 6)	….	….	(3 , 4, 5)	(3 , 4, 5)	(3 , 4, 5)
S2	(3, 4, 5)	(4, 5, 6)	(4, 5, 6)	….	….	(5, 6, 7)	(3 , 4, 5)	(2, 3, 4)
S3	(4, 5, 6)	(5, 6, 7)	(5, 6, 7)	….	….	(3 , 4, 5)	(4, 5, 6)	(3 , 4, 5)
….	….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….	….
S23	(5, 6, 7)	(4, 5, 6)	(3, 4, 5)	….	….	(2, 3, 4)	(3, 4, 5)	(3, 4, 5)
S24	(3, 4, 5)	(3, 4, 5)	(4, 5, 6)	….	….	(3, 4, 5)	(3, 4, 5)	(4, 5, 6)
S25	(5, 6, 7)	(4, 5, 6)	(3, 4, 5)	….	….	(2, 3, 4)	(3, 4, 5)	(3, 4, 5)

Source: Author's composition

Table 6.5 Comprehensive Fuzzy score matrix for strategies

	EB1	EB2	EB3	…	…	OB5	OB6	OB7
S1	(3, 5.6, 7)	(2, 4.1, 6)	(4, 6.1, 8)	….	….	(2, 4, 6)	(2, 4.6, 6)	(2, 3.5, 5)
S2	(2, 5.5, 7)	(4, 5.6, 7)	(3, 4.5, 6)	….	….	(3, 4.1, 6)	(1, 2.5, 4)	(3, 5.3, 7)
S3	(1, 3, 5)	(5, 6.5, 8)	(5, 6.2, 8)	….	….	(2, 3.5, 5)	(1, 3, 5)	(5, 6.5, 8)
….	….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….	….
S23	(5, 6.2, 8)	(3, 5.3, 7)	(2, 3.5, 5)	….	….	(1, 3.1, 5)	(3, 4.1, 6)	(2, 3.9, 5)
S24	(2, 4.5, 6)	(3, 4.5, 6)	(3, 5.3, 7)	….	….	(3, 5.5, 7)	(3, 5.3, 6)	(4, 5.9, 7)
S25	(5, 6.6, 8)	(4, 5.8, 7)	(1, 3.1, 5)	….	….	(4, 6.5, 8)	(4, 5.4, 7)	(1, 3.1, 5)

Source: Author's composition

Table 6.6 Normalized Fuzzy score matrix for strategies

	EB1	EB2	EB3	…….	OB5	OB6	OB7
S1	(0.14, 0.17, 0.33)	(0.17, 0.24, 0.5)	(0.13, 0.16, 0.25)	…….	(0.17, 0.25, 0.5)	(0.17, 0.22, 0.5)	(0.2, 0.29, 0.5)
S2	(0.14, 0.18, 0.5)	(0.14, 0.18, 0.25)	(0.17, 0.22, 0.33)	…….	(0.17, 0.24, 0.33)	(0.25, 0.4, 1)	(0.14,0.19, 0.33)
S3	(0.2, 0.33, 1)	(0.13, 0.15, 0.2)	(0.13, 0.16, 0.2)	…….	(0.2, 0.29, 0.5)	(0.2, 0.33, 1)	(0.13, 0.15, 0.2)
….	….	….	….	…….	….	….	….
….	….	….	….	…….	….	….	….
S23	(0.13, 0.16, 0.2)	(0.14, 0.19, 0.33)	(0.2, 0.29, 0.5)	…….	(0.2, 0.32, 1)	(0.17, 0.24, 0.33)	(0.2, 0.26, 0.5)
S24	(0.17, 0.22, 0.5)	(0.17, 0.22, 0.33)	(0.14, 0.19, 0.33)	…….	(0.14, 0.18, 0.33)	(0.14, 0.19, 0.33)	(0.14,0.17, 0.25)
S25	(0.13, 0.15, 0.2)	(0.14, 0.17, 0.25)	(0.2, 0.32, 1)	…….	(0.13, 0.15, 0.25)	(0.14, 0.19, 0.25)	(0.2, 0.32, 1)

Source: Author's composition

Table 6.7 Weighted normalized Fuzzy score matrix for strategies

	EB1	EB2	EB3	…….	OB5	OB6	OB7
S1	(0.022, 0.027, 0.05)	(0.036, 0.052, 0.107)	(0.022, 0.028, 0.043)	…….	(0.024, 0.036, 0.049)	(0.036, 0.058, 0.145)	(0.012, 0.015, 0.028)
S2	(0.022, 0.027, 0.075)	(0.031, 0.038, 0.054)	(0.029, 0.038, 0.058)	…….	(0.029, 0.042, 0.073)	(0.029, 0.048, 0.145)	(0.012, 0.015, 0.021)
S3	(0.03, 0.05, 0.151)	(0.027, 0.033, 0.047)	(0.022, 0.028, 0.035)	…….	(0.024, 0.037, 0.073)	(0.036, 0.069, 0.145)	(0.014, 0.02, 0.028)
….	….	….	….	…….	….	….	….
….	….	….	….	…….	….	….	….
S23	(0.019, 0.024, 0.030)	(0.031, 0.04, 0.071)	(0.035, 0.049, 0.086)	…….	(0.024, 0.042, 0.073)	(0.036, 0.058, 0.145)	(0.017, 0.024, 0.041)
S24	(0.025, 0.033, 0.075)	(0.036, 0.048, 0.071)	(0.025, 0.033, 0.058)	…….	(0.018, 0.023, 0.029)	(0.024, 0.032, 0.048)	(0.012, 0.016, 0.028)
S25	(0.019, 0.023, 0.030)	(0.031, 0.037, 0.054)	(0.035, 0.056, 0.176)	…….	(0.018, 0.024, 0.037)	(0.029, 0.048, 0.145)	(0.017, 0.027, 0.083)

Source: Author's composition

Table 6.8 Ranking list of the strategies

Code	Strategies	d_i^+	d_i^-	CC_i	Rank
S1	Greening the maritime supply chain operations	1.7832	44.3822	0.9614	16
S2	Transparency and competitive freight rates and other logistics costs	1.7760	44.3919	0.9615	15
S3	Effective measures on controlling corruption	1.9206	44.3001	0.9584	22
S4	Stable and ambitious governments, better relations with trading countries and to explore trade opportunities	1.8594	44.3131	0.9597	19
S5	To develop Inland Waterway (IW) network	1.6473	44.4890	0.9643	5
S6	Better management and transparency in organizational structure throughout the maritime supply chains	1.8565	44.3377	0.9598	18
S7	Relaxation in taxes and duties	1.8710	44.3248	0.9595	20
S8	Transparent and effective project planning, execution and resource allocation	1.7064	44.4495	0.9630	11
S9	Speedy single window custom clearance to reduce turnaround time	1.7253	44.4231	0.9626	13
S10	To develop better intra as well as inter-port logistics infrastructure	1.6737	44.4855	0.9637	8
S11	Relaxation and effectiveness in policy and regulatory framework to attract foreign direct investments	1.8561	44.3557	0.9598	17
S12	Identification and development of key ICDs/CFSs infrastructure and other freight depots/centers in the cargo hinterlands	1.9006	44.3091	0.9589	21
S13	Skill development programs and trainings to produce quality manpower	1.7003	44.4626	0.9632	10
S14	Rebates and incentives to promote exports, especially in trade prospective regions in the country	1.6830	44.4704	0.9635	9
S15	Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system etc.	1.5158	44.6109	0.9671	3
S16	Rapid approval of documents and other formalities	1.7174	44.4327	0.9628	12
S17	Competitive port charges	1.4991	44.6205	0.9675	2
S18	Better safety and security measures at ports	2.0000	44.2339	0.9567	25
S19	Better integration within the maritime supply chain network	1.9571	44.2362	0.9576	23
S20	Modern rail technology to increase productivity and efficiency of the entire maritime supply chains	1.6661	44.4830	0.9639	7
S21	Implementation of key digital technologies throughout the maritime supply chains	1.6499	44.4903	0.9642	6
S22	Dedicated Freight Corridors (DFCs)	1.6095	44.5255	0.9651	4
S23	Financial support to the stakeholders in the maritime supply chains	1.7651	44.3909	0.9618	14
S24	Identification and development of dedicated feeder and hub ports infrastructure	1.4274	44.6733	0.9690	1
S25	To invest more in buying modern fleet	1.9946	44.2406	0.9569	24

Source: Author's composition

6.4 Ranking of the strategies

To overcome or neutralize the impact of barriers, 25 strategies have been propounded; but it is strenuous to decide which solution strategy is more impactful and predominant. For that reason, prioritization of strategies with the help of this amalgamated framework made it systematized and structured for decision-makers and strategists. Strategies are ranked to eliminate barriers, which is done by perceiving the highest level of nearness coefficient value which indicates strategy S24 i.e., 'Identification and development of dedicated feeder and hub ports infrastructure' scored the first rank and strategy S18 which is 'Better safety and security measures at ports' received the least i.e., 25^{th} rank. Wang et al. (2020), Kashiha et al. (2016), Santini et al. (2018), and Wiradanti et al. (2020) argued about the development of dedicated feeder and hub ports infrastructure as a foremost strategy to boost the maritime supply chain sector. Ranking of all the 25 strategies is S24>S17>S15>S22>S5>S21>S20>S10>S14>S13>S8>S16>S9>S23>S2>S1>S11>S6>S4>S7>S12>S3>S19>S25>S18, where, S24 possesses rank one and S18 secured the least rank and other strategies have gained ranks in descending order (refer table 6.8).

6.4.1 Identification and development of dedicated feeder and hub ports infrastructure (S24)

Transshipment traffic is a certain amount of freight that is transported between a transshipment port in India and a hub port located in a different country. Many of the ports in India, especially on the eastern coast, do not have the required draft and other infrastructure capabilities to handle the latest-generation ships, and therefore, these ports mostly compete with each other for the same amount of cargo, that means they are not trying to get India bound cargo back from ports in other countries but rather fighting for the same share of cargo which is handled by them. On the back of immense growth in container volumes in the last two decades, there seems to be a colossal opportunity to build the transshipment hub

and feeder port infrastructure in India, perhaps one each on the East and West coast. The key requirements of feeder and transshipment hubs are to minimize transport costs using a ‘hub and spoke' system, less requirement for dredging, and the infrastructure to accommodate bigger size vessels. Therefore, the need is to look for feeder and hub ports on both coasts with deeper drafts. The foremost benefits of establishing a hub port would be a significant decrease in feeder time, the revenue from the transshipment operations and freight traffic from/to the hub port moving faster and at cheaper rates.

A study performed by Kavirathna et al. (2018) and Wang and Yeo (2019) suggest that how Port of Colombo has battled with some of the prominent ports in the South Asia region such as Port of Singapore Authority, Port Klang, and Port of Tanjung Pelepas in the race to become leading transshipment hub port. Despite geographically being in a significant position, no India port has ever been able to gain the status of transshipment port. Jawaharlal Nehru Port (or JNPT) is the largest container port in the country which is ranked 28th globally (Colombo, the biggest competitor at 22nd rank globally). Colombo accounts major chunk of India’s transshipment volume which is 48%, whereas Singapore handles 22% and Malaysia’s Port Klang 10% of India’s international cargo. India’s long coastline is full of ports (consists of 13 major and around 200 non-major ports) but the role of these ports is not defined. As mentioned earlier, about 75% of transshipment cargo at Colombo is India bound. This means around 3.5 million TEUs of India’s containerized cargo is handled by the Colombo port. The additional cost is $80-100, or ₹5,000-6,500, per TEU, which wouldn’t have been incurred if the containers could imported/export directly from Indian ports. An estimated $400 million of the extra cost paid by shippers in 2019-20. Mentioned loss is a result of a lack of dedicated feeder and hub port infrastructure. For that reason, S24 i.e., “Identification and development of dedicated feeder and hub ports infrastructure” has gained the first rank in the analysis which indicates that it is highly necessary to develop dedicated feeder and hub ports in order to save millions of dollars extra

costs and save the interest of Indian ports and shippers and other actors and stakeholders across the maritime supply chain.

6.4.2 Competitive port charges (S17)

The central government and other relevant bodies in India are working hard to convert some of their strategically located ports into regional, feeder, and transshipment hubs, but this goal is impeded by one major deterrent in this way i.e., port charges for mainline calls. The country's foremost industry association, the Associated Chambers of Commerce and Industry of India (ASSOCHAM), in a paper filed in June 2019 with the Ministry of Ports, Shipping and Waterways, mentioned how so inflated port tariffs make Indian ports uncompetitive compared to rivals in the competition to lure more big-size port calls. This study, apparently based on the input procured from industry, revealed that rival transshipment hubs such as Colombo, Jebel Ali, Singapore, and Port Klang offer considerably lower marine charges than those at Jawaharlal Nehru Port Trust (JNPT), Mundra, and Pipavav – which are the three busiest west coast gateways. Marine charges consist of port dues, berth hire, and pilotage fees. When it comes to cargo-related charges, Indian ports are also costlier compared with their rivals. The cargo-related charges typically cover stevedoring, wharfage, and demurrage. The study submitted by ASSOCHAM demonstrates cost differences are much inflated for newer terminals at ports like JNPT and Mundra. For instance, a port call with 2,500 container moves, at Nhava Sheva terminal (NSIGT) and PSA International's Bharat Mumbai Container Terminals (BMCT) the unit cost per container move to $128 on average. Whereas, Port of Colombo costs around $76 per container move, which is very competitive against Indian ports. Similarly, Jebel Ali, Port Klang, and Singapore are substantially competitive against Indian ports, costing carriers $72, $49, and $82, respectively, per container move.

As Baert and Reynaerts (2020) say, port charges are one of the key factors that influence the decision-making of the users when it comes to the selection of the ports. Ports with competitive charges will be able to lure more and more shipping

lines and shippers. Just because port charges at Colombo are lower than some of the well-performing Indian ports, shippers choose Colombo port over Indian ports. This directly impacts the reputation and productivity of the Indian ports. If the port charges in India will be competitive compared with other ports in the region, then the sector will be available to attract more and more foreign investments and this will help in raising revenues through the maritime supply chain sector. Port charges (whether related to vessel or cargo) at major ports are set by TAMP (Tariff Authority for Major Ports) in India which are non-negotiable, however, port charges at non-major ports (private ports) are negotiable some clients even get up to 20% discount on tariff if the volumes are huge. This is one of the major reasons for shifting cargo volumes from major ports to private ports. In this analysis, the S17 i.e., competitive port charges category of strategy gained the second rank.

6.4.3 Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system, etc. (S15)

Sluggish adoption of the latest technological changes is a noticeable and conspicuous bottleneck. Understanding among industry actors and stakeholders about the economic benefits of using the latest technology is low, and therefore, collaborations to import modern-day technologies are very rare. Which is why, the maritime supply chain network is hassled with operational inefficiencies, unproductive system and poor utilization of the available assets. Lack of required latest technologies and inadequate technical expertise are two add-on constraints. Over the years, technological infrastructure in the maritime supply chain sector has remained inefficient and outdated, slow speeds of the network, feeble performance, and untrustworthy hardware and software, where all the above-mentioned constraints lead to inflated costs, inefficiencies, and substandard performance. Technologies like Global Positioning System (GPS) and Radio-frequency Identification (RFID) systems are being adopted and utilized to give actors and stakeholders instantaneous intelligence on the geographic status of their cargo. The adoption of GPS and RFID helped make the logistics ecosystem

more responsive. The foremost benefits of GPS and RFID for the actors and stakeholders is to forecast delivery times and improvise asset utilization, it also allows customers to instantly trace their shipments. Modern technology is revolutionizing the maritime supply chain sector by installing unmanned electric/other clean fueled cranes, unmanned vehicles/AGVs (Automated guided vehicle), and other technological advancements to accelerate loading and unloading of vessels, transparency, tracking, safety, and security of the cargo in the entire maritime supply chain. With modern cranes and other equipments, the turnaround time of the vessels will be minimized, and also productivity and efficiency will be enhanced in the entire maritime supply chain. Ports in India must learn from the top-most modern ports in the world which are doing well in terms of productivity and efficiency, for instance, Port of Shanghai, Port of Singapore Authority, Port of Shenzhen, Port of Hong Kong, and Port of Busan. For that reason, the analysis performed using Fuzzy TOPSIS indicates S15 i.e., Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system, etc. to be the third most critical strategy that should be implemented in order to overcome the impact of many barriers.

6.4.4 Dedicated Freight Corridors or DFCs (S22)

The newly built dedicated freight corridor in India has two arms which are; the 1,840 km long Eastern Dedicated Freight Corridor (EDFC) that starts from Sahnewal (outskirts of Ludhiana) in Punjab state and ends at Dankuni (Hooghly district) in Bengal. The other arm is about 1,500 km long which is called Western Dedicated Freight Corridor (WDFC) from Dadri (Gautam Buddha Nagar district) in Uttar Pradesh state to JNPT in Mumbai. Why DFCs are important because freight trains currently running on the Indian Railway network and this leads to congestion on rail tracks. In case of delays, passenger trains are given importance over freight trains and the tracks are cleared for them, this slows down the transportation of cargo. The primary aim of the DFCs is to decongest the rail network and speed up the average transit time of freight trains. Freight trains in India experience uncertain running times and low average speeds of about 25

kmph, but on DFCs, they will achieve an average of 50-60 kmph. At present, about 70% of the freight rakes are running on the regular Indian Railway network are planned to shift to the new being constructed dedicated freight corridors, freeing up the rail network for more passenger trains. DFCs bring notable chances for freight logistics in India. However, the important thing is the growth of containerized freight traffic in India which largely depends upon industrialization and trade growth, and also the evolution of economic zones and industrial corridors. To take advantage of the full capability of the dedicated freight corridors, the add-on requirement is rolling stock that can take benefit of the risen axle loading capacity. On the Eastern Dedicated Freight Corridor (EDFC), the reliance on coal traffic would be worrisome since there could be troublesome amendments on the sources of energy in the long run. Moreover, the likelihood of growing containerized freight traffic could be impacted notably since the EDFC would allow single stacking only. Altogether, the DFCs possess the capability to act as a game-changing factor for the Indian economy. Therefore, considering all the facts mentioned above, this study concluded S22 i.e., "Dedicated Freight Corridors or DFCs" fourth censorious strategy that needs to be considered on an urgent basis in order to subjugate the impact of multiple barriers.

6.4.5 To develop Inland Waterway (IW) network (S5)

Since ancient times, rivers and canals have served us as effective waterways, transporting people and moving goods over long hauls. At present times, a lot many countries e.g., Germany, Austria, Netherlands, France, China, Canada, Russia, and United States are heavily dependent on inland waterways networks, especially for containerized cargo as it is a low-cost, more reliable, and green mode of freight transportation. The National Waterways Act 2016 has declared 111 rivers and other water bodies in India as National Waterways. India is in the developing stage of this economical and less polluting mode of freight transportation. Currently, the major share of inland freight is moved through railways and roadways and this jams the entire railroad network. Congested road and rail network leads to slower movement of freight, accidents, pilferage of in-

transit cargo and increases logistics cost. Inland waterway network has no continuous connectivity. It requires a multimodal network comprising water bodies and roadways, including culverts, bridges, etc., to be developed. This involves investment in a large number of activities to be carried out for infrastructure development. Inland waterways (IWs) have been granted a leading role in the maritime supply chain sector development in India. According to the National Waterways Act 2016, a total of 111 rivers or river stretches, creeks, and estuaries are announced as National Waterways in India. The use of water bodies for navigation through smaller vessels has been around for thousands of years, and therefore, inland waterways are playing a significant role. The use of inland waterways network should be nearer to ports, coastal areas, and places where there is a scope of it. In the future, the inland waterways are also planned to be connected to the eastern and western Dedicated Freight Corridors (DFCs). These future linkages are proposed in a way that containerized freight can be exchanged from and to the road transport, DFCs, and inland waterways. The future aim of the inland waterways is to connect industrial hubs and infrastructure projects in India. A well-organized inland waterways network could bring a foundational adjustment in the maritime supply chain domain of the country. It portrays a ready-made infrastructure network, which can be used without injecting any additional capital expenditure. The inland waterways network in India needs no greenfield funding, but only capital expenditure for customization and updating. Inland Waterways have the ability to decongest highways by shifting cargo and this will also help in decarbonizing the environment – which is of greater importance for a developing country like India. One forecast benefit of inland waterways is that it does not confront problems related to the acquisition of land, which has always been a delicate matter, resulting in time and cost overshoots of critical projects. The huge investment that a country like India requires to construct its road network can be supported through improved utilization of the inland waterways. The regulatory bodies can impose charges for the users to gather expenses that will incur for the regular maintenance of the inland

waterways. Because of all the above reasons, the analysis performed in this study concludes S5 i.e., “To develop Inland Waterway (IW) network” as the fifth censorious most strategy.

6.4.6 Implementation of key digital technologies throughout the maritime supply chains (S21)

The key digital technologies are; the Internet of Things (IoT) which means a web of tangible objects or things that are implanted with software, sensors, and other latest technologies for linkages and data transactions with other machines and networks over the Internet. A distributed ledger is yet another technology which means a database that is collaboratively distributed and harmonized covering numerous sites, organizations, or geographies, reachable by several individuals. Then comes, advanced analytics which means organized computational examination of data. It is employed for the detection, elucidation, and transmission of relevant sequences in data. Thereafter, machine learning (ML) is a branch of artificial intelligence (AI) that focuses on developing data learning applications and enhance their precision without being programmed for that over a period of time. Machine Learning is a science of making computers learn and implanting humans like brains in them. Further, 3D printing means a method of manufacturing three-dimensional solid products from a digital print. 3D printing allows us to create complicated structures consuming less amount of raw material than conventional manufacturing procedures. Moving on, 5G mobile internet which is the 5^{th} generation of mobile network. 5G internet allows a new type of system that is delineated for virtual linking of everyone and everything jointly that includes gadgets, objects, and modern-day machines. Next is cybersecurity which is the exercise of protecting electronic systems, computers and mobile devices, confidential data, and servers from malevolent hacks and attacks. Lastly, cloud computing i.e., on-demand accessibility of resources of a computer system, mainly storage of data and calculating power, with no straight active involvement of the user. In maritime supply chains of containerized freight, technology escort in better pricing and customized solutions, better integration among stages in the

maritime supply chain, and additional data-driven products and services. Not only this, but the foremost benefit of these key technologies for a growing country like India is that these technologies help immensely in subjugating the impact of barriers. Implementation of the above-mentioned technologies in the maritime supply chains helps in overcoming visible and invisible threats associated with orthodox methods/procedures followed in the transportation of containerized freight. For instance, advanced analytics and the Internet of Things (IoT) could deliver end-to-end consignment transparency - the pharmaceutical industry is one example where temperature-sensitive commodities require continuous tracing. As a result of the above-discussed reasons, the analysis performed in this study concludes "Implementation of key digital technologies throughout the maritime supply chains" or S21 to be the sixth most important strategy for subjugating the impact of barriers.

6.4.7 Modern rail technology to increase productivity and efficiency of the entire maritime supply chains (S20)

The success of Indian Railways is a foremost aim for the central government, ministry of railways, other relevant government bodies, and foreign investors. Technological modernization in the Indian Railways offers transformation of currently used decades-old infrastructure to world standards. The reason behind the fall of productivity and efficiency in freight railways is the lack of development, especially, lack of modernization of railways. For a vastly populated country like India, the railway is one of the most economical modes of transport. Despite being so economical, the freight share of railways reduced drastically over time. One of the foremost reasons behind this is the lack of interest in modernizing the rail infrastructure. Indian Railways brought various policies and strategies to fascinate the foreign investors for modernizing the rail network. Why focus should be on modernization because technology will uplift asset reliability, efficiency, and productivity of the rail network. Electrification of the rail network is yet another factor that helps significantly in increasing productivity and efficiency. This is also a step to decarbonize the environment

and cut emissions from the rail transport sector. Not only this, but a modernized rail network can improvise the safety of the rail network by monitoring the rail tracks from far locations, discerning defects in the rail tracks, digitizing the track maintenance and improvements in signaling and telecommunication can help in minimizing accidents. If the rail network is modernized considering the above-argued factors then it will definitely help in subjugating the impact of barriers associated with freight railways. As a result of the above-discussed reasons, the analysis performed in this study concludes "Modern rail technology to increase productivity and efficiency of the entire maritime supply chains" or S20 to be the seventh most important strategy for subjugating the impact of barriers.

6.4.8 To develop better intra as well as inter-port logistics infrastructure (S10)

The intra and inter-port logistics infrastructure is a crucial facilitator for economic development and coastal community development in India. Despite huge investments in the last decade, India's network of roads, rail, and waterways remained inadequate to handle huge growth in containerized freight traffic. Also, the way containerized freight traffic is growing every year it will be difficult to handle it efficiently with available intra as well as inter-port logistics infrastructure. Also, the available infrastructure is not in good condition. This inadequacy in logistics infrastructure will put the maritime supply chain growth of India at risk. A major chunk of logistics infrastructure that the country requires urgently is yet to be established, and therefore, India has a good opportunity to develop infrastructure to meet the expanding demand. To accomplish this target, India must chase an amalgamated and collaborated method that gives equal importance to the growth of transport modes such as—railways, roads, and inland waterways—from an angle of inter and intra- port logistics infrastructure. To balance the transportation of containerized freight, the need is to increase the railways' share by shifting freight from roads that are highly congested. To be very specific, India must increase its utilization of rail networks and recognize the capability of its inland waterways network. With the development of intra as well as inter-port logistics infrastructure, the connectivity among ports will enhance

and there is a high possibility of transshipment as well as coastal shipping to flourish. In India, the railway is not the first alternative for moving containerized freight within and between ports as rail haulage charges are so inflated and there is a dearth of reliable scheduling for freight trains and also last-mile connectivity is poor. Rail haulage charges are so inflated because of high cross-subsidization between freight and passenger segment, passenger rates are highly subsidized and compensated from the freight segment. Likewise, inland waterways face a variety of issues—higher unit economics due to heftier first and last-mile expanses, empty backhaul voyages in the majority of the cases, heftier voyage costs for specialized freight, and vessels, and heftier repositioning cost of domestic containers among others. Considering all the above discussion, the urgent need is to develop inter and intra-port logistics infrastructure so that extra costs and high lead time can be reduced, and also, associated barriers can be subjugated. Because of all these reasons, the analysis performed in this study concludes "To develop better intra as well as inter-port logistics infrastructure" or S11 to be the eighth most important strategy for subjugating the influence of barriers.

6.4.9 Rebates and incentives to promote exports, especially in trade prospective regions in the country (S14)

In order to increase the competitiveness in the global market, the central government offers incentives, rebates, and fewer taxes for export-bound cargo. The rebates and incentives are provided considering a good amount of availability of a specific commodity. These amounts of rebates and incentives are modified according to the dearth and plenteousness of commodities. The rebates and incentives are provided to BCOs as an appreciation for earning foreign exchange, and to recompense for the infrastructural constraints faced by the BCOs. The incentives provided, ensure a higher reach of the local product and the growth of the Indian Export Businesses. It is the central government export incentives often does so in order to keep domestic products competitive in the global market. There are rebates and incentives offered by the government to promote exports such as; subsidies, easy and fast payments, low or no-interest loans, and tax relief

on profits made from exports. However, not all the actors and stakeholders in the maritime supply chains are getting benefitted from such rebates and incentives, and also, the rebates and incentives are not offered on all the commodities. Rebates and incentives help significantly in boosting exports, and that is why, the analysis performed in this study concludes "Rebates and incentives to promote exports, especially in trade prospective regions in the country" or S14 to be the ninth most important strategy for subjugating the influence of barriers.

6.4.10 Skill development programs and training to produce quality manpower (S13)

It is indispensable to say that no sector can perform efficiently with a shortage of skilled and trained manforce. The maritime supply chain industry may install the most modern machines and equipments but if the manpower handling those machines and equipments is not skilled then the overall productivity and efficiency will be impacted. The essence of the situation is that for any sector to perform up to the mark, there is a need for skilled and trained manpower with the necessary skill set. The same is the situation in the maritime supply chain sector where there is a scarcity of skilled and trained workforce. For that reason, it is vital to train manpower in order to keep them at par with most modern technological advancements. The central government in India is offering training and skills related to infrastructure development, port operations, navigational training, disaster management, etc. specific to the maritime supply chain domain. scarcity of formal education, insufficient capacity of skill training, negative perception towards training, and dearth of industry-ready skills even in professional studies are the foremost reasons for the unskilled labor workforce in India. A huge number of skilled professionals migrate to developed countries for better remuneration and facilities. This migration is yet another reason for the scarcity of skilled and trained manforce in India. Because of all these reasons, the analysis performed in this study concludes "Skill development programs and training to produce quality manpower" or S13 to be the 10^{th} most important strategy for subjugating the influence of barriers.

Actors in the maritime supply chains of containerized freight should execute at least these top 10 strategies on a priority basis i.e., in the order of their ranks. This integrated approach helps decision-makers to analyze and choose a pertinent list of strategies for obliterating barriers present in the maritime supply chains of containerized freight. Once these most relevant top 10 strategies are executed, the actors should move on to adopt the next 10 strategies. This way, a lot of financial and operational burden will be managed and the impact of barriers will be subjugated from the entire maritime supply chains.

6.5 Sensitivity Analysis

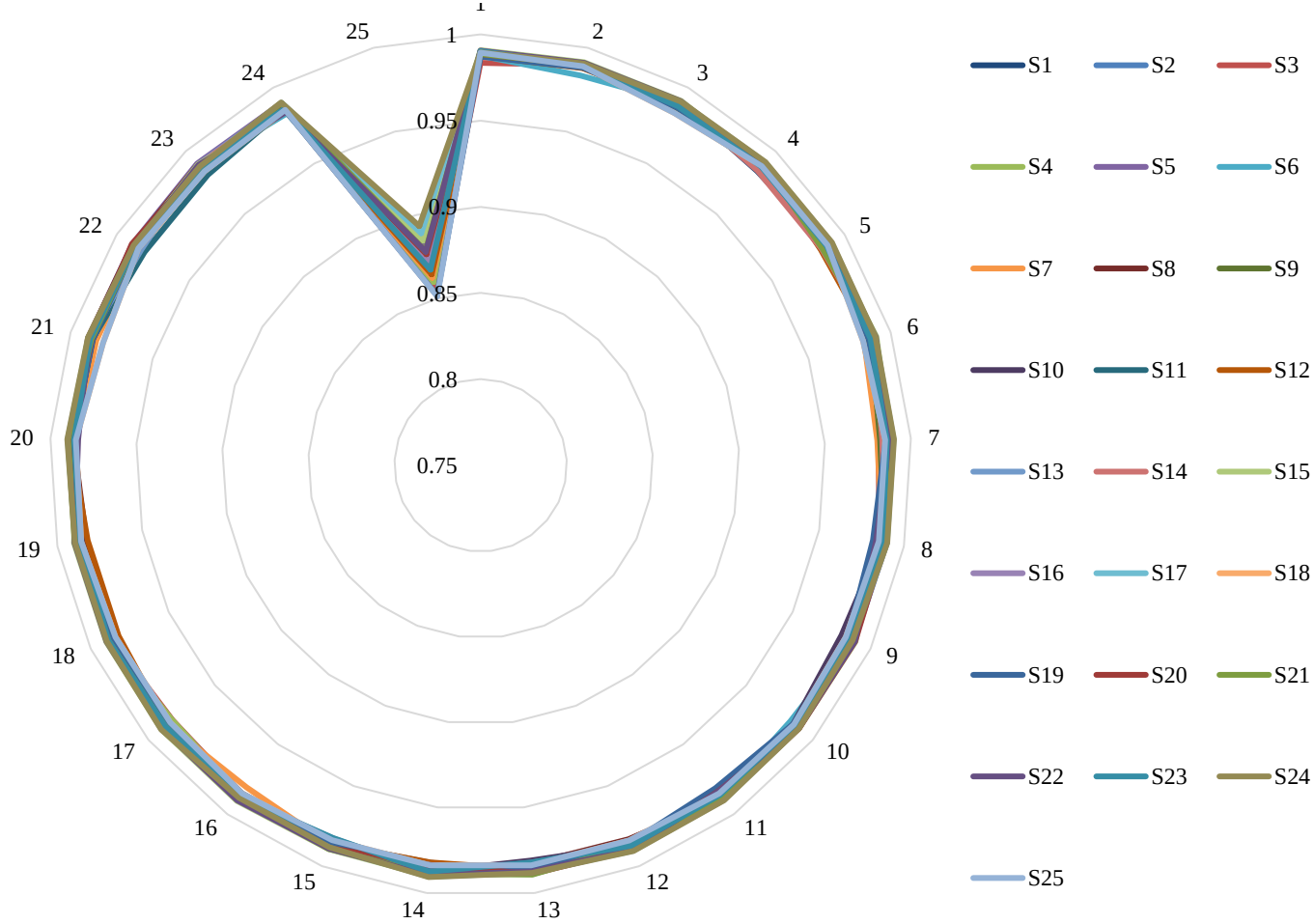
Sensitivity is exercised to assess the resilience of the propounded framework. It imparts a greater perception of the reasons for prioritizing the strategies to overcome maritime supply chain adoption barriers. Moreover, it provides insight into why the proposed integrated system has ranked specific strategies. Variation in the final ranking of the strategies is observed by changing the weight of a specific barrier (Vishwakarma et al.; 2019, Prakash and Barua; 2016c, and 2016d). For this, twenty-five experiments have been run as highlighted in table 21. To perform this maximum weight value barrier is replaced while other barriers' weight remains constant. In experiment 1, the value of the barrier EB1 (WEB1) = 0.65 and values of the rest of the 46 barriers that are WEB2-WOB7 = 0.025, remains identical. Hereafter, CC_i weights are obtained. Similarly, in experiment 2, the value of the barrier EB2 (WEB2) = 0.65 and the value of the rest of the 46 barriers that are WEB1, WEB3-WOB7 = 0.025 remains identical and CC_i weight is obtained to receive the priority list. The same approach is applied to 24 experiments. In the last experiment the value of all barriers are presumed identical i.e., WEB1-WOB7 = 0.45 then CC_i weight is obtained to receive a priority list as highlighted in table 21. The overview of the sensitivity runs is highlighted in the figure 6.3. The results of the sensitivity run highlight that S24 has a maximum weight value in eleven runs out of 25 runs. It suggests that the applied integrated approach is less sensitive.

Table 6.9 Sensitivity Runs

Run	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25
1	0.989	0.988	0.983	0.990	0.989	0.988	0.989	0.990	0.990	0.989	0.990	0.988	0.988	0.989	0.991	0.991	0.989	0.989	0.987	0.989	0.989	0.990	0.990	0.990	0.989
2	0.988	0.990	0.990	0.989	0.989	0.983	0.990	0.991	0.990	0.991	0.989	0.988	0.990	0.990	0.991	0.990	0.990	0.989	0.988	0.990	0.990	0.991	0.989	0.991	0.989
3	0.990	0.989	0.990	0.987	0.990	0.990	0.989	0.990	0.988	0.990	0.984	0.988	0.990	0.990	0.991	0.988	0.991	0.983	0.987	0.991	0.990	0.991	0.988	0.991	0.983
4	0.984	0.988	0.989	0.987	0.990	0.990	0.988	0.990	0.989	0.990	0.988	0.990	0.990	0.985	0.989	0.988	0.991	0.988	0.988	0.990	0.990	0.989	0.988	0.991	0.988
5	0.988	0.989	0.990	0.987	0.990	0.984	0.989	0.990	0.988	0.988	0.989	0.984	0.988	0.984	0.989	0.988	0.991	0.988	0.988	0.990	0.985	0.989	0.988	0.991	0.988
6	0.989	0.988	0.987	0.989	0.991	0.990	0.984	0.989	0.988	0.984	0.984	0.988	0.990	0.990	0.991	0.988	0.991	0.983	0.987	0.991	0.990	0.991	0.988	0.991	0.983
7	0.983	0.982	0.981	0.986	0.988	0.988	0.981	0.987	0.982	0.985	0.985	0.988	0.989	0.983	0.988	0.986	0.990	0.985	0.985	0.989	0.990	0.988	0.986	0.990	0.985
8	0.988	0.986	0.985	0.988	0.990	0.989	0.987	0.989	0.989	0.987	0.985	0.988	0.990	0.989	0.984	0.988	0.990	0.985	0.982	0.989	0.989	0.984	0.987	0.990	0.985
9	0.989	0.986	0.988	0.988	0.989	0.989	0.986	0.988	0.986	0.981	0.986	0.988	0.989	0.988	0.990	0.986	0.988	0.984	0.985	0.990	0.987	0.990	0.986	0.988	0.984
10	0.987	0.988	0.988	0.986	0.989	0.983	0.986	0.989	0.986	0.985	0.987	0.989	0.989	0.990	0.990	0.987	0.989	0.986	0.985	0.990	0.989	0.989	0.986	0.990	0.986
11	0.987	0.987	0.986	0.986	0.990	0.988	0.986	0.989	0.988	0.987	0.986	0.988	0.987	0.989	0.984	0.986	0.990	0.985	0.982	0.984	0.989	0.984	0.986	0.990	0.985
12	0.987	0.988	0.988	0.988	0.990	0.987	0.987	0.983	0.986	0.987	0.986	0.988	0.987	0.989	0.990	0.988	0.990	0.984	0.985	0.989	0.987	0.990	0.987	0.991	0.984
13	0.987	0.988	0.987	0.989	0.988	0.987	0.986	0.983	0.986	0.981	0.986	0.986	0.989	0.983	0.988	0.982	0.988	0.984	0.987	0.989	0.989	0.987	0.982	0.988	0.984
14	0.987	0.982	0.986	0.988	0.990	0.989	0.987	0.989	0.988	0.988	0.985	0.982	0.984	0.987	0.990	0.988	0.990	0.984	0.987	0.984	0.989	0.990	0.987	0.991	0.984
15	0.989	0.986	0.987	0.989	0.989	0.988	0.987	0.988	0.988	0.985	0.987	0.986	0.987	0.989	0.989	0.983	0.988	0.984	0.985	0.989	0.989	0.989	0.982	0.988	0.984
16	0.987	0.987	0.985	0.986	0.988	0.988	0.981	0.988	0.988	0.985	0.986	0.988	0.987	0.989	0.990	0.988	0.988	0.985	0.987	0.989	0.989	0.990	0.988	0.988	0.985
17	0.987	0.982	0.982	0.982	0.988	0.989	0.986	0.988	0.988	0.987	0.987	0.986	0.989	0.989	0.990	0.988	0.990	0.984	0.985	0.988	0.987	0.990	0.987	0.990	0.984
18	0.989	0.988	0.987	0.989	0.988	0.988	0.985	0.988	0.988	0.987	0.987	0.982	0.989	0.990	0.990	0.989	0.989	0.984	0.986	0.989	0.989	0.990	0.989	0.990	0.984
19	0.987	0.986	0.987	0.988	0.984	0.987	0.984	0.983	0.986	0.985	0.986	0.982	0.987	0.988	0.990	0.987	0.989	0.986	0.987	0.989	0.990	0.990	0.986	0.990	0.986
20	0.988	0.986	0.988	0.989	0.989	0.987	0.986	0.987	0.988	0.987	0.987	0.989	0.989	0.989	0.984	0.986	0.990	0.985	0.987	0.987	0.990	0.984	0.986	0.990	0.985
21	0.987	0.988	0.988	0.988	0.989	0.989	0.984	0.989	0.988	0.986	0.987	0.987	0.989	0.989	0.989	0.988	0.989	0.980	0.987	0.987	0.987	0.989	0.988	0.990	0.980
22	0.987	0.986	0.988	0.989	0.989	0.986	0.984	0.989	0.988	0.987	0.981	0.986	0.983	0.987	0.988	0.988	0.988	0.985	0.987	0.990	0.987	0.988	0.988	0.988	0.985
23	0.987	0.988	0.988	0.988	0.990	0.988	0.985	0.989	0.986	0.987	0.981	0.988	0.989	0.989	0.989	0.988	0.988	0.984	0.987	0.987	0.987	0.989	0.987	0.988	0.984
24	0.989	0.987	0.987	0.986	0.990	0.983	0.985	0.987	0.986	0.987	0.986	0.987	0.989	0.989	0.984	0.986	0.990	0.985	0.985	0.987	0.990	0.984	0.986	0.990	0.985
25	0.868	0.866	0.856	0.860	0.879	0.863	0.862	0.872	0.869	0.874	0.867	0.864	0.874	0.875	0.885	0.871	0.889	0.852	0.852	0.877	0.878	0.878	0.867	0.893	0.851

Source: Author's composition

Figure 6.3 Results of sensitivity runs



Source: Author's composition

6.6 Chapter summary

This chapter discussed the methodology and conducted the analysis with data obtained on strategies to overcome barriers in the maritime supply chains of containerized freight. To calculate that ranking of the strategies, the Fuzzy TOPSIS technique was employed. The results accomplished at each stage were demonstrated clearly and in a detailed manner. The preference weights and ranks gained by each strategy were based on the level of criticality they possess. Also, the top 10 ranked strategies were discussed in brief in this chapter, and thereafter, sensitivity analysis was performed to check the robustness of the overall framework. The next chapter concludes the overall research and provides a path for future research.

Chapter 7

Conclusion and future research

Overview

This chapter discussed a complete summary of the research carried out in this thesis report. The predominant inferences and results have been discussed in detail. In detail contributions to the existing literature and practical suggestions from the findings of this study are exhibited in this chapter. Also, limitations of this study and the future scope of the researched subject are also argued.

7.1 Introduction

The maritime supply chains (or MSCs) are not only supporting trade but are also an essential element of socio-economic development and prosperity. However, the presence of barriers in the maritime supply chains has slowed the overall socio-economic growth of the country. The occurrence and influence of barriers is a cause of concern for policymakers, government, investors, actors, and stakeholders.

However, understanding the nature and status of the maritime supply chains of containerized freight in India was a challenge in itself because of the lack of relevant literature, experts, and knowledge. For that reason, chapter four was based on understanding the maritime supply chains and the actors and stakeholders active in this domain.

Because India is a developing country and maritime supply chains are also in the developing stage, there hardly exists any study on the maritime supply chains of containerized freight in context to India. However, from available literature (which is very little) and consulting domain experts, it was learned that the maritime supply chains are crippled with the presence of barriers. And therefore,

available literature and domain experts helped in the identification of a set of categories and sub-categories of barriers which were evaluated using the Fuzzy AHP technique of MCDM. Barriers were prioritized considering the criticality level of each of them. This was chapter five.

Just identification and prioritization of the barriers is not enough, and therefore in chapter six, a set of 25 strategies were discerned in order to subjugate the impact of barriers. Thereafter, these strategies were analyzed using the Fuzzy TOPSIS method of MCDM.

7.2 Contributions of this research to literature

7.2.1 Identification and evaluation of barriers in the maritime supply chains of containerized freight using Fuzzy AHP framework.

- Through Delphi survey and in-depth analysis of existing literature, this study has identified the six categories and 46 sub-categories of barriers that impact the maritime supply chains of containerized freight.
- With the help of the Theory of Constraints (ToC), this study also defined how the existence of barriers impedes the smooth flow of containerized freight in the maritime supply chains.
- These identified barriers are then analyzed using the Fuzzy AHP method that allocates preference weight to each of the category and sub-category of the barriers.
- On the basis of preference weight, the categories and sub-categories of the barriers are ranked, which means, the most critical will obtain rank one and the least will acquire the lowest rank.
- The top management of the actors and stakeholders of the maritime supply chains should start with understanding the nature and impact of top-ranked barriers.

- Once the influence of top-ranked barriers is understood, management should then study other lower-ranked barriers.
- The practical implications of the results of this study are for the top management of actors and stakeholders, strategists, policymakers, and decision-makers. The cognizance of the barriers and how they impact the productivity, efficiency, and profitability of the actors and stakeholders in the maritime supply chain sector, is argued concisely.
- It is necessary and responsibility of the top management to ensure that these barriers are kept under control so that the situation does not become precarious. Management needs to be alert on when the internal and external conditions change and influence these barriers.

7.2.2 Identify the strategies to subjugate the impact of barriers in the maritime supply chains and assess them using the Fuzzy TOPSIS technique.

- As with barriers, a total of 25 strategies are discerned with the help of the Delphi survey and through a thorough assessment of available literature.
- The strategies are identified in such a way that they tend to subjugate the impact of all the categories and sub-categories of the barriers.
- Thereafter, the strategies are evaluated using the Fuzzy TOPSIS method that allocates preference weights to each of the strategies and ranks them on the basis of the criticality level they possess.
- Therefore, this study propounds Fuzzy AHP-TOPSIS integrated framework to rank barriers and evaluate the strategies to subjugate these barriers. The work done is completely unique, however, Zhang and Lam (2019), Venkatesh et al. (2017), and Yuen and Thai (2017) have followed a somewhat similar approach but totally in different contexts.
- This integrated framework can be used by analysts, strategists, decision-makers, policymakers, industrial managers, and other stakeholders to evaluate the influence of barriers on the maritime supply chains of

containerized freight. Not just this but the analysis will help the actors and stakeholders to figure out severe barriers and resolve them in order to make the entire process smooth.

- The Fuzzy AHP-TOPSIS integrated framework developed in this study is unique and has not been performed earlier for the maritime supply chains of containerized freight in India.

7.2.3 Theoretical implications and contribution of this research

This research offers an innovative and unique analytical and methodological approach for assessing barriers in the maritime supply chains of containerized freight and evaluating discerned strategies to overcome the impact/influence of these barriers. After screening all the existing literature, it was realized that no study was conducted to analyze barriers in the maritime supply chains of containerized freight in India. In fact, this study is the first of its type which has addressed the six categories of barriers which are; Economic, Legal, Technological, Administrative and Political, Infrastructural, and Organizational. The selection of key barriers is thoroughly performed by reviewing literature and confirmed through the maritime supply chain domain experts. It is clearly a more comprehensive integrated approach compared to the earlier ones where barriers were evaluated. The propounded categories and sub-categories of the barriers have predominantly covered prominent managerial and operational aspects such as; operational and non-operational, financial and non-financial, research and development, quantitative and non-quantitative, etc. Considering all the mentioned arguments, the Fuzzy AHP-TOPSIS integrated framework-based approach is unique and applied for the first time on barriers and strategies in the maritime supply chains of containerized freight in India. One of the domain experts in the Delphi panel gave the below statement on the theoretical implications of this study;

"Amid crippling maritime supply chain sector in India, this study may act as a boon as it has many implications. For instance, this study is the first of its kind

just like pilot research which will pave a way for future studies. There is very little literature available on barriers in the maritime supply chains of containerized freight, and therefore, this study will establish a base for future research scholars and industry researchers as well. It is not that the actors and stakeholders like the government are not aware of the presence of barriers, they are well aware, but there existed no study (prior to the current study) which systematically integrated knowledge of domain experts with academic aspect to rank those barriers."

Furthermore, rather than just focussing on the barriers, this study also discerned strategies and assessed them so that the actors and stakeholders can get a complete package. All in all, this research is a serious attempt to break the silence on barriers in the maritime supply chains of containerized freight, the critical problem which remained unanswered to date. Moreover, this study is among rare contributions which establish a theoretical and analytical framework to discern categories and sub-categories of barriers, to comprehend how they interact with each other, to discern 25 important strategies, and to rank barriers and strategies using integrated Fuzzy AHP-TOPSIS integrated framework. This study has significant additions to the existing literature. For instance, this study adds to the available literature by associating strategies to subjugate the influence of barriers in maritime supply chains of containerized freight in context to India. There are some studies that discern and evaluate the barriers such as; Kouhizadeh et al. (2021), Gupta et al. (2020), Tumpa et al. (2019), and Mangla et al. (2019). However, analyzing barriers in maritime supply chains of containerized freight, ascertaining strategies and the significance of those strategies to subjugate barriers does not exist in literature. Furthermore, this study is the first of its kind which is conducted on the maritime supply chains of containerized freight. This study has made two important contributions. First, most of the studies in operations and supply chain management are executed in the context of a particular sub-sector or large firms, and there exists no study that covers the entire maritime supply chain domain. Therefore, the current study augments the insufficient literature on the MSCs. Second, the existing literature is very less in the context of developing

nations, especially India. Considering socioeconomic differences, the findings obtained in the context of a developed nation may not be relevant to the maritime supply chain sector of a developing nation. Hence, by considering India's maritime supply chain sector, the current study adds to the literature in context to a developing nation.

7.2.4 Managerial and practical implications of this research

The results of this study possess notable practical implications, especially for actors and stakeholders in the maritime supply chain sector. This research discerns and segregates barriers into categories and sub-categories relevant to containerized freight trade. This study identifies a list of six categories and 46 sub-categories of barriers that are prevalent in the maritime supply chain sector. The domain experts have approved the set of barriers and have rated their impact as well. These findings give a chance to actors and stakeholders in the maritime supply chain domain to review and understand the situation of barriers. Further, the results can advise actors and stakeholders to recognize the censorious barriers so that the most critical ones can be focussed and eliminated. As discussed above, the barriers are assessed with the help of the Fuzzy AHP method, which is the most relevant technique to evaluate available data. The analysis concludes infrastructure barriers (IFBs) to be the most critical, followed by legal barriers (LGBs). Similarly, among sub-categories, LGB2 i.e., "Unsupportive laws, regulations and government policies for the actors in maritime supply chains" obtained the first rank, followed by TEB2 i.e., "Lack of seaport modernization in terms of technology". Whereas, ECB2 i.e., "Barriers to entry and expansion in maritime supply chain business" scored the third rank.

After analyzing the barriers, this research also discerns and prioritizes a list of 25 strategies that help professionals to subjugate the impact of barriers. The prioritization of the barriers is done through the Fuzzy TOPSIS method. This way an integrated Fuzzy AHP-TOPSIS framework is established. This framework can be used by the actors and stakeholders in the MSCs to discern and emphasize the

most efficacious strategies, as it is tough to uphold feasibility in the present-day tremendously competitive market. The actors and stakeholders in the maritime supply chain domain need to implement the prioritized strategies in order to remain strong during financial distress-like situations and to gain efficiency in the operational and managerial aspects. The analysis concludes S24 i.e., "Identification and development of dedicated feeder and hub ports infrastructure", S17 i.e., "Competitive port charges" and S15 i.e., "Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system, etc." to be the first, second and third, respectively, most critical in nature. The ranking of barriers and strategies acts as operational instruction to decide what to do next. The industry managers, strategists, and policymakers must attentively monitor and control the top critical categories and sub-categories of barriers by applying strategies accordingly. The prioritization and ranking of barriers and strategies done in this research will help the industry managers, strategists, and policymakers in strategic decision-making to subjugate the impact/influence of barriers.

The presence of barriers is putting operational and financial pressure on the smooth working of the maritime supply chain network. The segregation of barriers into categories and sub-categories will help the actors and stakeholders to understand the nature of the barriers and how they impact their business. Just the identification of barriers into proper categories and sub-categories format (which was not done earlier) will clarify many doubts. By just identifying the barriers, the actors and stakeholders will be able to either avoid the involvement of those barriers or will be able to eradicate those barriers, to enhance the performance of their part in the entire maritime supply chains. However, it is not that easy. Therefore, this study prioritized the barriers on the basis of their criticality by deploying the Fuzzy AHP technique. Now, with the ranking of each category and sub-category of the barriers, it became easy for the actors and stakeholders to comprehend the critical categories and sub-categories of the barriers. Also, the actors and stakeholders can differentiate on how the most critical ones

impact/influence their part in the entire maritime supply chains. This study will also help the actors and stakeholders in understanding how these barriers interact with each other and how they are connected to each other. Additionally, a set of 25 strategies is discerned and then ranked using the Fuzzy TOPSIS technique so that the most relevant and impactful can be brought ahead of others. This will help the actors and stakeholders to understand the strategies that need to be imposed/implemented on an urgent basis, especially to counter censorious categories of the barriers. Hence, this study acts as a complete guide for the actors and stakeholders to identify the barriers and subjugate them with the right strategies. Sensitivity analysis is performed on both Fuzzy AHP and Fuzzy TOPSIS stages in order to check whether the whole framework is robust and workable. As the business problem suggests that because of the presence of barriers, shippers are experiencing $400 million of extra expenses, however, if the right strategies are implemented, then those unnecessary expenses will be reduced. Likewise, many others unwanted costs and operational fatigues will be either minimized or completely subjugated. One of the domain experts in the Delphi panel gave the below statement on managerial and practical implications of this study;

"Many of the actors and stakeholders such as shipping lines and port operators were direly waiting for this type of study which has direct implications on their business. India is a developing country and the maritime supply chain sector is also being developed gradually. Therefore, no one can deny the existence of barriers in the maritime supply chains of containerized freight in India, as we look at the set of a business problem and research problem. All inclusively, this study is a complete package because it not just ranks the categories and sub-categories of the barriers but also prioritizes the 25 identified strategies in order to subjugate the impact/influence of barriers."

This study has some vital inferences for strategists, decision-makers, policymakers, and academicians who are into the maritime supply chain domain. Not only this, the study holds massive implications to the manufacturing sector in

India as they are the directly involved actors in the maritime supply chains. Many a time, manufacturing firms do not have the required knowledge and expertise of the maritime supply chains and because of this, the impact of barriers gets multiplied. This impacts the overall efficiency and productivity of the manufacturing firms. The presence of barriers in the maritime supply chains impacts the manufacturing index of India, which is around 55 points in April 2021. Similarly, India is ranked 44th in Logistics Performing Index (LPI) with an LPI score of 3.15. The current research espouses an integrated framework to the actors and stakeholders to work on overcoming these barriers. The decision-makers, policymakers, strategists, and regulatory bodies of the developing nation can benefit significantly from this research in a way that they can examine this integrated framework in different industries in order to comprehend the influence of prevailing barriers. By testing this framework, the policymakers can emphasize capacity building of various transport modes under the maritime supply chains.

7.3 Recommendations and Conclusions

7.3.1 Identification and analysis of barriers in the maritime supply chains of containerized freight using Fuzzy AHP technique and identification of strategies to subjugate the impact of barriers.

The industry managers, decision-makers, and strategists must acknowledge the benefits/advantages in embracing strategies to subjugate or eliminate the impression of barriers in the maritime supply chains of containerized freight. In a developing country like India, the maritime supply chains are facing operational and financial challenges and are managing issues like scarcity of resources and funds, old and obsolete technologies, unskilled labor, strict regulations and laws, unfriendly business policies, and environmental worries. India has aimed to attain a status of manufacturing hub by the successful implementation of policies like ‘Make in India’ and ‘Sagarmala’ etc. and has also identified sectors where more investments have been injected but nothing convincing is visible on the ground due to the presence of barriers. Decision-makers and strategists must understand that it is nearly impossible for India to become a manufacturing hub until and

unless the maritime supply chains are not productive, efficient, less costly and barriers free. Without this, India won't be able to attract FDIs either in manufacturing, agriculture, or even in the service sector. This research performs an empirical analysis of the barriers in various aspects like economic, technological, infrastructural, administrative and political, legal, and organizational, wherein, infrastructural barriers are predominant among all. This gives a clear idea that government should invest more in building dedicated feeder and hub ports in order to compete with ports in the neighboring countries. For instance, as discussed in the business problem, 80% of the throughput at Colombo port is India bound so why Indian ports are not able to attract this throughput. The problem lies in infrastructure, not just port and terminal infrastructure but also hinterland transport infrastructure which is under-developed. In terms of freight transport, regions like North-East India are not developed at all despite huge potential, which is why this research talks about poor ICD/CFS infrastructure and poor integration in the maritime supply chains (among different countries in a region). Similarly, because of the presence of the barriers, shippers alone are losing $400 million every year. This way, barriers are impacting the performance of the maritime supply chains as discussed earlier in the analysis and discussion section. Now, to eliminate the impact of barriers, a set of strategies is propounded in this study by reviewing the literature, consulting industry experts, and referring Drewry maritime research reports and data which is developed and maintained by the maritime experts. All this is sufficient to prove the validity and viability of this study. Hence it is recommended that in order to make the maritime supply chains of containerized freight efficient and productive, decision-makers and strategists need to execute strategies on a priority basis propounded in this study. Even the outcome of this research is confirmed by the sector specialists as effective and workable to counter barriers.

In this competitive world, it is difficult for actors in the maritime supply chains to remain sustainable. The presence of barriers puts pressure on the revenues of the actors and stakeholders, and in some cases, they may also go bankrupt. So, there

is a need for urgent remedy with which the impact of the barriers can be neutralized. A developing economy like India has its own set of problems, and therefore, executing all the strategies at once or simultaneously is different. Therefore, this study prioritized the strategies for organized implementation i.e., strategies with top ranks need to be implemented first or we can say in descending order.

This research propounds a strong MCDM framework for prioritization of the strategies to eliminate barriers present in the maritime supply chains. This is done by first identifying the barriers, and then, linguistic grading to the barriers' criteria is allocated by the expert decision-making panel. In total 46 sub-categories of barriers are identified. Thereafter, to eradicate the impact of these barriers, a set of 25 strategies are framed by following the same process as for barriers. Post this, an integrated Fuzzy AHP-TOPSIS model is exercised to attain the final ranks of the barriers and strategies. FAHP is implemented to acquire the relative weights and to prioritize the barriers, and for strategies, FTOPSIS is exercised. In this, the criteria of barriers that gained the first rank are infrastructural barriers (IFBs) - making them the most critical/severe, followed by legal barriers (LGBs). The propounded model is assisted by a case study of the maritime supply chains of containerized freight in India. Lastly, sensitivity analysis is worked out to examine the fluctuation in the decision with alteration in weights of the barriers. The foremost benefit of prioritizing strategies is to help actors and stakeholders (in the maritime supply chains) in policymaking in order to eliminate the influence of these barriers. This framework considers the uncertainty/inaccurateness of experts' feedback in the assessment process that makes this approach a sturdy framework. Further research in this direction is possible by generating a number of qualitative and qualitative characteristics.

7.3.2 An integrated framework to identify and evaluate strategies to overcome the barriers using the Fuzzy TOPSIS method.

This study not just identifies the barriers in the maritime supply chains of containerized freight but also propounds an integrated framework by discerning

strategies and assessing them with the Fuzzy TOPSIS method to subjugate the influence of barriers. Strategies are ranked to eliminate barriers which are done by perceiving the highest level of nearness coefficient value which indicates that the strategy S24, i.e., 'Identification and development of dedicated feeder and hub ports infrastructure' scored first rank and the strategy S18 which is 'Better safety and security measures at ports' received 25th rank. Wang et al. (2020), Kashiha et al. (2016), Santini et al. (2018), Yang and Chen (2016), and Wiradanti et al. (2020) also argued about the development of dedicated feeder and hub ports infrastructure as a foremost strategy to boost the maritime supply chain sector.

The results of Fuzzy TOPSIS analysis shows that the following are the top seven strategies to subjugate the impact of barriers: Identification and development of dedicated feeder and hub ports infrastructure (S24) > Competitive port charges (S17) > Modern cranes and equipments like AGVs, Automated gate systems, RFID, GPS, Ship profile scanning system, etc. (S15) > Dedicated Freight Corridors (DFCs) for containerized freight trains to the East and West coast ports from various cargo hinterlands (S22) > Effective business strategies to develop Inland Waterways (IWs) (S5) > Modern IT applications like and Internet of Things (IoT), Blockchain technology, Cloud computing, PCS and Big data analytics, etc. throughout the maritime supply chains (S21) > Modern rail technology to increase productivity and efficiency of the entire maritime supply chains (S20). Ranking of all the 25 strategies is S24>S17>S15>S22>S5>S21>S20>S10>S14>S13>S8>S16>S9>S23>S2>S1>S11 >S6>S4>S7>S12>S3>S19>S25>S18 where S24 possesses rank one and S18 secured the least rank and other solution strategies have gained ranks in descending order.

7.4 Limitations

7.4.1 Identification of evaluation of barriers in maritime supply chains of containerized freight using fuzzy AHP framework.

The barriers identified using one method of MCDM which is Fuzzy AHP and other multi-criteria decision-making approaches can be tried such as ANP, VIKOR, MAUT, DEMATEL, and BWM.

7.4.2 Identification and evaluation of strategies to subjugate the impact of barriers.

As with barriers, solution strategies are discerned and assessed using the Fuzzy TOPSIS technique which can be replaced with other MCDM methods, as mentioned above.

7.5 Scope of Further Research

7.5.1 Identification and ranking of barriers

Future studies can use the AHP method with Fuzzy logic for analyzing and ranking factors in different industries. This approach can also be tested in other countries for the aviation sector. A study can provide a comparison of the results for the airlines from different countries and show the variation of the top ten ranks of key factors among them.

7.5.2 Identification and ranking of strategies to overcome the barriers

Further studies in this area, can be made using other non-parametric methods such as neural network, decision tree analysis, Case-based Reasoning, etc. to confirm the results. Airline data from other countries can also be used to test whether there is uniformity in the influencing factors which comprise the model developed.

7.6 Chapter summary

This chapter discussed the final outcome of this study and inspect the contribution of the current study towards the subject on which the current study is performed. This section also explained how the method of ranking is used and the model

developed can be used by actors and stakeholders in the maritime supply chain sector. Additionally, this chapter explained the limitations and future scope of this study in the area of maritime supply chains.

References

1. Jarrige, J.F. and Meadow, R.H. (1980), 'The Antecedents of Civilization in the Indus Valley', Scientific American, Vol. 243 No. 2, pp. 122-137, https://www.jstor.org/stable/24966394

2. Leshnik, L.S. (1968), 'Prehistoric Exploration in North Gujerat and Parts of Rajasthan', East and West, Vol. 18 No. ¾, pp. 295-310, https://www.jstor.org/stable/29755337

3. Irwin, D.A. (1991), 'Mercantilism as Strategic Trade Policy: The Anglo-Dutch Rivalry for the East India Trade," Journal of Political Economy, Vol. 99 no. 6, pp. 1296-1314, https://doi.org/10.1086/261801

4. Bowen, H.V. (2002), 'Sinews of trade and empire: the supply of commodity exports to the East India Company during the late eighteenth century', Vol. 55, Issue3, pp. 466-486, https://doi.org/10.1111/1468-0289.00228

5. Lam, J.S.L. (2015), 'Designing a sustainable maritime supply chain: A hybrid QFD–ANP approach', Transportation Research Part E: Logistics and Transportation Review, Vol. 78, pp. 70-81, https://doi.org/10.1016/j.tre.2014.10.003

6. Lam, J.S.L. (2011), 'Patterns of maritime supply chains: slot capacity analysis', Journal of Transport Geography, Vol. 19 Issue 2, pp. 366-374, https://doi.org/10.1016/j.jtrangeo.2010.03.016

7. Lam, J.S.L. and Yap, W.Y. (2011), 'Dynamics of liner shipping network and port connectivity in supply chain systems: analysis on East Asia', Journal of Transport Geography, Vol. 19 Issue 6, pp. 1272-1281, https://doi.org/10.1016/j.jtrangeo.2011.06.007

8. Lam, J.S.L. and Zhang, L. (2014), 'Enhanced logistics service provider framework for higher integration and efficiency in maritime logistics', International Journal of Logistics Research and Applications, Vol. 17 Issue 2, pp. 89-113, https://doi.org/10.1080/13675567.2013.836161

9. Lam, J.S.L. and Bai, X. (2016), 'A quality function deployment approach to improve maritime supply chain resilience', Transportation Research Part E: Logistics and Transportation Review, Vol. 92, pp. 16-27, https://doi.org/10.1016/j.tre.2016.01.012

10. Tavasszy, L.A., Davydenko, I., Zhang, M., 2014. Assessment of SMART-CM platform benefits as the result of shorter transport time. Res. Gate, https://www. researchgate.net/figure/Generalized-international-maritime-supply-chain-adopted-from-SMART-CM-D121_fig1_265144496

11. Lai, X., Tao, Y., Wang, F. and Zou, Z. (2019), 'Sustainability investment in maritime supply chain with risk behavior and information sharing', International Journal of Production Economics, Vol 218, pp. 16-29, https://doi.org/10.1016/j.ijpe.2019.02.021

12. Vilko, J., Ritala, P. and Hallikas, J. (2019), 'Risk management abilities in multimodal maritime supply chains: Visibility and control perspectives', Accident Analysis & Prevention, Vol. 123, pp. 469-481, https://doi.org/10.1016/j.aap.2016.11.010

13. Luthra, S., Mangla, S.K., Xu, L. and Diabat, A. (2016), 'Using AHP to evaluate barriers in adopting sustainable consumption and production initiatives in a supply chain', International Journal of Production Economics, Vol. 181 Part B, pp. 342-349, https://doi.org/10.1016/j.ijpe.2016.04.001

14. Venkatesh, V.G., Zhang, A., Luthra, S., Dubey, R., Subramanian, N. and Mangla, S. (2017), 'Barriers to coastal shipping development: An Indian

perspective', Transportation Research Part D: Transport and Environment, Vol. 52 Part A, pp. 362-378, https://doi.org/10.1016/j.trd.2017.03.016

15. Kamble, S.K., Gunasekaran, A., Parekh, H. and Joshi, S. (2019), 'Modeling the internet of things adoption barriers in food retail supply chains', Journal of Retailing and Consumer Services, Vol. 48, pp. 154-168, https://doi.org/10.1016/j.jretconser.2019.02.020

16. Mudgal, R.K., Shankar, R., Talib, P. and Raj, T. (2016), 'Modelling the barriers of green supply chain practices: an Indian perspective', International Journal of Logistics Systems and Management, Vol. 7 Issue, International Journal Logistics Systems and Management, Vol. 7 No. 1, pp. 81-107, https://doi.org/10.1504/IJLSM.2010.033891

17. Roy, A., Sekhar, C. and Vyas, V. (2016), 'Barriers to internationalization: A study of small and medium enterprises in India', Journal of International Entrepreneurship, Vol. 14, pp. 513–538, https://doi.org/10.1007/s10843-016-0187-7

18. Yuen, K. and Thai, V. (2017), 'Barriers to supply chain integration in the maritime logistics industry', Maritime Economics and Logistics, Vol. 19, pp. 551–572, https://doi.org/10.1057/mel.2016.10

19. Chen, J., Zheng, T., Garg, A., Xu, L., Li, S. and Fei, Y. (2019), 'Alternative Maritime Power application as a green port strategy: Barriers in China', Journal of Cleaner Production, Vol. 213, pp. 825-837, https://doi.org/10.1016/j.jclepro.2018.12.177

20. Zhang, X. and Lam, J.S.L. (2019), 'A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: case of maritime organizations', Maritime Policy & Management, Vol. 46 Issue 7, pp. 781-801, https://doi.org/10.1080/03088839.2019.1628318

21. Barnett, M., Gatfield, D., Overgaard, B., Pekcan, C. and Graveson, A. (2006), 'Barriers to progress or windows of opportunity? A study in career path mapping in the maritime industries', WMU Journal of Maritime Affairs, Vol. 5, pp. 127-142, https://doi.org/10.1007/BF03195100

22. Grossmann, H., Otto, A., Stiller, S. and Wedemeier, J. (2007), 'Growth Potential for Maritime Trade and Ports in Europe', Intereconomics, Vol. 42, pp. 226–232, https://doi.org/10.1007/s10272-007-0223-x

23. Perakis, A.N. and Denisis, A. (2008), 'A survey of short sea shipping and its prospects in the USA', Maritime Policy & Management, Vol. 35 Issue 6, pp. 591-614, https://doi.org/10.1080/03088830802469501

24. Brooks, M.R. and Frost, J.D. (2004), 'Short sea shipping: a Canadian perspective', Maritime Policy & Management, Vol. 31 Issue 4, pp. 393-407, https://doi.org/10.1080/0308883042000304881

25. Bodolica, V. and Spraggon, M. (2018), 'An end-to-end process of writing and publishing influential literature review articles: Do's and don'ts', Management Decision, Vol. 56 No. 11, pp. 2472-2486. https://doi.org/10.1108/MD-03-2018-0253

26. Rewhorn, S. (2018), 'Writing your successful literature review', Journal of Geography in Higher Education, Vol. 42 Issue 1, pp. 143-147, https://doi.org/10.1080/03098265.2017.1337732

27. Koons, G.L., Schenke-Layland, K.L. and Mikos, A.G. (2019), 'Why, When, Who, What, How, and Where for Trainees Writing Literature Review Articles', Annals of Biomedical Engineering, Vol. 47, pp. 2334–2340, https://doi.org/10.1007/s10439-019-02290-5

28. Watson, R.T. and Webster, J. (2020), 'Analysing the past to prepare for the future: Writing a literature review a roadmap for release 2.0', Journal of

Decision Systems, Vol. 29 Issue 3, pp. 129-147, https://doi.org/10.1080/12460125.2020.1798591

29. Vanelslander, T. and Sys, C. (2020), 'Maritime Supply Chains', (Book) Paperback ISBN: 9780128184219,https://www.elsevier.com/books/maritime-supply-chains/vanelslander/978-0-12-818421-9

30. Honglu, L., Zhihong, T., Anqiang, H. and Zaili, Y. (2018), 'Analysis of vulnerabilities in maritime supply chains', Reliability Engineering & System Safety, Vol. 169, pp. 475-484, https://doi.org/10.1016/j.ress.2017.09.018

31. Garg, C.P. and Kashav, V. (2019), 'Evaluating value creating factors in greening the transportation of Global Maritime Supply Chains (GMSCs) of containerized freight', Transportation Research Part D: Transport and Environment, Vol. 73, pp. 162-186, https://doi.org/10.1016/j.trd.2019.06.011

32. Banomyang, R. (2005), 'The impact of port and trade security initiatives on maritime supply-chain management', Maritime Policy & Management, Vol. 32 Issue 1, pp. 3-13, https://doi.org/10.1080/0308883042000326102

33. Polatidis, N., Pavlidis, M. and Mouratidis, H. (2018), 'Cyber-attack path discovery in a dynamic supply chain maritime risk management system', Computer Standards & Interfaces, Vol. 56, pp. 74-82, https://doi.org/10.1016/j.csi.2017.09.006

34. Zavitsas, K., Zis, T. and Bell, M.G.H. (2018), 'The impact of flexible environmental policy on maritime supply chain resilience', Transport Policy, Vol. 72, pp. 116-128, https://doi.org/10.1016/j.tranpol.2018.09.020

35. Wan, C., Yan, X., Zhang, D. and Yang, Z. (2019), 'Analysis of risk factors influencing the safety of maritime container supply chains', International

Journal of Shipping and Transport Logistics, Vol. 11 Issue 6, https://doi.org/10.1504/IJSTL.2019.103872

36. Vilko, J., Ritala, P. and Hallikas, J. (2019), 'Risk management abilities in multimodal maritime supply chains: Visibility and control perspectives', Accident Analysis & Prevention, Vol. 123, pp. 469-481, https://doi.org/10.1016/j.aap.2016.11.010

37. Jasmi, M.F.A. and Fernando, Y. (2018), 'Drivers of maritime green supply chain management', Sustainable Cities and Society, Vol. 43, pp. 366-383, https://doi.org/10.1016/j.scs.2018.09.001

38. Barnes, P. and Oloruntoba, R. (2005), 'Assurance of security in maritime supply chains: Conceptual issues of vulnerability and crisis management', Journal of International Management, Vol. 11 Issue 4, pp. 519-540, https://doi.org/10.1016/j.intman.2005.09.008

39. Van Dyk, E., Maspero, E. and Ittmann, H. (2008), 'Maritime supply chain security: navigating through a sea of compliance requirements', Journal of Transport and Supply Chain Management, Vol. 2 Number 1, pp. 12-24, https://www.ingentaconnect.com/content/sabinet/jtscm/2008/00000002/00000001/art00003

40. Norbis, M, Meixell, M.J. and Tuggle, F.D. (2013), 'Modelling security in the maritime supply chain using knowledge constructs', International Journal of Logistics Systems and Management, Vol. 15 Issue 4, pp. 359-381, https://doi.org/10.1504/IJLSM.2013.054897

41. Yang, Y.C. (2011), 'Risk management of Taiwan's maritime supply chain security', Safety Science, Vol. 49 Issue 3, pp. 382-393, https://doi.org/10.1016/j.ssci.2010.09.019

42. Mallidis, I., Despoudi, S., Dekker, R., Iakovou, E. and Vlachos, D. (2018), 'The impact of sulphur limit fuel regulations on maritime supply chain network design', Annals of Operations Research, https://doi.org/10.1007/s10479-018-2999-4

43. Prahalathan, S. and Vijay, R, (2010), 'Indian Shipping Industry: A catalyst for growth', Report by Export-Import bank of India, Exim Bank of India - Occasional paper no. 142, pp.1-99, (Online – PDF) https://www.eximbankindia.in/Assets/Dynamic/PDF/Publication-Resources/ResearchPapers/Hindi/25file.pdf

44. Lam, J.S.L. (2013), 'Benefits and barriers of supply chain integration: empirical analysis of liner shipping', International Journal of Shipping and Transport Logistics, Vol. 5 Issue 1, pp. 13-30, https://doi.org/10.1504/IJSTL.2013.050553

45. Ishiguro, K. and Inamura, H. (2005), 'Identification and Elimination of Barriers in the Operations and Management of Maritime Transportation', Research in Transportation Economics, Vol. 13, pp. 337-368, https://doi.org/10.1016/S0739-8859(05)13015-7

46. Tanguy, M. and Napoli, A. (2016), 'A multi-agent system to assess the vulnerability on the maritime supply chain of energy', International Workshop on Maritime Flows and Networks - WIMAKS 2016, https://hal.univ-reunion.fr/CRC-THESE/hal-01417849v1

47. Konstantinus, A., Zuidgeest, M., Christodoulou, A., Raza, Z. and Woxenius, J. (2019), 'Barriers and Enablers for Short Sea Shipping in the Southern African Development Community', Sustainability, Vol. 11 No. 6, pp. 1-16, https://doi.org/10.3390/su11061532

48. Carlan, V., Sys, C., Vanelslander, T. and Roumboutsos, A. (2017), 'Digital innovation in the port sector: Barriers and facilitators', Competition and

Regulation in Network Industries, Vol. 18 Issue 1-2, pp. 71-93, https://doi.org/10.1177%2F1783591717734793

49. Ringsberg, A.H. and Cole, S. (2020), 'Maritime security guidelines: a study of Swedish ports' perceived barriers to compliance', Maritime Policy & Management, Vol. 47 Issue 3, pp. 388-401, https://doi.org/10.1080/03088839.2020.1711977

50. Wan, C., Yan, X., Zhang, D., Qu, Z. and Yang, Z. (2016), 'An advanced fuzzy Bayesian-based FMEA approach for assessing maritime supply chain risks', Transportation Research Part E: Logistics and Transportation Review, Vol. 125, pp. 222-240, https://doi.org/10.1016/j.tre.2019.03.011

51. Patil, S.K. and Kant, R. (2014), 'A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers', Expert Systems with Applications, Vol. 41 Issue 2, pp. 679-693, https://doi.org/10.1016/j.eswa.2013.07.093

52. Kabra, G., Ramesh, A. and Arshinder, K. (2015), "Identification and prioritization of coordination barriers in humanitarian supply chain management", International Journal of Disaster Risk Reduction, Vol. 13 No. 1, pp. 128-138, https://doi.org/10.1016/j.ijdrr.2015.01.011

53. Sirisawat, P. and Kiatcharoenpol, T. (2018), 'Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistics barriers', Computers & Industrial Engineering, Vol. 117, pp. 303-318, https://doi.org/10.1016/j.cie.2018.01.015

54. Phochanikorn, P., Tan, C. and Chen, W. (2019), 'Barriers analysis for reverse logistics in Thailand's palm oil industry using fuzzy multi-criteria decision-making method for prioritizing the solutions', Granul. Comput., https://doi.org/10.1007/s41066-019-00155-9

55. Agarwal, S., Kant, R. and Shankar, R. (2020), 'Modeling the enablers of humanitarian supply chain management: a hybrid group decision-making approach', Benchmarking: An International Journal, Vol. 28 No. 1, pp. 166-204. https://doi.org/10.1108/BIJ-03-2020-0093

56. Prakash, C. and Barua, M.K. (2015), 'Integration of AHP-TOPSIS method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment', Journal of Manufacturing Systems, Vol. 37, Part 3, pp. 599-615, https://doi.org/10.1016/j.jmsy.2015.03.001

57. Song, L., Yang, D., Chin, A.T.H., Zhang, G., He, Z., Guan, W. and Mao, B. (2016), 'A game-theoretical approach for modeling competitions in a maritime supply chain', Maritime Policy & Management, Vol. 43 Issue 8, pp. 976-991, https://doi.org/10.1080/03088839.2016.1231427

58. Vilko, J., Ritala, P. and Hallikas, J. (2019), 'Risk management abilities in multimodal maritime supply chains: Visibility and control perspectives', Accident Analysis & Prevention, Vol. 123, pp. 469-481, https://doi.org/10.1016/j.aap.2016.11.010

59. Chandra, D. and Kumar, D. (2018), 'A fuzzy MICMAC analysis for improving supply chain performance of basic vaccines in developing countries', Expert Review of Vaccines, Vol. 17 Issue 3, pp. 263-281, https://doi.org/10.1080/14760584.2018.1403322

60. Dube, A.S. and Gawande, R.R. (2016), 'ISM-fuzzy MICMAC approach for analysis of GSCM enablers', International Journal of Logistics Systems and Management, Vol. 24 Issue 4, pp. 426-451, https://doi.org/10.1504/IJLSM.2016.077281

61. Katiyar, R., Barua, M.K. and Meena, P.L. (2018), 'Analysing the Interactions Among the Barriers of Supply Chain Performance Measurement: An ISM with Fuzzy MICMAC Approach', Global Business

Review, Vol. 19 Issue 1, pp. 48-68, https://doi.org/10.1177%2F0972150917713283

62. Mangla, S.K., Luthra, S., Mishra, N., Singh, A., Rana, N.P., Dora, M. and Dwivedi, Y. (2018), 'Barriers to effective circular supply chain management in a developing country context', Production Planning & Control, Vol. 29 Issue 6: Supply chain operations for a circular economy, pp. 551-569, https://doi.org/10.1080/09537287.2018.1449265

63. Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S.J., Shibin, K.T. and Wamba, S.F. (2017), 'Sustainable supply chain management: framework and further research directions', Journal of Cleaner Production, Vol. 142 Part 2, pp. 1119-1130, https://doi.org/10.1016/j.jclepro.2016.03.117

64. Ogunsanya, O.A., Aigbavboa, C.O., Thwala, D.W. and Edwards, D.J. (2019), 'Barriers to sustainable procurement in the Nigerian construction industry: an exploratory factor analysis', International Journal of Construction Management, https://doi.org/10.1080/15623599.2019.1658697

65. Ambekar, S. and Hudnurkar, M. (2017), 'Factorial structure for Six Sigma project barriers in Indian manufacturing and service industries', The TQM Journal, Vol. 29 No. 5, pp. 744-759. https://doi.org/10.1108/TQM-02-2017-0021

66. Maldonado-Guzmán, G., Garza-Reyes, J.A., Pinzón-Castro, S.Y. and Kumar, V. (2017), 'Barriers to innovation in service SMEs: evidence from Mexico', Industrial Management & Data Systems, Vol. 117 No. 8, pp. 1669-1686. https://doi.org/10.1108/IMDS-08-2016-0339

67. Klein, M.M., Biehl, S.S. and Friedli, T. (2018), 'Barriers to smart services for manufacturing companies – an exploratory study in the capital goods

industry', Journal of Business & Industrial Marketing, Vol. 33 No. 6, pp. 846-856. https://doi.org/10.1108/JBIM-10-2015-0204

68. Jayant, A and Azhar, M. (2014), 'Analysis of the Barriers for Implementing Green Supply Chain Management (GSCM) Practices: An Interpretive Structural Modeling (ISM) Approach', Procedia Engineering, Vol. 97, pp. 2157-2166, https://doi.org/10.1016/j.proeng.2014.12.459

69. Faisal, M.N. (2010), 'Analysing the barriers to corporate social responsibility in supply chains: an interpretive structural modelling approach', International Journal of Logistics Research and Applications, Vol. 13 Issue 3, pp. 179-195, https://doi.org/10.1080/13675560903264968

70. Agrawal, P., Narain, R. and Ullah, I. (2019), 'Analysis of barriers in implementation of digital transformation of supply chain using interpretive structural modelling approach', Journal of Modelling in Management, Vol. 15 No. 1, pp. 297-317. https://doi.org/10.1108/JM2-03-2019-0066

71. Muruganantham, G., Vinodh, S., Arun, C.S. and Ramesh, K. (2018), 'Application of interpretive structural modelling for analysing barriers to total quality management practices implementation in the automotive sector', Total Quality Management & Business Excellence, Vol. 29 Issue 5-6, pp. 524-545, https://doi.org/10.1080/14783363.2016.1213627

72. Majumdar, A. and Sinha, S.K. (2019), 'Analyzing the barriers of green textile supply chain management in Southeast Asia using interpretive structural modeling', Sustainable Production and Consumption, Vol. 17, pp. 176-187, https://doi.org/10.1016/j.spc.2018.10.005

73. Kaur, J., Sidhu, R., Awasthi, A., Chauhan, S. and Goyal, S. (2018), 'A DEMATEL based approach for investigating barriers in green supply chain

management in Canadian manufacturing firms', International Journal of Production Research, Vol. 56 Issue 1-2: Leading scholars in Production Research for the 55th volume anniversary of IJPR, pp. 312-332, https://doi.org/10.1080/00207543.2017.1395522

74. Costa, F., Granja, A.D., Fregola, A. and Picchi, F. (2019), 'Understanding Relative Importance of Barriers to Improving the Customer–Supplier Relationship within Construction Supply Chains Using DEMATEL Technique', Journal of Management in Engineering, Vol. 35 Issue 3, https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29ME.1943-5479.0000680

75. Bhatia, M.S. and Srivastava, R.K. (2018), 'Analysis of external barriers to remanufacturing using grey-DEMATEL approach: An Indian perspective', Resources, Conservation and Recycling, Vol. 136, pp. 79-87, https://doi.org/10.1016/j.resconrec.2018.03.021

76. Singh, C., Singh, D. and Khamba, J.S. (2020), 'Analyzing barriers of Green Lean practices in manufacturing industries by DEMATEL approach', Journal of Manufacturing Technology Management, Vol. 32 No. 1, pp. 176-198. https://doi.org/10.1108/JMTM-02-2020-0053

77. Sahebi, I.G., Arab, A. and Moghadam, M.R.S. (2017), 'Analyzing the barriers to humanitarian supply chain management: A case study of the Tehran Red Crescent Societies', International Journal of Disaster Risk Reduction, Vol. 24, pp. 232-241, https://doi.org/10.1016/j.ijdrr.2017.05.017

78. Singh, P.K. and Sarkar, P. (2020), 'A framework based on fuzzy Delphi and DEMATEL for sustainable product development: A case of Indian automotive industry', Journal of Cleaner Production, Vol. 246, 118991, https://doi.org/10.1016/j.jclepro.2019.118991

79. Gupta, P., Anand, S. and Gupta, H. (2017), 'Developing a roadmap to overcome barriers to energy efficiency in buildings using best worst method', Sustainable Cities and Society, Vol. 31, pp. 244-259, https://doi.org/10.1016/j.scs.2017.02.005

80. Gupta, H., Kusi-Sarpong, S. and Rezaei, J. (2020), 'Barriers and overcoming strategies to supply chain sustainability innovation', Resources, Conservation and Recycling, Vol. 161, 104819, https://doi.org/10.1016/j.resconrec.2020.104819

81. Khan, M.I., Khan, S. and Haleem, A. (2019), 'Analysing barriers towards management of Halal supply chain: a BWM approach', Journal of Islamic Marketing, https://doi.org/10.1108/JIMA-09-2018-0178

82. Singh, M., Singh, K. and Sethi, A. (2019), 'An empirical investigation and prioritizing critical barriers of green manufacturing implementation practices through VIKOR approach', World Journal of Science, Technology and Sustainable Development, Vol. 17 No. 2, pp. 235-254. https://doi.org/10.1108/WJSTSD-08-2019-0060

83. Rostamzadeh, R., Govindan, K., Esmaeili, A., and Sabaghi, M. (2015), 'Application of fuzzy VIKOR for evaluation of green supply chain management practices', Ecological Indicators, Vol. 49, pp. 188–203. doi:10.1016/j.ecolind.2014.09.045

84. Rajesh, R. (2018), 'Measuring the barriers to resilience in manufacturing supply chains using Grey Clustering and VIKOR approaches', Measurement, Vol. 126, pp. 259-273, https://doi.org/10.1016/j.measurement.2018.05.043

85. Zhang, X. and Xing, X. (2017), 'Probabilistic Linguistic VIKOR Method to Evaluate Green Supply Chain Initiatives', Sustainability, Vol. 9 Issue 7, pp. 1-18, https://doi.org/10.3390/su9071231

86. Rathore, R., Thakkar, J.J. and Jha, J.K. (2020), 'Evaluation of risks in foodgrains supply chain using failure mode effect analysis and fuzzy VIKOR', International Journal of Quality & Reliability Management, Vol. 38 No. 2, pp. 551-580. https://doi.org/10.1108/IJQRM-02-2019-0070

87. Govindan, K., Shankar, K.M. and Kannan, D. (2016), 'Application of fuzzy analytic network process for barrier evaluation in automotive parts remanufacturing towards cleaner production – a study in an Indian scenario', Journal of Cleaner Production, Vol. 114, pp. 199-213, https://doi.org/10.1016/j.jclepro.2015.06.092

88. Patil, A., Shardeo, V. and Madaan, J. (2020), 'Modelling performance measurement barriers of humanitarian supply chain', International Journal of Productivity and Performance Management, https://doi.org/10.1108/IJPPM-01-2020-0031

89. Sangari, M.S., Nikkhoo, F. and Khoshsirat, M. (2020), 'An integrated GRA-DEMATEL-ANP framework for evaluation of barriers to implementation of green supply chain management in manufacturing industries', International Journal of Business and Systems Research, Vol. 14 Issue 2, pp. 228-248, https://doi.org/10.1504/IJBSR.2020.106280

90. Faisal, M.N., Banwet, D.N. and Shankar, R. (2007), 'Supply chain risk management in SMEs: analysing the barriers', International Journal of Management and Enterprise Development, Vol. 4 Issue 5, pp. 588-607, https://doi.org/10.1504/IJMED.2007.013460

91. Ruben, R.B., Vinodh, S. and Asokan, P. (2018), 'ISM and Fuzzy MICMAC application for analysis of Lean Six Sigma barriers with environmental considerations', International Journal of Lean Six Sigma, Vol. 9 No. 1, pp. 64-90. https://doi.org/10.1108/IJLSS-11-2016-0071

92. Khaba, S. and Bhar, C. (2018), 'Lean awareness and potential for lean implementation in the Indian coal mining industry: An empirical study', International Journal of Quality & Reliability Management, Vol. 35 No. 6, pp. 1215-1231. https://doi.org/10.1108/IJQRM-02-2017-0024

93. Tripathi, K.A. and Singh, S. (2018), 'Analysis of barriers to women entrepreneurship through ISM and MICMAC: A case of Indian MSMEs', Journal of Enterprising Communities: People and Places in the Global Economy, Vol. 12 No. 3, pp. 346-373. https://doi.org/10.1108/JEC-12-2017-0101

94. Kumar, S. and Sharma, R. (2018), 'Key barriers in the growth of rural health care: an ISM-MICMAC approach', Benchmarking: An International Journal, Vol. 25 No. 7, pp. 2169-2183. https://doi.org/10.1108/BIJ-05-2017-0095

95. Tseng, P.H. and Cullinane, K. (2018), 'Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model', Maritime Policy & Management, Vol. 45 Issue 4, pp. 422-438, https://doi.org/10.1080/03088839.2018.1443225

96. Göçer, A., Vural, C.A. and Deveci, D.A. (2019), 'Drivers of and barriers against market orientation: a study of Turkish container ports', Maritime Economics & Logistics, Vol. 21, pp. 278–305, https://doi.org/10.1057/s41278-017-0092-6

97. Lamba, D., Yadav, D.K., Barve, A. and Panda, G. (2020), 'Prioritizing barriers in reverse logistics of E-commerce supply chain using fuzzy-analytic hierarchy process', Electronic Commerce Research, Vol. 20, pp. 381–403, https://doi.org/10.1007/s10660-019-09333-y

98. Mangla, S.K., Govindan, K. and Luthra, S. (2017), 'Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains

using fuzzy Analytical Hierarchy Process', Journal of Cleaner Production, Vol. 151, pp. 509-525, https://doi.org/10.1016/j.jclepro.2017.02.099

99. Vishwakarma, V., Garg, C.P. and Barua, M.K. (2019), 'Modelling the barriers of Indian pharmaceutical supply chain using fuzzy AHP', International Journal of Operational Research, Vol. 34 Issue 2, pp. 240-268, https://doi.org/10.1504/IJOR.2019.097578

100. Kumar, R. and Kansara, S. (2018), 'Information technology barriers in Indian sugar supply chain: an AHP and fuzzy AHP approach', Benchmarking: An International Journal, Vol. 25 No. 7, pp. 1978-1991. https://doi.org/10.1108/BIJ-01-2017-0004

101. Othman, M.K., Rahman, N.S.F.A., Ismail, A. and Saharuddin, A.H. (2020), 'Factors contributing to the imbalances of cargo flows in Malaysia large-scale minor ports using a fuzzy analytical hierarchy process (FAHP) approach', The Asian Journal of Shipping and Logistics, Vol. 36 Issue 3, pp. 113-126, https://doi.org/10.1016/j.ajsl.2019.12.012

102. Fan, S., Zhang, J., Blanco-Davis, E., Yang, Z. and Yan, X. (2020), 'Maritime accident prevention strategy formulation from a human factor perspective using Bayesian Networks and TOPSIS', Ocean Engineering, Vol. 210, 107544, https://doi.org/10.1016/j.oceaneng.2020.107544

103. Sahin, B., Yip, T.L., Tseng, P.H., Kabak, M. and Soylu, A. (2020), 'An Application of a Fuzzy TOPSIS Multi-Criteria Decision Analysis Algorithm for Dry Bulk Carrier Selection', Information, Vol. 11 Issue 5, pp. 1-16, https://doi.org/10.3390/info11050251

104. Phruksaphanrat, B. and Borisutiyanee, M. (2019), 'Ranking barriers and solutions of supply chain information technology adoption in Thai industrial sector by AHP and fuzzy TOPSIS', International Journal of Integrated

Supply Management, Vol. 12 Issue 3, https://doi.org/10.1504/IJISM.2019.099719

105. Lamba, N. and Thareja, P. (2020), 'Developing the structural model based on analyzing the relationship between the barriers of green supply chain management using TOPSIS approach', Materials today PROCEEDINGS, https://doi.org/10.1016/j.matpr.2020.09.487

106. Gupta, H. and Barua, M.K. (2018), 'A framework to overcome barriers to green innovation in SMEs using BWM and Fuzzy TOPSIS', Science of The Total Environment, Vol. 633, pp. 122-139, https://doi.org/10.1016/j.scitotenv.2018.03.173

107. Chen, J., Zheng, T., Garg, A., Xu, L., Li, S. and Fei, Y. (2019), 'Alternative Maritime Power application as a green port strategy: Barriers in China', Journal of Cleaner Production, Vol. 213, pp. 825-837, https://doi.org/10.1016/j.jclepro.2018.12.177

108. Vural, C.A., Roso, V., Halldórsson, Á., Ståhle, G. and Yaruta, M. (2020), 'Can digitalization mitigate barriers to intermodal transport? An exploratory study', Research in Transportation Business & Management, Vol. 37, 100525, https://doi.org/10.1016/j.rtbm.2020.100525

109. Ozdemir, A.I., Erol, I., Ar, I.M., Peker, I., Asgary, A., Medeni, T.D. and Medeni, I.T. (2020), 'The role of blockchain in reducing the impact of barriers to humanitarian supply chain management', The International Journal of Logistics Management, https://doi.org/10.1108/IJLM-01-2020-0058

110. Puche, J., Ponte, B., Costas, J., Pino, R. and Fuente, D.D.L. (2016), 'Systemic approach to supply chain management through the viable system model and the theory of constraints', Production Planning & Control, Vol. 27 Issue 5, pp. 421-430, https://doi.org/10.1080/09537287.2015.1132349

111. Lowalekar, H. and Basu, S. (2020), 'Theory of constraints based mafia offer for supply chains of deteriorating products', International Journal of Production Research, Vol. 58 Issue 14, pp. 4421-4449, https://doi.org/10.1080/00207543.2019.1654629

112. Jiang, X.Y. and Wu, H.H. (2013), 'Optimization of setup frequency for TOC supply chain replenishment system with capacity constraints', Neural Computing and Applications, Vol. 23, pp. 1831–1838, https://doi.org/10.1007/s00521-013-1376-0

113. Gupta, M.C., Sahi, G.K. and Chahal, H. (2013), 'Improving market orientation: the theory of constraints-based framework', Journal of Strategic Marketing, Vol. 21 Issue 4, pp. 305-322, https://doi.org/10.1080/0965254X.2013.790467

114. Jiang, X., Wu, H., Tsai, T. and Hu, H. (2013), 'Diverse replenishment frequency model for TOC supply chain replenishment systems with capacity constraints', International Journal of Modelling, Identification and Control, Vol. 19 Issue 3, pp. 248-256, https://doi.org/10.1504/IJMIC.2013.055430

115. Zivaljevic, A. (2015), 'Theory of constraints – application in land transportation systems', Management of Environmental Quality, Vol. 26 No. 4, pp. 505-517. https://doi.org/10.1108/MEQ-07-2014-0110)

116. Tishby, N. and Zaslavsky, N. (2015), 'Deep learning and the information bottleneck principle', 2015 IEEE Information Theory Workshop (ITW), https://doi.org/10.1109/ITW.2015.7133169

117. Sun, Z., Fox, G., Gu, W. and Li, Z. (2014), 'A parallel clustering method combined information bottleneck theory and centroid-based clustering', The Journal of Supercomputing, Vol. 69, pp. 452–467, https://doi.org/10.1007/s11227-014-1174-1

118. Liu, Y., Ouyang, Y. and Xiong, Z. (2011), 'INCREMENTAL CLUSTERING USING INFORMATION BOTTLENECK THEORY', International Journal of Pattern Recognition and Artificial Intelligence, Vol. 25 No. 05, pp. 695-712, https://doi.org/10.1142/S0218001411008622

119. Reynier, P., Chrétien, M.F., Savagner, F., Larcher, G., Rohmer, V., Barrière, P. and Malthièry, Y. (1998), 'Long PCR Analysis of Human Gamete mtDNA Suggests Defective Mitochondrial Maintenance in Spermatozoa and Supports the Bottleneck Theory for Oocytes', Biochemical and Biophysical Research Communications, Vol. 252, Issue 2, pp. 373-377, https://doi.org/10.1006/bbrc.1998.9651

120. Yang, H. and Huang, H.J. (1997), 'Analysis of the time-varying pricing of a bottleneck with elastic demand using optimal control theory', Transportation Research Part B: Methodological, Vol. 31 Issue 6, pp. 425-440, https://doi.org/10.1016/S0191-2615(97)00005-2

121. Narayana, S., A. Elias, A. and K. Pati, R. (2014), 'Reverse logistics in the pharmaceuticals industry: a systemic analysis', The International Journal of Logistics Management, Vol. 25 No. 2, pp. 379-398. https://doi.org/10.1108/IJLM-08-2012-0073

122. Rahi, S. (2017), 'Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development', International Journal of Economics & Management Sciences, Vol. 6 Issue 2, pp. 1-5, https://d1wqtxts1xzle7.cloudfront.net/54953128/research-paradigms-sampling-issues-and-instruments-development-2162-6359-1000403.pdf?1510173593=&response-content-disposition=inline%3B+filename%3DResearch_Design_and_Methods_A_Systematic.pdf&Expires=1615807160&Signature=I5U1C3jml7VQxs0zdv6kZC72TlD-k2weYtM9uth6j94g8wB1Kj7jchcqYpohM-Y4TIaBiCJ3NkljVR7vDIDmN6Jc3Qcon~UiYgR21-

slFt9kDbnNmcX9F5~q80iJwkrgnc4X4gBksqikxNsPtF9cYWcAU94pBJnWc1vF5f0PYvplEq2N4GLlfl7Erdb6libF0hu3YlhFVzLnUz331KptOByq7232XFAU3I6tm7doM2CCJIQCYlGkf0hmPY2RRGrJb~XxiIIpkgNqm-DRVrhk1-r-mPp8erEnfI1fCUZRLGyue0GhPGcYSAQDiDiyuQFee11Kg3CvlfkbmQbjwekqaw__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

123. Akhtar, M.I. (2016), 'Research Design', SSRN Electronic Journal, pp. 68-84, https://dx.doi.org/10.2139/ssrn.2862445

124. Sovacool, B.K., Axsen, J. and Sorrell S. (2018), 'Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design', Energy Research & Social Science, Vol. 45, pp. 12-42, https://doi.org/10.1016/j.erss.2018.07.007

125. Crowther, D. and Lancaster, G. (2008), 'Research Methods: A concise introduction to research in management and business consultancy', Routledge, pp. 1-292, https://books.google.co.in/books/about/Research_Methods.html?id=NCBPODPeaNUC&redir_esc=y

126. Prakash, C. and Barua, M.K. (2016), 'An analysis of integrated robust hybrid model for third-party reverse logistics partner selection under fuzzy environment', Resources, Conservation and Recycling, Vol. 108, pp. 63-81, https://doi.org/10.1016/j.resconrec.2015.12.011

127. Prakash, C. and Barua, M.K. (2016), 'A combined MCDM approach for evaluation and selection of third-party reverse logistics partner for Indian electronics industry', Sustainable Production and Consumption, Vol. 7, pp. 66-78, https://doi.org/10.1016/j.spc.2016.04.001

128. Moghtadernejad, S., Chouinard, L.E. and Mirza, M.S. (2018), 'Multi-criteria decision-making methods for preliminary design of sustainable facades',

Journal of Building Engineering, Vol. 19, pp. 181-190, https://doi.org/10.1016/j.jobe.2018.05.006

129. Tan, T., Mills, G., Papadonikolaki, E. and Liu, Z. (2021), 'Combining multi-criteria decision making (MCDM) methods with building information modelling (BIM): A review', Automation in Construction, Vol. 121, pp. 248-258, https://doi.org/10.1016/j.autcon.2020.103451

130. Abdel-Basset, M., Ding, W., Mohamed, R. and Metawa, N. (2020), 'An integrated plithogenic MCDM approach for financial performance evaluation of manufacturing industries', Risk Management, Vol. 22, pp. 192–218, https://doi.org/10.1057/s41283-020-00061-4

131. Kumar, A., Sah, B., Singh, A.R., Deng, Y., He, X., Kumar, P. and Bansal, R.C. (2017), 'A review of multi criteria decision making (MCDM) towards sustainable renewable energy development', Renewable and Sustainable Energy Reviews, Vol. 69, pp. 596-609, https://doi.org/10.1016/j.rser.2016.11.191

132. Yildiz, A., Ayyildiz, E., Gumus, A.T. and Ozkan, C. (2020), 'A Modified Balanced Scorecard Based Hybrid Pythagorean Fuzzy AHP-Topsis Methodology for ATM Site Selection Problem', International Journal of Information Technology & Decision Making, Vol. 19 No. 02, pp. 365-384, https://doi.org/10.1142/S0219622020500017

133. Yousefzadeh, S., Yaghmaeian, K., Mahvi, A.H., Nasseri, S., Alavi, N. and Nabizadeh, R. (2020), 'Comparative analysis of hydrometallurgical methods for the recovery of Cu from circuit boards: Optimization using response surface and selection of the best technique by two-step fuzzy AHP-TOPSIS method', Journal of Cleaner Production, Vol. 249, https://doi.org/10.1016/j.jclepro.2019.119401

134. Singh, P.K. and Sarkar, P. (2019), 'A framework based on fuzzy AHP-TOPSIS for prioritizing solutions to overcome the barriers in the implementation of ecodesign practices in SMEs', International Journal of Sustainable Development & World Ecology, Vol. 26 Issue 6, pp. 506-521, https://doi.org/10.1080/13504509.2019.1605547

135. Sarkar, B. and Biswas, A. (2021), 'Pythagorean fuzzy AHP-TOPSIS integrated approach for transportation management through a new distance measure', Soft Computing, Vol. 25, pp. 4073–4089, https://doi.org/10.1007/s00500-020-05433-2

136. Beskese, A., Camci, A., Temur, G.T. and Erturk, E. (2020), 'Wind turbine evaluation using the hesitant fuzzy AHP-TOPSIS method with a case in Turkey', Journal of Intelligent & Fuzzy Systems, Vol. 38 No. 1, pp. 997-1011, https://content.iospress.com/articles/journal-of-intelligent-and-fuzzy-systems/ifs179464

137. Venkatesh, V.G., Zhang, A., Deakins, E., Luthra, S. and Mangla, S. (2019), 'A fuzzy AHP-TOPSIS approach to supply partner selection in continuous aid humanitarian supply chains', Annals of Operations Research, Vol. 283, pp. 1517–1550, https://doi.org/10.1007/s10479-018-2981-1

138. Ocampo, L.A. (2019), 'Applying fuzzy AHP–TOPSIS technique in identifying the content strategy of sustainable manufacturing for food production', Environment, Development and Sustainability, Vol. 21, pp. 2225–2251, https://doi.org/10.1007/s10668-018-0129-8

139. Wang, B., Xie, H.L., Ren, H.Y., Li, X., Chen, L. and W., B.C. (2019), 'Application of AHP, TOPSIS, and TFNs to plant selection for phytoremediation of petroleum-contaminated soils in shale gas and oil fields', Journal of Cleaner Production, Vol. 233, pp. 13-22, https://doi.org/10.1016/j.jclepro.2019.05.301

140. İç, Y.T. and Yurdakul, M. (2020), 'Development of a new trapezoidal fuzzy AHP-TOPSIS hybrid approach for manufacturing firm performance measurement', pp. 1-15, https://doi.org/10.1007/s41066-020-00238-y

141. Prasad, R.V., Rajesh, R. and Thirumalaikumarasamy, D. (2020), 'Selection of coating material for magnesium alloy using Fuzzy AHP-TOPSIS', Sādhanā, Vol. 45 No. 23, https://doi.org/10.1007/s12046-019-1261-3

142. Du, Y., Chen, W., Cui, K. and Zhang, K. (2020), 'Study on Damage Assessment of Earthen Sites of the Ming Great Wall in Qinghai Province Based on Fuzzy-AHP and AHP-TOPSIS', International Journal of Architectural Heritage, Conservation, Analysis, and Restoration, Vol. 14 Issue 6, pp. 903-916, https://doi.org/10.1080/15583058.2019.1576241

143. Tyagi, M., Kumar, P. and Kumar, D. (2018), 'Assessment of CSR based supply chain performance system using an integrated fuzzy AHP-TOPSIS approach', International Journal of Logistics Research and Applications, Vol. 21 Issue 4, pp. 378-406, https://doi.org/10.1080/13675567.2017.1422707

144. Galankashi, M.R., Helmi, S.A. and Hashemzahi, P. (2016), 'Supplier selection in automobile industry: A mixed balanced scorecard–fuzzy AHP approach', Alexandria Engineering Journal, Vol. 55 Issue 1, pp. 93-100, https://doi.org/10.1016/j.aej.2016.01.005

145. Hanine, M., Boutkhoum, O., Maknissi, A.E., Tikniouine, A. and Agouti, T. (2016), 'Decision making under uncertainty using PEES–fuzzy AHP–fuzzy TOPSIS methodology for landfill location selection', Environment Systems and Decisions, Vol. 36, pp. 351–367, https://doi.org/10.1007/s10669-016-9609-2

146. Kusumawardani, R.P. and Agintiara, M. (2015), 'Application of Fuzzy AHP-TOPSIS Method for Decision Making in Human Resource Manager

Selection Process', Procedia Computer Science, Vol. 72, pp. 638-646, https://doi.org/10.1016/j.procs.2015.12.173

147. Vinodh, S., Prasanna, M. and Prakash, N.H. (2014), 'Integrated Fuzzy AHP–TOPSIS for selecting the best plastic recycling method: A case study', Applied Mathematical Modelling, Vol. 38 Issues 19–20, pp. 4662-4672, https://doi.org/10.1016/j.apm.2014.03.007

148. Samvedi, A., Jain, V. and Chan, F.T.S. (2013), 'Quantifying risks in a supply chain through integration of fuzzy AHP and fuzzy TOPSIS', International Journal of Production Research, Vol. 51 Issue 8, pp. 2433-2442, https://doi.org/10.1080/00207543.2012.741330

149. Aktan, H.E. and Tosun, Ö. (2013), 'An integrated fuzzy AHP – fuzzy TOPSIS approach for AS/RS selection', International Journal of Productivity and Quality Management, Vol. 11 Issue 2, https://doi.org/10.1504/IJPQM.2013.052026

150. Panchal, D. and Kumar, D. (2017), 'Maintenance decision-making for power generating unit in thermal power plant using combined fuzzy AHP-TOPSIS approach', International Journal of Operational Research, Vol. 29 Issue 2, pp. 248-272, https://doi.org/10.1504/IJOR.2017.083958

151. Sindhu, S., Nehra, V. and Luthra, S. (2017), 'Investigation of feasibility study of solar farms deployment using hybrid AHP-TOPSIS analysis: Case study of India', Renewable and Sustainable Energy Reviews, Vol. 73, pp. 496-511, https://doi.org/10.1016/j.rser.2017.01.135

152. Boutkhoum, O., Hanine, M., Agouti, T. and Tikniouine, A. (2017), 'A decision-making approach based on fuzzy AHP-TOPSIS methodology for selecting the appropriate cloud solution to manage big data projects', International Journal of System Assurance Engineering and Management, Vol. 8, pp. 1237–1253, https://doi.org/10.1007/s13198-017-0592-x

153. Lipset, S.M. (1959), 'Some Social Requisites of Democracy: Economic Development and Political Legitimacy', The American Political Science Review, Vol. 53 No. 1, pp. 69-105, https://doi.org/10.2307/1951731

154. Benhabib, J. and Spiegel, M.M. (1994), 'The role of human capital in economic development evidence from aggregate cross-country data', Journal of Monetary Economics, Vol. 34 Issue 2, pp. 143-173, https://doi.org/10.1016/0304-3932(94)90047-7

155. Munnell, A.H. (1992), 'Policy Watch: Infrastructure Investment and Economic Growth', Journal of Economic Perspectives, Vol. 6 No. 4, pp. 189-198, DOI: 10.1257/jep.6.4.189

156. Vandermeulen, V., Verspecht, A., Vermeire, B., Huylenbroeck, G.V. and Gellynck, X. (2011), 'The use of economic valuation to create public support for green infrastructure investments in urban areas', Landscape and Urban Planning, Vol. 103 Issue 2, pp. 198-206, https://doi.org/10.1016/j.landurbplan.2011.07.010

157. Mačiulis, A., Vasiliauskas, A.V. and Jakubauskas, G. (2009), 'The impact of transport on the competitiveness of national economy', Transport, Vol. 24 Issue 2, pp. 93-99, https://doi.org/10.3846/1648-4142.2009.24.93-99

158. Almeida, R. and Fernandes, A.M. (2008), 'Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys', The Journal of Development Studies, Vol. 44 Issue 5: Technology, Institutions and Development, pp. 701-727, https://doi.org/10.1080/00220380802009217

159. Makki, S.S. and Somwaru, A. (2004), 'Impact of Foreign Direct Investment and Trade on Economic Growth: Evidence from Developing Countries', American Journal of Agricultural Economics, Vol. 86 Issue 3, pp. 795-801, https://doi.org/10.1111/j.0002-9092.2004.00627.x

160. Cullinane, K. and Khanna, M. (1999), 'Economies of Scale in Large Container Ships', Journal of Transport Economics and Policy, Vol. 33 No. 2, pp. 185-207, https://www.jstor.org/stable/20053805

161. Levitsky, S. and Way, L.A. (2002), 'Elections Without Democracy: The Rise of Competitive Authoritarianism', Vol. 13 No. 2, pp. 51-65, https://doi.org/10.1353/jod.2002.0026

162. Gowa, J. and Mansfield, E.D. (1993), 'Power Politics and International Trade', American Political Science Review, Vol. 87 Issue 2, pp. 408 – 420, https://doi.org/10.2307/2939050

163. Milner, H.V. and Rosendorff, B.P. (1997), 'Democratic Politics and International Trade Negotiations: Elections and Divided Government As Constraints on Trade Liberalization', Vol. 41 Issue 1, pp. 117-146, https://doi.org/10.1177%2F0022002797041001006

164. He, K., Huo, H., Zhang, Q., He, D., An, F., Wang, M. and Walsh, M.P. (2005), 'Oil consumption and CO2 emissions in China's road transport: current status, future trends, and policy implications', Energy Policy, Vol. 33 Issue 12, pp. 1499-1507, https://doi.org/10.1016/j.enpol.2004.01.007

165. Amis, P. and Kumar, S. (2000), 'Urban economic growth, infrastructure and poverty in India: lessons from Visakhapatnam', Environment and Urbanization, Vol. 12 Issue 1, pp. 185-196, https://doi.org/10.1177%2F095624780001200113

166. Baud, I., Sridharan, N. and Pfeffer, K. (2008), 'Mapping Urban Poverty for Local Governance in an Indian Mega-City: The Case of Delhi', Urban Studies, Vol. 45 Issue 7, pp. 1385-1412, https://doi.org/10.1177%2F0042098008090679

167. Aghion, P., Burgess, R., Redding, S.J. and Zilibotti, F. (2008), 'The Unequal Effects of Liberalization: Evidence from Dismantling the License Raj in India', American Economic Review, Vol. 98, No. 4, pp. 1397-1412, DOI: 10.1257/aer.98.4.1397

168. Majumdar, S.K. (2004), 'The hidden hand and the license raj to An evaluation of the relationship between age and the growth of firms in India', Journal of Business Venturing, Vol. 19 Issue 1, pp. 107-125, https://doi.org/10.1016/S0883-9026(02)00115-5

169. McDowell, S.D. (1995), 'The Decline of the License Raj: Indian Software Export Policies', Journal of Communication, Vol. 45 No. 4, pp. 25-50, https://www.learntechlib.org/p/82849/

170. Murshid, K.A.S. (2011), 'Transit and Trans-shipment: Strategic Considerations for Bangladesh and India', Economic and Political Weekly, Vol. 46 No. 17, pp. 43-51, https://www.jstor.org/stable/41152131

171. Álvarez-SanJaime, Ó., Cantos-Sánchez, P., Moner-Colonques, R. and Sempere-Monerris, J.J. (2013), 'Vertical integration and exclusivities in maritime freight transport' Transportation Research Part E: Logistics and Transportation Review, Vol. 51, pp. 50-61, https://doi.org/10.1016/j.tre.2012.12.009

172. Franc, P. and Van der Horst, M. (2010), 'Understanding hinterland service integration by shipping lines and terminal operators: a theoretical and empirical analysis', Journal of Transport Geography, Vol. 18 Issue 4, pp. 557-566, https://doi.org/10.1016/j.jtrangeo.2010.03.004

173. Mwemezi, J.J. and Huang, Y. (2012), 'Inland container depot integration into logistics networks based on network flow model: The Tanzanian perspective', African Journal of Business Management, Vol. 6 Issue 24, pp. 7149-7157, DOI: 10.5897/AJBM12.294

174. Ng, A.K.Y. and Gujar, G. (2009), 'The spatial characteristics of dry ports in India', Transport and Communications Bulletin for Asia and the Pacific, No. 78, pp. 112-120, https://core.ac.uk/download/pdf/327177365.pdf#page=113

175. Pedersen, P.O. (2001), 'Freight transport under globalisation and its impact on Africa', Journal of Transport Geography, Vol. 9 Issue 2, pp. 85-99, https://doi.org/10.1016/S0966-6923(01)00006-0

176. Hesse, M. and Rodrigue, J.P. (2004), 'The transport geography of logistics and freight distribution', Journal of Transport Geography, Vol. 12 Issue 3, pp. 171-184, https://doi.org/10.1016/j.jtrangeo.2003.12.004

177. Ducruet, C. and Notteboom, T. (2012), 'The worldwide maritime network of container shipping: spatial structure and regional dynamics', Global Networks, Vol. 12 Issue 3, pp. 395-423, https://doi.org/10.1111/j.1471-0374.2011.00355.x

178. Wang, S. and Meng, Q. (2012), 'Liner ship route schedule design with sea contingency time and port time uncertainty', Transportation Research Part B: Methodological, Vol. 46 Issue 5, pp. 615-633, https://doi.org/10.1016/j.trb.2012.01.003

179. Notteboom, T. (2006), 'The Time Factor in Liner Shipping Services', Maritime Economics & Logistics, Vol. 8, pp. 19–39, https://doi.org/10.1057/palgrave.mel.9100148

180. Panayides, P.M. and Song, D.W. (2013), 'Maritime logistics as an emerging discipline', Maritime Policy & Management, Vol. 40 Issue 3: 40th Anniversary Special Issue, pp. 295-308, https://doi.org/10.1080/03088839.2013.782942

181. Notteboom, T. and Rodrigue, J.P. (2008), 'Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping

Networks', Maritime Economics & Logistics, Vol. 10, pp. 152–174, https://doi.org/10.1057/palgrave.mel.9100196

182. Cullinane, K. and Khanna, M. (2000), 'Economies of scale in large containerships: optimal size and geographical implications', Journal of Transport Geography, Vol. 8 Issue 3, pp. 181-195, https://doi.org/10.1016/S0966-6923(00)00010-7

183. Banomyong, R. and Beresford, A.K.C. (2001), 'Multimodal transport: the case of Laotian garment exporters', International Journal of Physical Distribution & Logistics Management, Vol. 31 No. 9, pp. 663-685. https://doi.org/10.1108/09600030110408161

184. Heaver, T.D. (2002), 'The Evolving Roles of Shipping Lines in International Logistics', International journal of maritime economics, Vol. 4, pp. 210–230, https://doi.org/10.1057/palgrave.ijme.9100042

185. Fleming, D.K. and Hayuth, Y. (1994), 'Spatial characteristics of transportation hubs: centrality and intermediacy', Journal of Transport Geography, Vol. 2 Issue 1, pp. 3-18, https://doi.org/10.1016/0966-6923(94)90030-2

186. Rodrigue, J.P. and Notteboom, T. (2010), 'Foreland-based regionalization: Integrating intermediate hubs with port hinterlands', Research in Transportation Economics, Vol. 27 Issue 1, pp. 19-29, https://doi.org/10.1016/j.retrec.2009.12.004

187. Wiegmans, B., Witte, P. and Spit, T. (2015), 'Characteristics of European inland ports: A statistical analysis of inland waterway port development in Dutch municipalities', Transportation Research Part A: Policy and Practice, Vol. 78, pp. 566-577, https://doi.org/10.1016/j.tra.2015.07.004

188. Hayut, Y. (1980), 'Inland container terminal—function and rationale', Maritime Policy & Management, Vol. 7 Issue 4, pp. 283-289, https://doi.org/10.1080/03088838000000042

189. Van Der Horst, M.R. and Langen, P.W.D. (2008), 'Coordination in Hinterland Transport Chains: A Major Challenge for the Seaport Community', Maritime Economics & Logistics, Vol. 10, pp. 108–129, https://doi.org/10.1057/palgrave.mel.9100194

190. Milios, L., Beqiri, B., Whalen, K.A. and Jelonek, S.H. (2019), 'Sailing towards a circular economy: Conditions for increased reuse and remanufacturing in the Scandinavian maritime sector', Journal of Cleaner Production, Vol. 225, pp. 227-235, https://doi.org/10.1016/j.jclepro.2019.03.330

191. Masood, M.T., Farooq, M. and Hussain, S.B. (2016), 'PAKISTAN'S POTENTIAL AS A TRANSIT TRADE CORRIDOR AND TRANSPORTATION CHALLENGES', PAKISTAN BUSINESS REVIEW, Vol 18 No. 1, pp. 267-289, https://www.journals.iobmresearch.com/index.php/PBR/article/view/668/141

192. Song, D.W. (2002), 'Regional container port competition and co-operation: the case of Hong Kong and South China', Journal of Transport Geography, Vol. 10 Issue 2, pp. 99-110, https://doi.org/10.1016/S0966-6923(02)00003-0

193. Grossmann, H., Otto, A., Stiller, S. and Wedemeier, J. (2007), 'Growth Potential for Maritime Trade and Ports in Europe', Intereconomics, Vol. 42, pp. 226–232, https://doi.org/10.1007/s10272-007-0223-x

194. Ramachandran, V., Shoberg, T., Long, S., Corns, S. and Carlo, H. (2015), 'Identifying Geographical Interdependency in Critical Infrastructure Systems Using Open-Source Geospatial Data in Order to Model Restoration

Strategies in the Aftermath of a Large-Scale Disaster', International Journal of Geospatial and Environmental Research: Vol. 2 No. 1, Article 4, pp. 1-19, https://dc.uwm.edu/ijger/vol2/iss1/4

195. Meherishi, L., Narayana, S.A. and Ranjani, K.S. (2019), 'Sustainable packaging for supply chain management in the circular economy: A review', Journal of Cleaner Production, Vol. 237, 117582, https://doi.org/10.1016/j.jclepro.2019.07.057

196. Luthra, S., Govindan, K., Kannan, D., Mangla, S.K. and Garg, C.P. (2017), 'An integrated framework for sustainable supplier selection and evaluation in supply chains', Journal of Cleaner Production, Vol. 140 Part 3, pp. 1686-1698, https://doi.org/10.1016/j.jclepro.2016.09.078

197. Christodoulou, A. and Kappelin, H. (2020), 'Determinant factors for the development of maritime supply chains: The case of the Swedish forest industry', Case Studies on Transport Policy, Vol. 8 Issue 3, pp. 711-720, https://doi.org/10.1016/j.cstp.2020.07.008

198. Baindur, D. and Viegas, J. (2011), 'Challenges to implementing motorways of the sea concept—lessons from the past', Maritime Policy & Management, Vol. 38 Issue 7, pp. 673-690, https://doi.org/10.1080/03088839.2011.625990

199. Chen, A.Y. and Yu, T.Y. (2016), 'Network based temporary facility location for the Emergency Medical Services considering the disaster induced demand and the transportation infrastructure in disaster response', Transportation Research Part B: Methodological, Vol. 91, pp. 408-423, https://doi.org/10.1016/j.trb.2016.06.004

200. Langen, P.W.D. and Chouly, A. (2004), 'Hinterland Access Regimes in Seaports', European Journal of Transport and Infrastructure Research, Vol. 4 Issue 4, https://doi.org/10.18757/ejtir.2004.4.4.4273

201. Fouda, R.A.N. (2012), 'Protectionism and Free Trade: A Country's Glory or Doom?', International Journal of Trade, Economics and Finance, Vol. 3 No. 5, pp. 351-355, http://www.ijtef.org/papers/226-CF312.pdf

202. Tongzon, J.L. and Lee, S.Y. (2015), 'The challenges of economic integration: the case of shipping in ASEAN countries', The Pacific Review, Vol. 28 Issue 4, pp. 483-504, https://doi.org/10.1080/09512748.2015.1011215

203. Razzaque, M.A. (1997), 'Challenges to logistics development: the case of a Third World country - Bangladesh', International Journal of Physical Distribution & Logistics Management, Vol. 27 No. 1, pp. 18-38. https://doi.org/10.1108/09600039710162268

204. Wilmsmeier, G., Monios, J. and Lambert, B. (2011), 'The directional development of intermodal freight corridors in relation to inland terminals', Journal of Transport Geography, Vol. 19 Issue 6, pp. 1379-1386, https://doi.org/10.1016/j.jtrangeo.2011.07.010

205. Ramachandran, V., Long, S.K., Shoberg, T. and Corns, S. (2015), 'Framework for Modeling Urban Restoration Resilience Time in the Aftermath of an Extreme Event', Natural Hazards Review, Vol. 16 Issue 4, https://doi.org/10.1061/(ASCE)NH.1527-6996.0000184

206. Chen, Z., Ming, X., Zhang, X., Yin, D. and Sun, Z. (2019), 'A rough-fuzzy DEMATEL-ANP method for evaluating sustainable value requirement of product service system', Journal of Cleaner Production, Vol. 228, pp. 485-508, https://doi.org/10.1016/j.jclepro.2019.04.145

207. Khan, S., Khan, M.I. and Haleem, A. (2019), 'Evaluation of barriers in the adoption of halal certification: a fuzzy DEMATEL approach', Journal of Modelling in Management, Vol. 14 No. 1, pp. 153-174. https://doi.org/10.1108/JM2-03-2018-0031

208. Angelstam, P., Barnes, G., Elbakidze, M., Marais, C., Marsh, A., Polonsky, S., Richardson, D.M., Rivers, N., Shackleton, R.T. and Stafford, W. (2017), 'Collaborative learning to unlock investments for functional ecological infrastructure: Bridging barriers in social-ecological systems in South Africa', Ecosystem Services, Vol. 27 Part B, pp. 291-304, https://doi.org/10.1016/j.ecoser.2017.04.012

209. Iacovidou, E. and Purnell, P. (2016), 'Mining the physical infrastructure: Opportunities, barriers and interventions in promoting structural components reuse', Science of The Total Environment, Vol. 557–558, pp. 791-807, https://doi.org/10.1016/j.scitotenv.2016.03.098

210. Jia, J.J., Xu, J.H., Fan, Y. and Ji, Q. (2018), 'Willingness to accept energy-saving measures and adoption barriers in the residential sector: An empirical analysis in Beijing, China', Renewable and Sustainable Energy Reviews, Vol. 95, pp. 56-73, https://doi.org/10.1016/j.rser.2018.07.015

211. Majumdar, A. and Sinha, S.K. (2019), 'Analyzing the barriers of green textile supply chain management in Southeast Asia using interpretive structural modeling', Sustainable Production and Consumption, Vol. 17, pp. 176-187, https://doi.org/10.1016/j.spc.2018.10.005

212. Govindan, K. and Hasanagic, M. (2018), 'A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective', International Journal of Production Research, Vol. 56 Issue 1-2: Leading scholars in Production Research for the 55th volume anniversary of IJPR, pp. 278-311, https://doi.org/10.1080/00207543.2017.1402141

213. Govindan, K. and Bouzon, M. (2018), 'From a literature review to a multi-perspective framework for reverse logistics barriers and drivers', Journal of Cleaner Production, Vol. 187, pp. 318-337, https://doi.org/10.1016/j.jclepro.2018.03.040

214. Owusu, E.K., Chan, A.P.C. and Hosseini, M.R. (2020), 'Impacts of anti-corruption barriers on the efficacy of anti-corruption measures in infrastructure projects: Implications for sustainable development', Journal of Cleaner Production, Vol. 246, 119078, https://doi.org/10.1016/j.jclepro.2019.119078

215. Chan, A.P.C., Darko, A., Olanipekun, A.O. and Ameyaw, E.E. (2018), 'Critical barriers to green building technologies adoption in developing countries: The case of Ghana, Journal of Cleaner Production, Vol. 172, pp. 1067-1079, https://doi.org/10.1016/j.jclepro.2017.10.235

216. Karlis, T. (2018), 'Maritime law issues related to the operation of unmanned autonomous cargo ships', WMU Journal of Maritime Affairs, Vol. 17, pp. 119–128, https://doi.org/10.1007/s13437-018-0135-6

217. De Sousa, E.F., Roos, E.C., Neto, F.J.K. and Vieira, G.B.B. (2021), 'Tariff policies and economic management: A position of the Brazilian ports', Case Studies on Transport Policy, Vol. 9 Issue 1, pp. 374-382, https://doi.org/10.1016/j.cstp.2020.05.004

218. Bandara, Y.M., and Nguyen, H.O. (2016), 'Influential factors in port infrastructure tariff formulation, implementation and revision', Transportation Research Part A: Policy and Practice, Vol. 85, pp. 220-232, https://doi.org/10.1016/j.tra.2016.01.011

219. Gumede, S. and Chasomeris, M. (2018), 'Pricing strategy and tariff structure for a port authority: a case study of South Africa', Maritime Policy & Management, Vol. 45 Issue 6, pp. 756-769, https://doi.org/10.1080/03088839.2018.1446103

220. Engström, R. (2016), 'The Roads' Role in the Freight Transport System', Transportation Research Procedia, Vol. 14, pp. 1443-1452, https://doi.org/10.1016/j.trpro.2016.05.217

221. Behiri, W., Belmokhtar-Berraf, S. and Chu, C. (2018), 'Urban freight transport using passenger rail network: Scientific issues and quantitative analysis', Transportation Research Part E: Logistics and Transportation Review, Vol. 115, pp. 227-245, https://doi.org/10.1016/j.tre.2018.05.002

222. Yu, Y., Li, Y., Xia, T., Deng, H., Bao, L. and Li, W. (2017), 'Organizational Mode Innovation and Credit Supervision in Road Freight Transportation under Smart Mobile Devices Applications Services', Transportation Research Procedia, Vol. 25, pp. 762-771, https://doi.org/10.1016/j.trpro.2017.05.456

223. Joanna, N.G. and Monika, S. (2016), 'Problem of Air Pollution and Road Freight in European Union', Transportation Research Procedia, Vol. 16, pp. 418-424, https://doi.org/10.1016/j.trpro.2016.11.039

224. Baik, J. S., and Park, Y. A. (2002), 'Elimination of barriers in maritime and multimodal transport: Korea's case study. Building an Integrated Transport Market for China, Japan, and Korea: Elimination of Barriers', Edited by Lee JC and Kim YH, Korea Transport Institute and East-West Center, pp. 247-280.

225. Borchert, S.M., Osland, M.J., Enwright, N.M. and Griffith, K.T. (2018), 'Coastal wetland adaptation to sea level rise: Quantifying potential for landward migration and coastal squeeze', Journal of Applied Ecology, Vol. 55 Issue 6, pp. 2876-2887, https://doi.org/10.1111/1365-2664.13169

226. Ansong, E., Boateng, S.L., Boateng, R. and Effah, J. (2017), 'Determinants of E-Learning Adoption in Universities: Evidence from a Developing Country', Conference: 2016 49th Hawaii International Conference on System Sciences (HICSS), pp. 21-30, DOI: 10.1109/HICSS.2016.12

227. Hofmann, E., Strewe, U.M. and Bosia, N. (2018) Discussion—How Does the Full Potential of Blockchain Technology in Supply Chain Finance Look

Like?', Supply Chain Finance and Blockchain Technology, pp. 77-87, https://doi.org/10.1007/978-3-319-62371-9_6

228. Kembro, J., Näslund, D. and Olhager, J. (2017), 'Information sharing across multiple supply chain tiers: A Delphi study on antecedents', International Journal of Production Economics, Vol. 193, pp. 77-86, https://doi.org/10.1016/j.ijpe.2017.06.032

229. Ikram, M., Sroufe, R. and Zhang, Q. (2020), 'Prioritizing and overcoming barriers to integrated management system (IMS) implementation using AHP and G-TOPSIS', Journal of Cleaner Production, Vol. 254, 120121, https://doi.org/10.1016/j.jclepro.2020.120121

230. Beltagui, A., Kunz, N. and Gold, S. (2020), 'The role of 3D printing and open design on adoption of socially sustainable supply chain innovation', International Journal of Production Economics, Vol. 221, 107462, https://doi.org/10.1016/j.ijpe.2019.07.035

231. Delmonico, D., Jabbour, C.J.C., Pereira, S.C.F., Jabbour, A.B.L.D.S., Renwick, D.W.S. and Thomé, A.M.T. (2018), 'Unveiling barriers to sustainable public procurement in emerging economies: Evidence from a leading sustainable supply chain initiative in Latin America', Resources, Conservation and Recycling, Vol. 134, pp. 70-79, https://doi.org/10.1016/j.resconrec.2018.02.033

232. Luthra, S. and Mangla, S.K. (2018), 'Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies', Process Safety and Environmental Protection, Vol. 117, pp. 168-179, https://doi.org/10.1016/j.psep.2018.04.018

233. Gupta, S. and Chaudhary, S. (2020), 'State of the art review on Supplementary Cementitious Materials in India – I: An overview of legal perspective, governing organizations, and development patterns', Journal of

Cleaner Production, Vol. 261, 121203, https://doi.org/10.1016/j.jclepro.2020.121203

234. Büyüközkan, G. and Göçer, F. (2018), 'Digital Supply Chain: Literature review and a proposed framework for future research', Computers in Industry, Vol. 97, pp. 157-177, https://doi.org/10.1016/j.compind.2018.02.010

235. MacCarthy, B.L., Blome, C., Olhager, J., Srai, J.S. and Zhao, X. (2016), 'Supply chain evolution – theory, concepts and science', International Journal of Operations & Production Management, Vol. 36 No. 12, pp. 1696-1718. https://doi.org/10.1108/IJOPM-02-2016-0080

236. Merchan, A.L., Léonard, A., Limbourg, S. and Mostert, M. (2019), 'Life cycle externalities versus external costs: The case of inland freight transport in Belgium', Transportation Research Part D: Transport and Environment, Vol. 67, pp. 576-595, https://doi.org/10.1016/j.trd.2019.01.017

237. Liang, K.Y., Van de Hoef, S., Terelius, H., Turri, V., Besselink, B., Mårtensson, J. and Johansson, K.H. (2016), 'Networked control challenges in collaborative road freight transport', European Journal of Control, Vol. 30, pp. 2-14, https://doi.org/10.1016/j.ejcon.2016.04.008

238. Visser, J.G.S.N. (2018), 'The development of underground freight transport: An overview', Tunnelling and Underground Space Technology, Vol. 80, pp. 123-127, https://doi.org/10.1016/j.tust.2018.06.006

239. Burl, D. (2019), 'Freight Transport Technology: A Cost-Effective/Time-Efficient Solution to Sub-Saharan Africa's Logistics Problems', Logistics and Global Value Chains in Africa, pp. 91-129, https://doi.org/10.1007/978-3-319-77652-1_4

240. Prussi, M., Padella, M., Conton, M., Postma, E.D. and Lonza, L. (2019), 'Review of technologies for biomethane production and assessment of Eu transport share in 2030', Journal of Cleaner Production, Vol. 222, pp. 565-572, https://doi.org/10.1016/j.jclepro.2019.02.271

241. ImranUddin, M., Islam, R.M., Awal, Z.I. and Newaz, K.M.S. (2017), 'An Analysis of Accidents in the Inland Waterways of Bangladesh: Lessons from a Decade (2005-2015)', Procedia Engineering, Vol. 194, pp. 291-297, https://doi.org/10.1016/j.proeng.2017.08.148

242. Peeters, G., Kotzé, M., Afzal, M.R., Catoor, T., Baelen, S.V., Geenen, P., Vanierschot, M., Boonen, R. and Slaets, P. (2020), 'An unmanned inland cargo vessel: Design, build, and experiments', Ocean Engineering, Vol. 201, 107056, https://doi.org/10.1016/j.oceaneng.2020.107056

243. Barnes, S.J. (2019), 'Understanding plastics pollution: The role of economic development and technological research', Environmental Pollution, Vol. 249, pp. 812-821, https://doi.org/10.1016/j.envpol.2019.03.108

244. Kouhizadeh, M., Saberi, S. and Sarkis, J. (2021), 'Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers', International Journal of Production Economics, Vol. 231, 107831, https://doi.org/10.1016/j.ijpe.2020.107831

245. Gupta, H., Kusi-Sarpong, S. and Rezaei, J. (2020), 'Barriers and overcoming strategies to supply chain sustainability innovation', Resources, Conservation and Recycling, Vol. 161, 104819, https://doi.org/10.1016/j.resconrec.2020.104819

246. Kamilaris, A., Fonts, A. and Prenafeta-Boldύ, F.X. (2019), 'The rise of blockchain technology in agriculture and food supply chains', Trends in Food Science & Technology, Vol. 91, pp. 640-652, https://doi.org/10.1016/j.tifs.2019.07.034

247. Raj, A., Dwivedi, G., Sharma, A., Jabbour, A.B.L.D.S. and Rajak, S. (2020), 'Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective', International Journal of Production Economics, Vol. 224, 107546, https://doi.org/10.1016/j.ijpe.2019.107546

248. Wang, Z., Mathiyazhagan, K., Xu, L. and Diabat, A. (2016), 'A decision making trial and evaluation laboratory approach to analyze the barriers to Green Supply Chain Management adoption in a food packaging company', Journal of Cleaner Production, Vol. 117, pp. 19-28, https://doi.org/10.1016/j.jclepro.2015.09.142

249. Shi, J., Zhou, J. and Zhu, Q. (2019), 'Barriers of a closed-loop cartridge remanufacturing supply chain for urban waste recovery governance in China', Journal of Cleaner Production, Vol. 212, pp. 1544-1553, https://doi.org/10.1016/j.jclepro.2018.12.114

250. Shah, S.A.A., Solangi, Y.A. and Ikram, M. (2019), 'Analysis of barriers to the adoption of cleaner energy technologies in Pakistan using Modified Delphi and Fuzzy Analytical Hierarchy Process', Journal of Cleaner Production, Vol. 235, pp. 1037-1050, https://doi.org/10.1016/j.jclepro.2019.07.020

251. Jiang, Y., Zhu, Z., Tian, G. and Nie, H. (2019), 'Determinants of within and cross-country economic policy uncertainty spillovers: Evidence from US and China', Finance Research Letters, Vol. 31, pp.1-12, https://doi.org/10.1016/j.frl.2019.08.004

252. Blanchard, J.M.F. (2017), 'Probing China's Twenty-First-Century Maritime Silk Road Initiative (MSRI): An Examination of MSRI Narratives', Geopolitics, Vol. 22, Issue 2, pp. 246-268, https://doi.org/10.1080/14650045.2016.1267147

253. Blanchard, J.M.F. (2017), 'China's Maritime Silk Road Initiative (MSRI) and Southeast Asia: A Chinese 'pond' not 'lake' in the Works', Journal of Contemporary China, Vol. 27 Issue 111, pp. 329-343, https://doi.org/10.1080/10670564.2018.1410959

254. Hastig, G.M. and Sodhi, M.M.S. (2020), 'Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors', Production and Operations Management, Vol. 29 Issue 4, pp. 935-954, https://doi.org/10.1111/poms.13147

255. Chan, E.Y. and Ilicic, J. (2019), 'Political ideology and brand attachment', International Journal of Research in Marketing, Vol. 36 Issue 4, pp. 630-646, https://doi.org/10.1016/j.ijresmar.2019.04.001

256. Stough, R.R. (2005), 'INSTITUTIONAL BARRIERS TO PORT INFRASTRUCTURE AND HARBOR DEVELOPMENT', IATSS Research, Vol. 29 Issue 2, pp. 30-40, https://doi.org/10.1016/S0386-1112(14)60131-X

257. Ferreira, F.D.A.L., Scavarda, L.F., Ceryno, P.S. and Leiras, A. (2018), 'Supply chain risk analysis: a shipbuilding industry case', International Journal of Logistics Research and Applications, Vol. 21 Issue 5, pp. 542-556, https://doi.org/10.1080/13675567.2018.1472748

258. Duin, H. and Thoben, K.D. (2019), 'Future Scenarios of maritime Logistics and their Impact on Vocational Training', 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), 18904636, pp. 1-9, https://doi.org/10.1109/ICE.2019.8792618

259. Notteboom, T. (2007), 'Consolidation and Contestability in the European Container Handling Industry', Maritime Policy & Management, Vol. 29 Issue 3, pp. 257-269, http://dx.doi.org/10.1080/03088830210132614

260. Verhoeven, P. (2009), 'Corporate actors in Western European television news', Public Relations Review, Vol. 35 Issue 3, pp. 297-300, https://doi.org/10.1016/j.pubrev.2009.05.001

261. Suárez-Alemán, A. and Hernández, A. (2014), 'Incentives to reduce port inefficiency: a theoretical approach', Maritime Policy & Management, Vol. 41 Issue 5: Addressing special challenges in maritime and port logistics, pp. 462-479, https://doi.org/10.1080/03088839.2014.929752

262. Pittman, R., Jandová, M., Król, M., Nekrasenko, L. and Paleta, T. (2020), 'The effectiveness of EC policies to move freight from road to rail: Evidence from CEE grain markets', Research in Transportation Business & Management, Vol. 37, 100482, https://doi.org/10.1016/j.rtbm.2020.100482

263. Kurosaki, F. and Singh, M. (2016), 'Comparison of Three Models for Introducing Competition in Rail Freight Transport', Transportation Research Procedia, Vol. 14, pp. 2820-2829, https://doi.org/10.1016/j.trpro.2016.05.348

264. Park, K., Min, H. and Min, S. (2016), 'Inter-relationship among risk taking propensity, supply chain security practices, and supply chain disruption occurrence', Journal of Purchasing and Supply Management, Vol. 22 Issue 2, pp. 120-130, https://doi.org/10.1016/j.pursup.2015.12.001

265. Carrara, S. and Longden, T. (2017), 'Freight futures: The potential impact of road freight on climate policy', Transportation Research Part D: Transport and Environment, Vol. 55, pp. 359-372, https://doi.org/10.1016/j.trd.2016.10.007

266. Ruan, X., Bandara, Y.M., Lee, J.Y., Lee, P.T.W. and Chhetri, P. (2019), 'Impacts of the Belt and Road Initiative in the Indian subcontinent under future port development scenarios', Maritime Policy & Management, Vol. 46 Issue 8, https://doi.org/10.1080/03088839.2019.1594425

267. Dawda, N., Joshi, G., Arkatkar, S. and Vasudevan, N. (2019), 'Multimodal of Lateral Transport System: A Case Study of Successful Cities Worldwide', Innovative Research in Transportation Infrastructure, pp. 101-110, https://doi.org/10.1007/978-981-13-2032-3_10

268. Kumar, A., Mangla, S.K., Kumar, P. and Karamperidis, S. (2020), 'Challenges in perishable food supply chains for sustainability management: A developing economy perspective', Business Strategy and the Environment, Vol. 29 Issue 5, pp. 1809-1831, https://doi.org/10.1002/bse.2470

269. Repetto, M.P., Burlando, M., Solari, G., Gaetano, P.D. and Pizzo, M. (2017), 'Integrated tools for improving the resilience of seaports under extreme wind events', Sustainable Cities and Society, Vol. 32, pp. 277-294, https://doi.org/10.1016/j.scs.2017.03.022

270. Kumar, A. and Anbanandam, R. (2020), 'A Flexible Policy Framework for Analysing Multimodal Freight Transportation System in India: SAP–LAP and Efficient IRP Method', Global Journal of Flexible Systems Management, Vol. 21, pp. 35–52, https://doi.org/10.1007/s40171-019-00226-5

271. Dadsena, K.K., Sarmah, S.P. and Naikan, V.N.A. (2019), 'Risk evaluation and mitigation of sustainable road freight transport operation: a case of trucking industry', International Journal of Production Research, Vol. 57 Issue 19, pp. 6223-6245, https://doi.org/10.1080/00207543.2019.1578429

272. Yadav, V.S., Singh, A.R., Raut, R.D. and Govindarajan, U.H. (2020), 'Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach', Resources, Conservation and Recycling, Vol. 161, 104877, https://doi.org/10.1016/j.resconrec.2020.104877

273. Chauhan, C., Singh, A. and Luthra, S. (2021), 'Barriers to industry 4.0 adoption and its performance implications: An empirical investigation of emerging economy', Journal of Cleaner Production, Vol. 285, 124809, https://doi.org/10.1016/j.jclepro.2020.124809

274. Singh, R.K., Luthra, S., Mangla, S.K. and Uniyal, S. (2019), 'Applications of information and communication technology for sustainable growth of SMEs in India food industry', Resources, Conservation and Recycling, Vol. 147, pp. 10-18, https://doi.org/10.1016/j.resconrec.2019.04.014

275. Rajput, S. and Singh, S.P. (2019), 'Connecting circular economy and industry 4.0', International Journal of Information Management, Vol. 49, pp. 98-113, https://doi.org/10.1016/j.ijinfomgt.2019.03.002

276. Moktadir, M.A., Ali, S.M., Paul, S.K. and Shukla, N. (2019), 'Barriers to big data analytics in manufacturing supply chains: A case study from Bangladesh', Computers & Industrial Engineering, Vol. 128, pp. 1063-1075, https://doi.org/10.1016/j.cie.2018.04.013

277. Praharaj, S., Han, J.H. and Hawken, S. (2018), 'Urban innovation through policy integration: Critical perspectives from 100 smart cities mission in India', City, Culture and Society, Vol. 12, pp. 35-43, https://doi.org/10.1016/j.ccs.2017.06.004

278. Kumar, S., Luthra, S. and Haleem, A. (2015), 'Benchmarking supply chains by analyzing technology transfer critical barriers using AHP approach', Benchmarking: An International Journal, Vol. 22 No. 4, pp. 538-558. https://doi.org/10.1108/BIJ-05-2014-0040

279. Rauer, J. and Kaufmann, L. (2015), 'Mitigating External Barriers to Implementing Green Supply Chain Management: A Grounded Theory Investigation of Green-Tech Companies' Rare Earth Metals Supply Chains',

Journal of Supply Chain Management, Vol. 51 Issue 2, pp. 65-88, https://doi.org/10.1111/jscm.12063

280. Farooque, M., Zhang, A. and Liu, Y. (2019), 'Barriers to circular food supply chains in China', Supply Chain Management, Vol. 24 No. 5, pp. 677-696. https://doi.org/10.1108/SCM-10-2018-0345

281. Bienhaus, F. and Haddud, A. (2018), 'Procurement 4.0: factors influencing the digitisation of procurement and supply chains', Business Process Management Journal, Vol. 24 No. 4, pp. 965-984. https://doi.org/10.1108/BPMJ-06-2017-0139

282. Malik, L. and Tiwari, G. (2017), 'Assessment of interstate freight vehicle characteristics and impact of future emission and fuel economy standards on their emissions in India', Energy Policy, Vol. 108, pp. 121-133, https://doi.org/10.1016/j.enpol.2017.05.053

283. Kamble, S., Gunasekaran, A. and Arha, H. (2019), 'Understanding the Blockchain technology adoption in supply chains-Indian context', International Journal of Production Research, Vol. 57 Issue 7, pp. 2009-2033, https://doi.org/10.1080/00207543.2018.1518610

284. Suarez-Aleman, A. and Hernandez, A. (2014), 'Incentives to reduce port inefficiency: a theoretical approach', Maritime Policy & Management, Vol. 41 Issue 5: Addressing special challenges in maritime and port logistics, pp. 462-479, https://doi.org/10.1080/03088839.2014.929752

285. Prakash, C. and Barua, M.K. (2017), 'Flexible modelling approach for evaluating reverse logistics adoption barriers using fuzzy AHP and IRP framework', International Journal of Operational Research, Vol. 30 Issue 2, pp. 151-171, https://doi.org/10.1504/IJOR.2017.086523

286. Chaudhary, K., Mathiyazhagan, K. and Vrat, P. (2017), 'Analysis of barriers hindering the implementation of reverse supply chain of electronic waste in India', International Journal of Advanced Operations Management, Vol. 9 Issue 3, pp. 143-168, https://doi.org/10.1504/IJAOM.2017.088241

287. Rahman, M., Akter, M., Odunukan, K. and Haque, S.E. (2020), 'Examining economic and technology-related barriers of small- and medium-sized enterprises internationalisation: An emerging economy context', Business Strategy and Development, Vol. 3 Issue 1, pp. 16-27, https://doi.org/10.1002/bsd2.71

288. Kavirathna, C.A., Kawasaki, T. and Hanaoka, S. (2018), 'Transshipment Hub Port Competitiveness of the Port of Colombo against the Major Southeast Asian Hub Ports', The Asian Journal of Shipping and Logistics, Vol. 34 Issue 2, pp. 71-82, https://doi.org/10.1016/j.ajsl.2018.06.004

289. Hossain, N.U.I., Amrani, S.E., Jaradat, R., Marufuzzaman, M., Buchanan, R., Rinaudo, C. and Hamilton, M. (2020), 'Modeling and assessing interdependencies between critical infrastructures using Bayesian network: A case study of inland waterway port and surrounding supply chain network', Reliability Engineering & System Safety, Vol. 198, 106898, https://doi.org/10.1016/j.ress.2020.106898

290. Durán, C.A., Córdova, F.M. and Palominos, F. (2018), 'Method for improving critical strategic and operational success factors in a port system', Procedia Computer Science, Vol. 139, pp. 448-455, https://doi.org/10.1016/j.procs.2018.10.253

291. Wilmsmeier, G. and Monios, J. (2016), 'Institutional structure and agency in the governance of spatial diversification of port system evolution in Latin America', Journal of Transport Geography, Vol. 51, pp. 294-307, https://doi.org/10.1016/j.jtrangeo.2015.02.004

292. Bavincks, M., Berkes, F., Charles, A., Dias, A.C.E., Doubleday, N., Nayak, P. and Sowman, M. (2017), 'The impact of coastal grabbing on community conservation – a global reconnaissance', Maritime Studies, Vol. 16 No. 8, pp. 1-17, https://doi.org/10.1186/s40152-017-0062-8

293. Karim, S. and Abdul-Mageed, L. (2016), 'Enabling Better Port Governance in Developing Countries: The Role of Information Technology. In: Dey B., Sorour K., Filieri R. (eds) ICTs in Developing Countries. Palgrave Macmillan, London. https://doi.org/10.1057/9781137469502_11

294. Radwan, M.E., Chen, J., Wan, Z., Zheng, T., Hua, C. and Huang, X. (2019), 'Critical barriers to the introduction of shore power supply for green port development: case of Djibouti container terminals', Clean Technologies and Environmental Policy, Vol. 21, pp. 1293–1306, https://doi.org/10.1007/s10098-019-01706-z

295. Alfaqiri, A., Hossain, N.U.I, Jaradat, R., Abutabenjeh, S., Keating, C.B., Khasawneh, M.T. and Pinto, C.A. (2019), 'A systemic approach for disruption risk assessment in oil and gas supply chains', International Journal of Critical Infrastructures, Vol. 15 Issue 3, pp. 230-259, https://doi.org/10.1504/IJCIS.2019.100428

296. Lu, V.N., Wirtz, J., Kunz, W.H., Paluch, S., Gruber, T., Martins, A. and Patterson, P.G. (2020), 'Service robots, customers and service employees: what can we learn from the academic literature and where are the gaps?,' Journal of Service Theory and Practice, Vol. 30 No. 3, pp. 361-391. https://doi.org/10.1108/JSTP-04-2019-0088

297. El Baz, J. and Laguir, I. (2017), 'Third-party logistics providers (TPLs) and environmental sustainability practices in developing countries: The case of Morocco', International Journal of Operations & Production Management,

Vol. 37 No. 10, pp. 1451-1474. https://doi.org/10.1108/IJOPM-07-2015-0405

298. Lin, C.C. and Chang, C.H. (2018), 'Evaluating skill requirement for logistics operation practitioners: based on the perceptions of logistics service providers and academics in Taiwan', The Asian Journal of Shipping and Logistics, Vol. 34 Issue 4, pp. 328-336, https://doi.org/10.1016/j.ajsl.2018.12.006

299. Vural, C.A., Göçer, A. and Halldórsson, Á. (2019), 'Value co-creation in maritime logistics networks: A service triad perspective', Transport Policy, Vol. 84, pp. 27-39, https://doi.org/10.1016/j.tranpol.2018.12.017

300. Ellinger, A.E., Adams, F.G., Franke, G.R., Herrin, G.D., deCoster, T.E. and Filips, K.E. (2020), 'A triadic longitudinal assessment of multiple supply chain participants' performance and the extended enterprise concept', International Journal of Physical Distribution & Logistics Management, Vol. 50 No. 7/8, pp. 745-767. https://doi.org/10.1108/IJPDLM-07-2019-0209

301. Garg, C.P. (2020), 'A robust hybrid decision model to evaluate critical factors of reverse logistics implementation using Grey-DEMATEL framework', OPSEARCH, Vol. 57, pp. 837–873, https://doi.org/10.1007/s12597-020-00453-w

302. Mahtani, U.S. and Garg, C.P. (2018), 'An analysis of key factors of financial distress in airline companies in India using fuzzy AHP framework', Transportation Research Part A: Policy and Practice, Vol. 117, pp. 87-102, https://doi.org/10.1016/j.tra.2018.08.016

303. Jasmi, M.F.A and Fernando, Y. (2018), 'Drivers of maritime green supply chain management', Sustainable Cities and Society, Vol. 43, pp. 366-383, https://doi.org/10.1016/j.scs.2018.09.001

304. Adland, R., Benth, F.E. and Koekebakker, S. (2018), 'Multivariate modeling and analysis of regional ocean freight rates', Transportation Research Part E: Logistics and Transportation Review, Vol. 113, pp. 194-221, https://doi.org/10.1016/j.tre.2017.10.014

305. Yin, M., Wan, Z., Kim, K.H. and Zheng, S.Y. (2019), 'An optimal variable pricing model for container line revenue management systems', Maritime Economics & Logistics, Vol. 21, pp. 173–191, https://doi.org/10.1057/s41278-017-0082-8

306. Hansen, H.K. (2018), 'Policing Corruption Post- and Pre-Crime: Collective Action and Private Authority in the Maritime Industry', Indiana Journal of Global Legal Studies, Vol. 25 No. 1, pp. 131-156, https://www.jstor.org/stable/10.2979/indjglolegstu.25.1.0131

307. Choi, J.-W. (2018), 'Corruption control and prevention in the Korean government: Achievements and challenges from an institutional perspective', Asian Education and Development Studies, Vol. 7 No. 3, pp. 303-314. https://doi.org/10.1108/AEDS-11-2017-0111

308. Sehgal, S., Pandey, P., Deisting, F. and McMillan, D. (2018), 'Time varying integration amongst the South Asian equity markets: An empirical study', Cogent Economics & Finance, Vol. 6 Issue 1, 1452328, https://doi.org/10.1080/23322039.2018.1452328

309. Vanelslander, T. and Voorde, E.V.D. (2018), 'Special Issue on "Infrastructure, Pricing and Regulatory Issues in Maritime Supply Chains', Maritime Policy & Management, Vol. 45 Issue 6, pp. 717-719, https://doi.org/10.1080/03088839.2018.1496293

310. Chen, Z., Xue, J., Wu, C., Qin, L., Liu, L. and Cheng, X. (2018), 'Classification of vessel motion pattern in inland waterways based on

Automatic Identification System', Ocean Engineering, Vol. 161, pp. 69-76, https://doi.org/10.1016/j.oceaneng.2018.04.072

311. Ahadi, K., Sullivan, K.M. and Mitchell, K.N. (2018), Budgeting maintenance dredging projects under uncertainty to improve the inland waterway network performance', Transportation Research Part E: Logistics and Transportation Review, Vol. 119, pp. 63-87, https://doi.org/10.1016/j.tre.2018.08.013

312. Trivedi, A., Jakhar, S.K. and Sinha, D. (2021), 'Analyzing barriers to inland waterways as a sustainable transportation mode in India: A dematel-ISM based approach', Journal of Cleaner Production, Vol. 295, 126301, https://doi.org/10.1016/j.jclepro.2021.126301

313. Neutzling, D.M., Land, A., Seuring, S. and Nascimento, L.F.M.D. (2018), 'Linking sustainability-oriented innovation to supply chain relationship integration', Journal of Cleaner Production, Vol. 172, pp. 3448-3458, https://doi.org/10.1016/j.jclepro.2017.11.091

314. Sherafati, M., Bashiri, M., Tavakkoli-Moghaddam, R. and Pishvaee, M.S. (2020), 'Achieving sustainable development of supply chain by incorporating various carbon regulatory mechanisms', Transportation Research Part D: Transport and Environment, Vol. 81, 102253, https://doi.org/10.1016/j.trd.2020.102253

315. Mönch, L., Uzsoy, R. and Fowler, J.W. (2018), 'A survey of semiconductor supply chain models part III: master planning, production planning, and demand fulfilment', International Journal of Production Research, Vol. 56 Issue 13, pp. 4565-4584, https://doi.org/10.1080/00207543.2017.1401234

316. Ivanov, D., Dolgui, A., Sokolov, B. and Ivanova, M. (2017), 'Literature review on disruption recovery in the supply chain', International Journal of

Production Research, Vol. 55 Issue 20, pp. 6158-6174, https://doi.org/10.1080/00207543.2017.1330572

317. Schepler, X., Balev, S., Michel, S. and Sanlaville, É. (2017), 'Global planning in a multi-terminal and multi-modal maritime container port', Transportation Research Part E: Logistics and Transportation Review, Vol. 100, pp. 38-62, https://doi.org/10.1016/j.tre.2016.12.002

318. Vaghi, C. and Lucietti, L. (2016), 'Costs and Benefits of Speeding up Reporting Formalities in Maritime Transport', Transportation Research Procedia, Vol. 14, pp. 213-222, https://doi.org/10.1016/j.trpro.2016.05.057

319. Garcia-Alonso, L., Monios, J. and Vallejo-Pinto, J.A. (2019), 'Port competition through hinterland accessibility: the case of Spain', Maritime Economics & Logistics, Vol. 21, pp. 258–277, https://doi.org/10.1057/s41278-017-0085-5

320. Jaffee, D. (2019), 'Neoliberal urbanism as 'Strategic Coupling' to global chains: Port infrastructure and the role of economic impact studies', Environment and Planning C: Politics and Space, Vol. 37 Issue 1, pp. 119-136, https://doi.org/10.1177%2F2399654418771134

321. Parola, F., Ferrari, C., Tei, A., Satta, G. and Musso, E. (2017), 'Dealing with multi-scalar embeddedness and institutional divergence: Evidence from the renovation of Italian port governance', Research in Transportation Business & Management, Vol. 22, pp. 89-99, https://doi.org/10.1016/j.rtbm.2016.12.005

322. Ibrahim, O.A., Abdel- Gadir, S.E.M. and Devesh, S. (2019), 'The potential of foreign direct investment (FDI) as a means of developing ports: Evidence from Oman', International Journal of Maritime History, Vol. 31 Issue 4, pp. 879-895, https://doi.org/10.1177%2F0843871419874005

323. Karlis, T. and Polemis, D. (2018), 'Chinese outward FDI in the terminal concession of the port of Piraeus', Case Studies on Transport Policy, Vol. 6 Issue 1, pp. 17-24, https://doi.org/10.1016/j.cstp.2018.01.002

324. Cruz, C.O. and Sarmento, J.M. (2019), 'Institutional "tetris" in infrastructure regulation: Harmonizing governance, regulation and policy-making in the transport sector', Case Studies on Transport Policy, Vol. 7 Issue 1, pp. 22-27, https://doi.org/10.1016/j.cstp.2018.11.003

325. Raimbault, N. (2019), 'From regional planning to port regionalization and urban logistics. The inland port and the governance of logistics development in the Paris region', Journal of Transport Geography, Vol. 78, pp. 205-213, https://doi.org/10.1016/j.jtrangeo.2019.06.005

326. Witte, P., Wiegmans, B. and Rodrigue, J.P. (2017), 'Competition or complementarity in Dutch inland port development: A case of overproximity?', Journal of Transport Geography, Vol. 60, pp. 80-88, https://doi.org/10.1016/j.jtrangeo.2017.02.008

327. Chhetri, P., Gekara, V., Shaorong, L. and Lee, J.Y. (2020), 'Changing global production network and its implication on Belt and Road Initiative', Journal of International Logistics and Trade, Vol. 18, Issue 1, pp. 13-14, DOI:10.24006/jilt.2020.18.1.013

328. Mijiyawa, A.G. (2017), 'Does Foreign Direct Investment Promote Exports? Evidence from African Countries', The World Economy, Vol. 40 Issue 9, pp. 1934-1957, https://doi.org/10.1111/twec.12465

329. Rong, Q., Cai, Y., Chen, B., Yue, W., Yin, X. and Tan, Q. (2017), 'An enhanced export coefficient based optimization model for supporting agricultural nonpoint source pollution mitigation under uncertainty', Science of The Total Environment, Vol. 580, pp. 1351-1362, https://doi.org/10.1016/j.scitotenv.2016.12.099

330. Giudice, M.D., Vaio, A.D., Hassan, R. and Palladino, R. (2021), 'Digitalization and new technologies for sustainable business models at the ship–port interface: a bibliometric analysis', Maritime Policy & Management, https://doi.org/10.1080/03088839.2021.1903600

331. Heilig, L., Lalla-Ruiz, E. and Voß, S. (2017), 'Digital transformation in maritime ports: analysis and a game theoretic framework', NETNOMICS: Economic Research and Electronic Networking, Vol. 18, pp. 227–254, https://doi.org/10.1007/s11066-017-9122-x

332. Vaio, A.D. and Varriale, L. (2020), 'Digitalization in the sea-land supply chain: experiences from Italy in rethinking the port operations within inter-organizational relationships', Production Planning & Control, Vol. 31 Issue 2-3: Rethinking Supply Chains in the Age of Digitalization, pp. 220-232, https://doi.org/10.1080/09537287.2019.1631464

333. Jeevan, J., Chen, S.L. and Cahoon, S. (2019), 'The impact of dry port operations on container seaports competitiveness', Maritime Policy & Management, Vol. 46 Issue 1, pp. 4-23, https://doi.org/10.1080/03088839.2018.1505054

334. Berg, R.V.D., Langen, P.W.D. and Zuijlen, P.C.J.B. (2017), 'Revisiting port pricing; a proposal for seven port pricing principles', WMU Journal of Maritime Affairs, Vol. 16, pp. 421–438, https://doi.org/10.1007/s13437-017-0127-y

335. Ding, J.F., Kuo, J.F., Shyu, W.H. and Chou, C.C. (2019), 'Evaluating determinants of attractiveness and their cause-effect relationships for container ports in Taiwan: users' perspectives', Maritime Policy & Management, Vol. 46 Issue 4, pp. 466-490, https://doi.org/10.1080/03088839.2018.1562245

336. Vukić, L., Peronja, I. and Slišković, M. (2018), 'Port Pricing in the North Port of Split: A Comparative Analysis', Transactions on Maritime Science, Vol. 07 No. 01, pp. 59-70, https://doi.org/10.7225/toms.v07.n01.006

337. John, A., Yang, Z., Riahi, R. and Wang, J. (2018), 'A Decision Support System for the Assessment of Seaports' Security Under Fuzzy Environment', Modeling, Computing and Data Handling Methodologies for Maritime Transportation, Vol. 131, pp. 145-177, https://doi.org/10.1007/978-3-319-61801-2_6

338. Bazaras, D. and Palšaitis, R. (2018), 'Evaluation of the Risk Management Issues in the Seaports of Latvia and Lithuania', International Conference on Reliability and Statistics in Transportation and Communication RelStat 2017: Reliability and Statistics in Transportation and Communication, Vol. 36, pp. 150-156, https://doi.org/10.1007/978-3-319-74454-4_14

339. Palmieri, A., Parola, F., Song, D.W. and Baglieri, E. (2019), 'Integrating firms in a complex network: evidence from maritime logistics', International Journal of Logistics Research and Applications, Vol. 22 Issue 1: The One-Belt-One-Road initiative and its impact on global supply chain and logistics, pp. 64-77, https://doi.org/10.1080/13675567.2018.1474860

340. Naweed, A., Balakrishnan, G. and Dorrian, J. (2018), 'Going solo: Hierarchical task analysis of the second driver in "two-up" (multi-person) freight rail operations', Applied Ergonomics, Vol. 70, pp. 202-231, https://doi.org/10.1016/j.apergo.2018.01.002

341. Balog, M., Sokhatska, H. and Iakovets, A. (2019), 'Intelligent Systems in the Railway Freight Management', International Scientific-Technical Conference MANUFACTURING, MANUFACTURING 2019: Advances in Manufacturing II, pp. 390-405, https://doi.org/10.1007/978-3-030-18715-6_33

342. Hartley, J.L. and Sawaya, W.J. (2019), 'Tortoise, not the hare: Digital transformation of supply chain business processes', Business Horizons, Vol. 62 Issue 6, pp. 707-715, https://doi.org/10.1016/j.bushor.2019.07.006

343. Upadhyay, A. and Bolia, N. (2014), 'Combined empty and loaded train scheduling for dedicated freight railway corridors', Computers & Industrial Engineering, Vol. 76, pp. 23-31, https://doi.org/10.1016/j.cie.2014.07.007

344. Shankar, R., Pathak, D.K. and Choudhary, D. (2019), 'Decarbonizing freight transportation: An integrated EFA-TISM approach to model enablers of dedicated freight corridors', Technological Forecasting and Social Change, Vol. 143, pp. 85-100, https://doi.org/10.1016/j.techfore.2019.03.010

345. Lee, S. (2008), 'Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives', Supply Chain Management, Vol. 13 No. 3, pp. 185-198. https://doi.org/10.1108/13598540810871235

346. Koilo, V. and Grytten, O.H. (2019), 'Maritime Financial Instability and Supply Chain Management Effects', Problems and Perspectives in Management, Vol. 17 Issue 4, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3486992

347. Wang, Y. and Yeo, G.T. (2019), 'Transshipment hub port selection for shipping carriers in a dual hub-port system', Maritime Policy & Management, Vol. 46 Issue 6, pp. 701-714, https://doi.org/10.1080/03088839.2019.1627012

348. Shintani, K., Konings, R. and Imai, A. (2019), 'Combinable containers: A container innovation to save container fleet and empty container repositioning costs', Transportation Research Part E: Logistics and Transportation Review, Vol. 130, pp. 248-272, https://doi.org/10.1016/j.tre.2019.09.004

349. Martínez-López, A., Sobrino, P.C., González, M.C. and Trujillo, L. (2018), 'Optimization of a container vessel fleet and its propulsion plant to articulate sustainable intermodal chains versus road transport', Transportation Research Part D: Transport and Environment, Vol. 59, pp. 134-147, https://doi.org/10.1016/j.trd.2017.12.021

350. Luthra, S., Mangla, S.K., Chan, F.T.S. and Venkatesh, V.G. (2018), 'Evaluating the Drivers to Information and Communication Technology for Effective Sustainability Initiatives in Supply Chains', International Journal of Information Technology & Decision Making, Vol. 17 No. 01, pp. 311-338, https://doi.org/10.1142/S0219622017500419

351. Wang, G., Chang, W.H., Cui, Y., Qi, G. and Li, K.X. (2020), 'Introducing an economic impact platform to navigate cruise value-added chain with environmental considerations', Marine Policy, Vol. 112, 103713, https://doi.org/10.1016/j.marpol.2019.103713

352. Kashiha, M., Depken, C. and Thill, J.C. (2017), 'Border effects in a free-trade zone: Evidence from European wine shipments', Journal of Economic Geography, Vol. 17 Issue 2, pp. 411–433, https://doi.org/10.1093/jeg/lbw017

353. Santini, A., Plum, C.E.M. and Ropke, S. (2018), 'A branch-and-price approach to the feeder network design problem', European Journal of Operational Research, Vol. 264 Issue 2, pp. 607-622, https://doi.org/10.1016/j.ejor.2017.06.063

354. Wiradanti, B., Pettit, S., Potter, A. and Abouarghoub, W. (2020), 'Willingness to invest in peripheral ports: perceptions of Indonesian port and maritime industry stakeholders', Maritime Economics & Logistics, Vol. 22, pp. 699–714, https://doi.org/10.1057/s41278-020-00147-6

355. Baert, L. and Reynaerts, J. (2020), 'An examination of the determinants of inter-port competition for U.S. imports', Case Studies on Transport Policy, Vol. 8 Issue 2, pp. 281-292, https://doi.org/10.1016/j.cstp.2020.01.008

356. Tumpa, T.J., Ali, S.M., Rahman, M.H., Paul, S.K., Chowdhury, P. and Khan, S.A.R. (2019), 'Barriers to green supply chain management: An emerging economy context', Journal of Cleaner Production, Vol. 236, 117617, https://doi.org/10.1016/j.jclepro.2019.117617

357. Meersman, H., Voorde, E.V.D. and Vanelslander, T. (2010), 'Port Competition Revisited', Review of Business and Economics, pp. 210-232, https://www.vliz.be/imisdocs/publications

358. Lejars, C., Daoudi, A. and Amichi, H. (2017), 'The key role of supply chain actors in groundwater irrigation development in North Africa', Hydrogeology Journal, Vol. 25, pp. 1593–1606, https://doi.org/10.1007/s10040-017-1571-7

359. Aronietis, R., Voorde, E.V.D. and Vanelslander, T. (2010), 'Port competitiveness determinants of selected European ports in the containerized cargo market', Proceedings of IAME 2010, pp. 1-17, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.680.4083&rep=rep1&type=pdf

360. Taner, M.E., Kulak, O. and Koyuncuoglu, M. U. (2014), 'Layout analysis affecting strategic decisions in artificial container terminals', Computers & Industrial Engineering, Vol. 75, pp. 1-14, 10.1016/j.cie.2014.05.025

Appendix A

Questionnaire form to facilitate the comparison of criteria with respect to the goal (Similar types of questionnaire are used for sub-criteria w.r.t. each criterion) due to space constraint only 1 sub-criteria are presented and other sub-criteria questionnaire is not given:

Criteria	ECB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	IFB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	TEB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ADPB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	LGB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	OGB Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)
ECB	--					
IFB		--				
TEB			--			
ADPB				--		
LGB					--	
OGB						--

Economic Barriers

Criteria code	Sub criteria	ECB1 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ECB2 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ECB3 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ECB4 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ECB5 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)	ECB6 Equal (1, 1, 1) Very Low (1, 2, 3) Low (2, 3, 4) Medium (3, 4, 5) High (4, 5, 6) Very High (5, 6, 7) Excellent (6, 7, 8)
ECB1	Lack of FDIs and other investments in maritime supply chain sector	--					
ECB2	Barriers to entry and expansion in maritime supply chain business		--				
ECB3	High and frequent increments in rail haulage charges			--			
ECB4	Higher hinterland transport cost				--		
ECB5	High port tariffs compared to rivals					--	
ECB6	Slow growth of cargo generating sectors						
ECB7	Other (please specify)						--

Appendix B

Questionnaire form to facilitate the solutions for sub-criteria barriers due to space constraint only 1 sub-criteria are presented and other sub-criteria questionnaire is not given:

Set of solutions for sub-criteria barrier ECB1

	Very Low (1, 2, 3)	Low (2, 3, 4)	Medium (3, 4, 5)	High (4, 5, 6)	Very High (5, 6, 7)	Excellent (6, 7, 8)
S1						
S2						
S3						
..						
..						
S23						
S24						
S25						

Research Publications

Journals

1. Garg, C.P. and Kashav, V. (2021), 'Modeling the supply chain finance (SCF) barriers of Indian SMEs using BWM framework', Journal of Business and Industrial marketing (Accepted for publication). https://doi.org/10.1108/JBIM-05-2020-0248

2. Kashav, V., Garg, C.P., Kumar, R. (2021), 'Ranking the strategies to overcome the barriers of the Maritime Supply Chain (MSC) of containerized freight under fuzzy environment', Annals of Operations Research, (Accepted for publication).

3. Garg, C.P. and Kashav, V. (2019), 'Evaluating value creating factors in greening the transportation of Global Maritime Supply Chains (GMSCs) of containerized freight', Transportation Research Part D: Transport and Environment, Vol. 73, pp. 162-186, https://doi.org/10.1016/j.trd.2019.06.011

4. Garg, C.P. and Kashav, V. (2020), 'Assessment of Sustainable Initiatives in the Containerized Freight Railways of India using Fuzzy AHP Framework', Transportation Research Procedia, Vol. 48, pp. 522-539, https://doi.org/10.1016/j.trpro.2020.08.057

5. Kashav, V., Garg, C.P. and Behera, S.K. (2021), 'Evolution of maritime supply chains of containerised freight in India: Taaffe, Morrill and Gould model revisited', International Journal of Logistics Systems and Management, Vol.38 No.1, pp. 105–134, 10.1504/IJLSM.2021.112447

6. Raju, T.B., Chauhan, P., Tiwari, S. and Kashav, V. (2021), 'Evolution of maritime supply chains of containerised freight in India: Taaffe, Morrill and Gould model revisited', Journal of International Logistics and Trade, Vol. 18 No. 4, pp. 149-157, 10.24006/jilt.2020.18.4.149

Conferences

1. World Conference on Transport Research (WCTR), IIT Bombay, Mumbai, India – 2019
2. GLOGIFT, IIT Roorkee, Roorkee, India - 2019
3. International Association of Maritime Economists (IAME) conference, Athens University of Economics and Business, Athens, Greece - 2019

Brief Background

Name: Vishal Kashav

Qualifications:

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Department: Drewry Supply Chain Advisors

Designation: Senior Research Analyst – Product Manager

Article

ORIGINALITY REPORT

8%	5%	5%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Chandra Prakash, M.K. Barua. "Integration of AHP-TOPSIS method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment", Journal of Manufacturing Systems, 2015 Publication	1%
2	Kumari Amrita, Chandra Prakash Garg, Saumya Singh. "Modelling the critical success factors of women entrepreneurship using fuzzy AHP framework", Journal of Entrepreneurship in Emerging Economies, 2018 Publication	<1%
3	Submitted to University of Petroleum and Energy Studies Student Paper	<1%
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