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Research Article

An integrated intermodal freight transportation system to avoid container supply chain disruptions in Chattogram Port of Bangladesh

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Abstract

An integrated intermodal freight transportation system is a derived demand to transport shipping containers from/to the seaport to/from the hinterland, instead of undertaking cargo loading and unloading activities in port-protected areas. The concept of the intermodal system is to transfer containers to nearby hinterland nodes, such as dry ports, inland rail, road, and river terminals as a part of port development, as well as increasing port efficiency and productivity. Lloyd's List ranked Chattogram Port as the 67th busiest container port in the world as per container port throughput in 2022. Chattogram Port has small-scale intermodal facilities for off-docks/ICDs in the port city only. In addition, a pure intermodal system has been developed by one rail ICD in the capital city, Dhaka, and two RICTs nearby Dhaka, but less than 5 % of port throughput. A large-scale intermodal for serving the major cities, SEZs, EPZs, and industrial areas is absent due to planning and policy problems, as well as the unavailability of intermodal infrastructure and network. Due to an improper hinterland intermodal chain, the port faced container supply chain disruptions at the port yard and exceeded port capacity, resulting in container vessel congestion at the outer anchorage of Chattogram Port. By developing rail and road infrastructure, and utilizing natural river connectivity, it is possible to develop road, rail, and river intermodal systems, and shape an integrated intermodal freight transportation system to avoid container supply chain disruptions in Chattogram Port. To develop an integrated intermodal system, this research chose a quantitative research methodology for port throughput data analysis and forecasting future throughputs that are advanced to the intermodal model for Chattogram Port. Overall, this paper aims to develop an integrated intermodal freight transportation system to support Chattogram Port to keep and increase the record of port productivity, efficiency, and competitiveness actively.

1. Introduction

Bangladesh is a country that has been very fortunate in terms of its access to a vast water network. Its lengthy coastline, extensive river system, and prime position on the Bay of Bengal make it an attractive destination. An integrated intermodal freight transportation system is a derived demand to transport shipping containers from/to the seaport to/from the hinterland, instead of undertaking cargo loading and unloading activities in port-protected areas. The concept of the intermodal system

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is to transfer containers to nearby hinterland nodes, such as dry ports, inland rail, road, and river terminals as a part of port development, as well as increasing port efficiency and productivity. Lloyd's List (2023) ranked Chattogram Port as the 67th busiest container port in the world as per container port throughput in 2022. Chattogram Port has small-scale intermodal facilities for off-docks/ICDs (Inland Container Depots) in the port city only. In addition, a pure intermodal system has been developed by one rail ICD in the capital city, Dhaka, and two RICTs (Riverine Inland Container Terminals) nearby Dhaka, but less than 5 % of port throughput. A large-scale intermodal for serving the major cities, SEZs (Special Economic Zones), EPZs (Export Processing Zones), and industrial areas is absent due to planning and policy problems, as well as the unavailability of intermodal infrastructure and network. Due to an improper hinterland intermodal chain, the port faced container supply chain disruptions at the port yard and exceeded port capacity, resulting in container vessel congestion at the outer anchorage of Chattogram Port. By developing rail and road infrastructure, and utilizing natural river connectivity, it is possible to develop road, rail, and river intermodal systems, and shape an integrated intermodal freight transportation system to avoid container supply chain disruptions in Chattogram Port.

Ports (Verschuur et al., 2020) are critical nodes in the global trade network that face huge disruptions which reduce the amount of freight for a certain duration, causing delays, the depreciation of goods, and the potential need for cargo to be re-routed. Chattogram Port (Saha, 2015) is the country's primary entry point for foreign trade, although the country's intermodal infrastructure is far from complete. Container (Song, 2021) supply chain disruptions, port congestion, infrastructure constraints, and coordination concerns are only some of the dangers and difficulties associated with intermodal shipping. Intermodal freight transportation, which involves the transfer of commodities between multiple transport modalities, including ships, trucks, and trains, can benefit significantly from these water resources. Traffic congestion, transportation costs, port efficiency, and environmental protection are some areas where intermodal transport may help Bangladesh. This would be a win-win scenario for every stakeholder.

To state the disruptions in the global supply chain, Panwar et al. (2022) found that unforeseen shifts in demand points such as ports, in addition to logistical crises, brought negative trends for trade globally. However, fortunately, they observed a quick recovery in major economies. Disruptions in the flow of containers are a huge hassle for everyone who uses a port. These can happen due to several reasons, such as natural disasters, human errors, technical faults, or security concerns. Delays, losses, damages, or accidents are all possible results. Port users, port authorities, the government, and society at large are all potentially impacted. Ports (Cervinska, 2012) that lack a unified intermodal freight transportation infrastructure are more likely to experience disruptions. This network links the port to the surrounding area using a combination of rail, road, and river. The intermodal system can boost the port's capacity, productivity, and flexibility by diverting containers to other terminals or dry ports; hence, reducing the number of loading and unloading operations in the port region. Importantly, Lahdeaho et al. (2020) emphasized sustainability practices in the shipping industry due to regulations on emissions from transportation, as well as increasing customer demand for sustainability worldwide that will be a big part of port and hinterland development, and also a part of the decarbonization process.

A literature assessment of previous works focusing on multimodal transportation, port disruptions, and other port-related supply chains is assessed to explore the research gaps. This paper hypothesizes that Chattogram Port can strengthen its intermodal system and develop an integrated network that can serve Dhaka, Mongla, Chattogram, and Narayanganj, four major cities and economic powerhouses in Bangladesh. Furthermore, Holguín-Veras et al. (2014) explored the notion that the freight transport system is a key giver to the vivacity of national and regional economies, also keeping

the role of providing logistics support not only to domestic users, but also offering regional connectivity and economic development. The overall goal of this study is to create an intermodal freight transportation system that will help the port of Chattogram to maintain and improve upon its already impressive productivity, efficiency, and competitiveness.

2. Problem statement

In the course of writing this research, several issues were uncovered that plague Bangladesh's transportation sector. Chattogram Port, Bangladesh's primary entry point to foreign trade, is particularly vulnerable to the issues afflicting the country's intermodal freight transportation infrastructure.

The most pressing issues include:

1. Only one Rail ICD in Dhaka and two RICTs nearby Dhaka for moving intermodal containers from Chattogram Port are not sufficient to cover inland freight transport. The intermodal system's capacity and rail connectivity are both reduced, compared to the port throughput of Chattogram Port.

2. Overutilization of rail mode: Dhaka rail ICD has a capacity of 90,000 Twenty-foot Equivalent Units (TEUs), which was exceeded in 2021, carried 96,642 TEUs. This results in gridlock and increased travel times on the rails for containers.

3. On the other hand, waterways, or river mode, is underutilized, where PICT (Pangaon Inland Container Terminal) performed 27,596 TEUs in 2021, but which has a capacity of 1,16,000 TEUs. This is a missed opportunity to reap the environmental benefits of the river system.

4. Bangladesh has not yet introduced a drayage system of container hauling by using road mode. The intermodal system's adaptability and productivity suffer as a result.

5. Road mode is dominated by conventional trucks and covered vans that are responsible for excessive CO_2 emissions, as well as air pollution, and which also causes traffic congestion at the main transport corridor of the Dhaka-Chattogram Highway. This threatens the long-term viability of the intermodal system as a whole, including its economic, social, and environmental aspects.

6. Mindset of users for working in Chattogram Port directly. This decreases the likelihood that port users and stakeholders will adopt and embrace the intermodal system.

The disintegration (Akter et al., 2019) of seaports, railways, and inland container depots and terminals is putting logistical challenges on the Dhaka-Chattogram corridor. As a result of these issues, Chattogram Port needs an integrated intermodal freight transportation system to maintain a reliable container supply chain.

3. Research methodology

To help Chattogram Port prevent disruptions in its container supply chain, a quantitative approach will be utilized to analyze current conditions and identify potential solutions for improving the intermodal freight transportation system. To determine the elements affecting the container shipping supply chain from a logistical stance, a conceptual framework is used as the theoretical foundation. Song (2021) categorized the components of supply chain resilience factors into four groups: external environment, internal environment, operational performance, and strategic performance, and these four groups constitute the basis of the conceptual framework. The conceptual framework is useful for analyzing container supply chain disruptions and the part multimodal transportation plays in preventing or resolving them. Finally, the conceptual framework is developed in the light of Notteboom et al. (2021), and three basic indicators, Global Supply Chain, Foreland and Hinterland, and Port Performance, are selected to develop an integrated freight transportation system in Bangladesh. Chattogram Port throughput and its inland share via multimodal transport are both analyzed quantitatively as part of the research methodology. Data from government publications, scholarly articles, case studies, and stakeholder perspectives are only some examples of the secondary sources utilized by the quantitative approach. Port throughput, intermodal share, port ranking, port

efficiency, port productivity, port competitiveness, container supply chain disruptions, intermodal infrastructure, intermodal network, intermodal coordination, and intermodal benefits are some of the metrics measured for the years 2010 to 2022.

This study will add to the current literature on intermodal freight transportation by conducting a thorough and systematic examination of the IFT (Intermodal Freight Transportation) system in Bangladesh. This developing country has received little attention in previous research. Furthermore, this paper will provide practical implications and recommendations for Bangladesh's policymakers, port authorities, transport operators, and logistics providers who are interested in developing and implementing an integrated IFT system to avoid container supply chain disruptions in Chattogram Port. Furthermore, recommendations are given to conduct research in underdeveloped nations like Bangladesh in the future. To predict Chattogram Port throughput and intermodal share for the next twenty-four years, from 2022 to 2045, the time series method is employed. Presenting the existing state and potential developments, the time series approach also makes use of descriptive statistics and visual displays. The approach here also tries to analyze, in depth, the interrelationships between the various variables and factors contributing to disruptions in the intermodal system and the container supply chain. Based on the data analysis and literature evaluation, the research technique creates a network model for Chattogram Port's intermodal transport. The network concept takes trips to strategic transportation hubs, such as dry ports, inland terminals, train stations, river ports, highways, and manufacturing centers. To improve intermodal connection and capacity, the network model also takes into account ongoing and future infrastructure initiatives. By reducing costs, increasing benefits, and lowering risks associated with container supply chain interruptions, the network model seeks to optimize the intermodal system.

Recognizing the assumptions and constraints inherent in the research process is important. This study only focuses on Chattogram Port, and does not expand to other ports in Bangladesh. Due to data availability and feasibility difficulties, the study does not include South Bengal (Barisal and Khulna) in the network model. The study uses secondary data, which could contain inaccuracies or biases, and some potential future disruptions to the intermodal system or container supply chain are not taken into consideration thoroughly.

4. Conceptual framework

The conceptual framework is designed for an intermodal freight transportation network that connects Chattogram Port and its hinterland via all available and possible forms of transportation via rail, road, and waterways for the smooth transaction of international trade. Here, the conceptual framework is useful for gaining insight into the history, context, and current state of Bangladesh's container shipping supply chain, focusing on Chattogram Port. It also aids in locating the gaps in the existing literature, which this study can fill in the next section of the literature review.

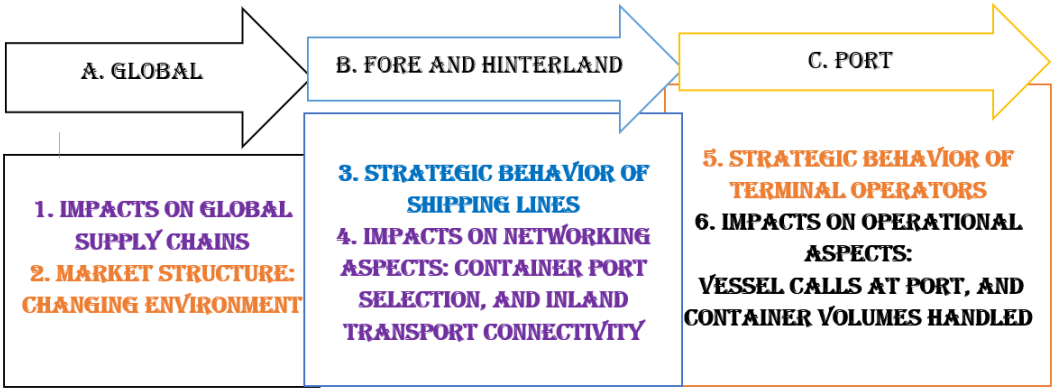

Figure 1 Conceptual framework in the light of Notteboom et al. (2021).

Figure 1 uses the concept of Notteboom et al. (2021), who identified three major areas of disruption that were observed during COVID-19, just after the financial crisis in 2008. In addition, the conceptual framework is a diagram that illustrates the logistics-focused components of the container shipping supply chain. It is a useful resource for figuring out how everything in the supply chain works together. Environmental, internal, operational, and strategic aspects are the four groups into which Song (2021) divided the variables. Market demand, competition, regulations, and innovations are all examples of elements of the external environment. Organization, strategy, culture, and available resources are all internal environment elements.

The operational performance considers things like price, quality, timeliness, and adaptability. Satisfaction of customers, market share, profits, and expansion are all part of the strategic performance. Furthermore, freight, container, vessel, inland transport, port/terminal, and container shipping supply chain are the six primary components of the conceptual framework that describe the physical and operational aspects of the container shipping supply chain. The functioning and results of each part depend on the functioning and results of the others. Transported products are represented by the freight component, which can be measured in terms of volume, weight, value, or density, depending on the type of container being used. Song (2018) presented a thorough framework for container shipping supply chain factors, which this framework is built on. The inland transport element stands in for the trucks, trains, and other vehicles used to move containers between the various ports and terminals (such as the gateway port of Chattogram, the transshipment port of Colombo, the hub port of Singapore, and the spoke port of Kolkata), along varying dimensions (distance, time, cost, and reliability). The container shipping supply chain consists of three distinct phases: pre-carriage, main carriage, and on-carriage.

5. Port performance analysis

To understand the intermodal transportation system of Chattogram Port, the study analyzes the port performance and ranking of Chattogram Port using secondary data from various sources. The data cover the period from 2011 to 2021 and include variables such as port throughput, intermodal share, port ranking, port efficiency, port productivity, port competitiveness, container supply chain disruptions, intermodal infrastructure, intermodal network, intermodal coordination, and intermodal benefits. According to the study conducted by Saha (2023), the intermodal share of Chattogram Port has increased over the years, but it is still low compared to other ports in South Asia.

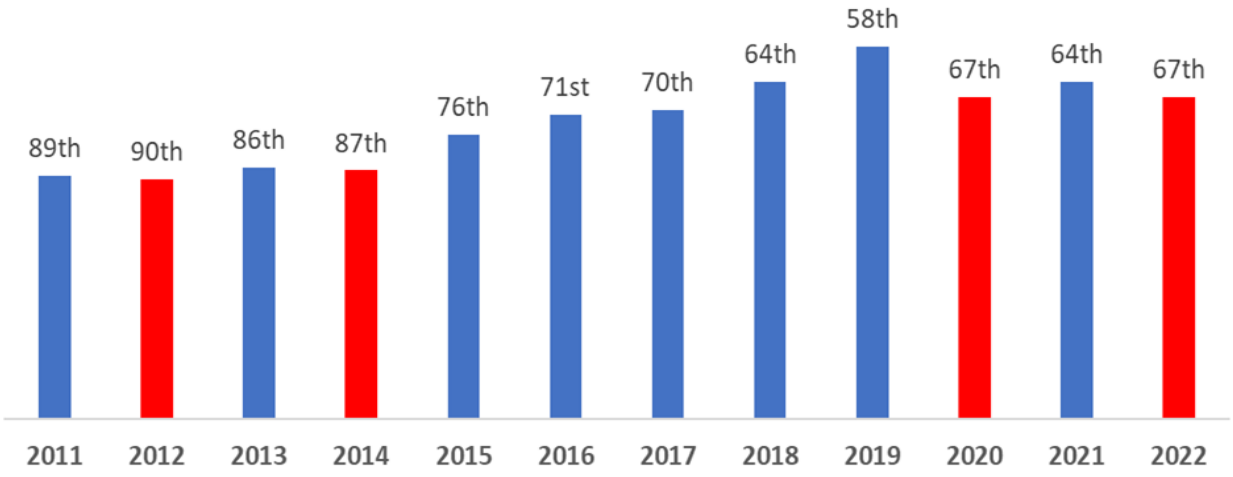

Figure 2 Container port ranking of Chattogram Port (Lloyds List, 2023).

Chattogram Port (TBS Report, 2022) is responsible for handling about 92 % of the total import and export trade of the country. Additionally, about 98 % of the cargo containers are transported through this seaport. However, only about 25 % of the goods are imported and exported through containers. The remaining 75 % is moved by bulk carriers. The port throughput of Chattogram Port has increased steadily over the years, reaching a peak of 3.1 mTEUs (Million Twenty-foot Equivalent Unit) in 2019 (**See Appendix-A**). However, the COVID-19 pandemic impacted the port's performance, and it declined significantly in 2020, dropping to 2.7 million TEUs. As per **Figure 2**, in 2022, the port recovered, and regained its 67th position in the world ranking of container ports (Lloyds List 2023). On the opposite side of the coin, The World Bank (2023) published a technical report where Chattogram Port ranked in the 307th position, not considering port throughput only.

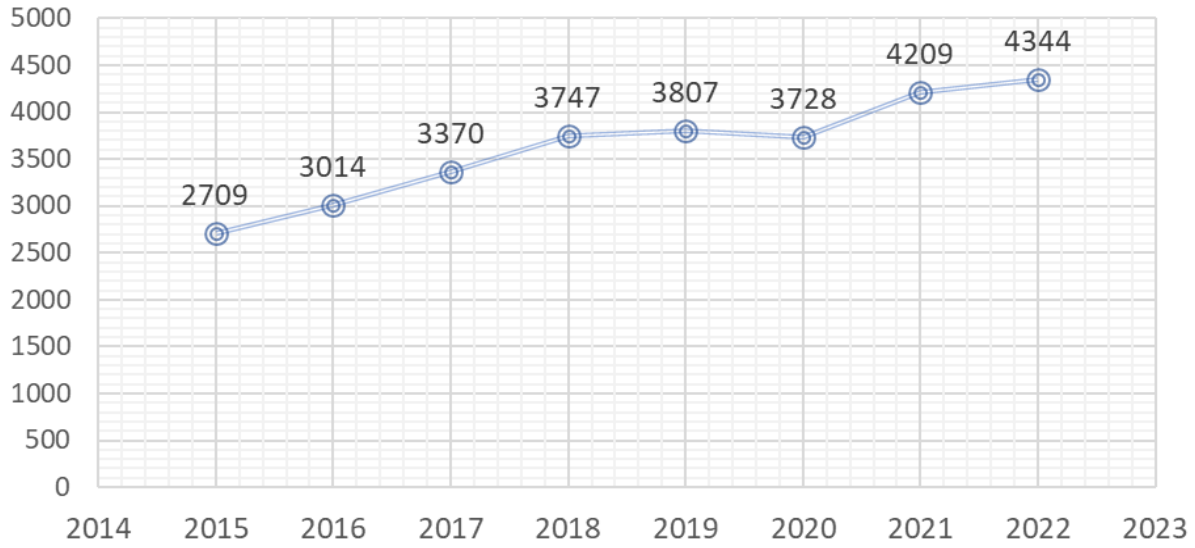

Figure 3 Vessels handled by Chattogram Port in 2015 - 2022 (The Daily Star, 2023; Saha, 2023).

Figure 3 shows the number of vessels handled by Chattogram Port in 2015 - 2022, where the port increased its efficiency. The premier port of the country increased handling more than 1.5 times from 2015 to 2022. The Daily Star (2023) reported that the port failed to increase its throughput in 2022, and handled 3.1 mTEUs, which is lower than in 2021, but the vessel number increased slightly.

The turnaround time for cargo ships is a useful metric for gauging the severity of problems at Chattogram Port. The time it takes for a container ship to go from docking to setting sail is known as its turnaround time. The congestion and efficiency of the port are reflected in the time it takes to turn around a container ship.

Figure 4 depicts the effects of disruptions at Chattogram Port on container vessel turnaround times between Fiscal Years 2010 - 2011 and 2019 - 2020, as reported by CPA (Chattogram Port Authority) in their yearly overview of 2020. The graph shows a gradual decline in the amount of time it takes for a container ship to make a complete turnaround in the port of Chattogram. The turnaround time has decreased from roughly five days in FY2010-2011 to about two days in FY2019-2020. The container ships were able to get in and out of the port more quickly and spend less time there. Chattogram Port's turnaround time for container ships fluctuates from year to year, as seen in the graph, due to external factors, including demand, supply, weather, and accidents. Because of an increase in container traffic, and a lack of resources and capacity, the turnaround time increased to roughly four days in FY2016-2017, for instance. With better operational efficiency and collaboration, the turnaround time dropped to roughly two days in FY2018-2019. Overall, **Figure 4** shows that

Chattogram Port has decreased disruptions and increased service quality and customer satisfaction over time.

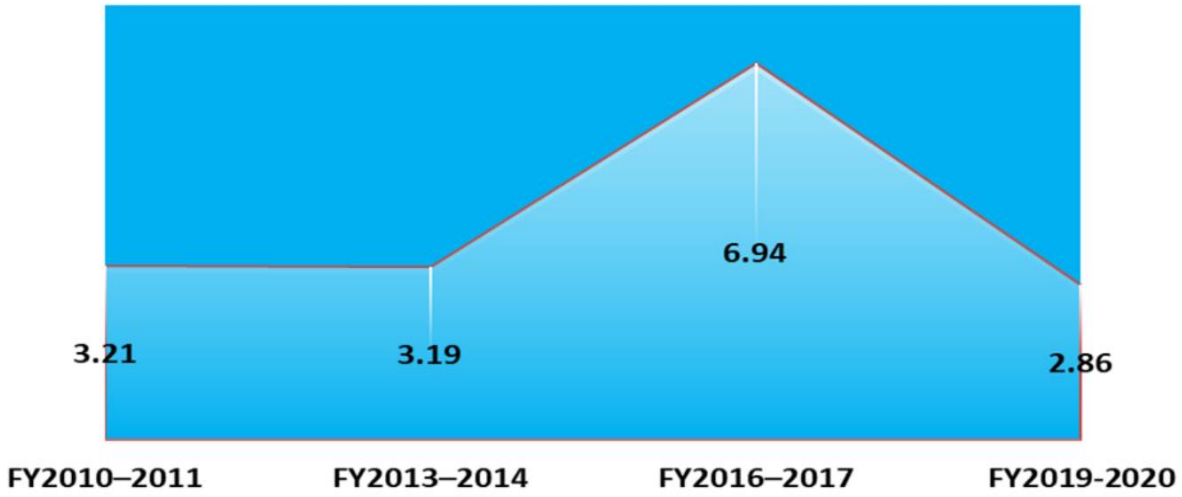

Figure 4 Container vessel turnaround time in Chattogram Port (CPA, 2021; Saha, 2023).

6. Literature review

Researchers have presented and evaluated various models (such as the Parameterized Model by Prado et al. and the Chartaring Model by Ozpeynirci et al.) and approaches for creating and managing an integrated intermodal freight transportation system. For marine service optimization, Prado et al. (2014) introduced a parameterized model of the IFT (Intermodal Freight Transportation) system that considers demand, cost, and service level characteristics to find the best possible mix of transport modes, routes, and frequencies. Ozpeynirci et al. (2013) provided a freight transportation model with ship chartering to allocate containers to different ships and modes based on capacity, cost, and time restrictions. Gurning and Cahoon (2011) categorized four broad negative consequences in the maritime industry- delay, deviation, stoppage, and loss of service platform- that created uncertainty in the maritime supply chain internally and externally. Luo and Grigalunas (2003) created a spatial-economic intermodal transportation simulation model to simulate container intermodal transport in response to varying demand, port expansions, and governmental interventions for coastal container ports. Agamez-Arias and Moyano-Fuentes (2017) argued for technological solutions to improve information and communication flows across the entire transportation system chain that will help stakeholders in decision-making for inland intermodal transport and port selection. Wang et al. (2023) expected that logistics service integrators will face the challenge of setting up multimodal transport corridors that can respond efficiently to the heterogeneous demand of shippers and that are cost- and price-competitive against other transport solutions.

Intermodal freight transportation is transporting goods via multiple modes simultaneously, providing benefits such as time, money, and energy savings, increased port efficiency, and reduced environmental impact. AITD (2004) analyzed the growth potential of intermodal transport in South Asia and identified vital elements, such as policy, infrastructure, network, technology, market, and environment, that influence growth. UNESCAP (2009) studied the efficiency of intermodal transport in Bangladesh and suggested investment in infrastructure, network integration, coordination enhancement, and legislation harmonization to boost intermodal transport. Siddiqui and Rahman (2018) highlighted the need for an integrated intermodal freight transportation system to increase port capacity, productivity, efficiency, and competitiveness. Jeong et al. (2022) examined the costs associated with disruptions in the container supply chain at port terminals. Wendler-Bosco and

Nicholson (2019) advocated for identifying port stakeholders and addressing sources of uncertainty in the maritime supply chain to prevent port disruptions.

Compared to traditional single-mode transportation, intermodal transportation saves money, reduces waste, safeguards the environment, and offers increased adaptability (Zamparini & Reggiani, 2007). However, intermodal transportation must overcome infrastructure limitations, network fragmentation, coordination problems, regulatory hurdles, and security threats to reach its full potential (Mathisen & Hanssen, 2014). Therefore, it is crucial to investigate the variables that influence the intermodal system and how it connects to the maritime supply chain, a set of interconnected people, organizations, and processes engaged in transporting commodities by sea. Agamez-Arias and Moyano-Fuentes (2017) found that the growth of international trade inspired the systemic generation of intermodal transportation systems, enabling freight, transport mode, and vehicle planning, and activated intermodal terminals and supported the logistics activities in the transport routes for reducing external costs.

Loh and van Thai (2014) addressed the vulnerability of ports, as well as port-related disruption (see **Figure 5**), which can generate a domino effect on a network of supply chains; it is crucial to make this clear ensure the functionality of ports and enhance supply chain resilience. The port, which links land and marine transport, is critical to intermodal transportation. The port serves as a hub for the intermodal movement of containers, which are uniformly sized for easy transfer between modes of transportation. Shippers, carriers, terminal operators, and logistics providers are some of the stakeholders who can benefit from the port's services, including loading, unloading, storage, and customs clearance. However, the port can also be a source of potential disruptions, such as congestion, delays, accidents, strikes, and natural disasters, which can influence the transportation system's dependability, efficiency, and resilience (Vilko et al., 2019). Bhattacharya et al. (2014) suggested that an integrated IFT system's increased visibility, control, and flexibility over container flows can improve service quality, customer happiness, and competitiveness.

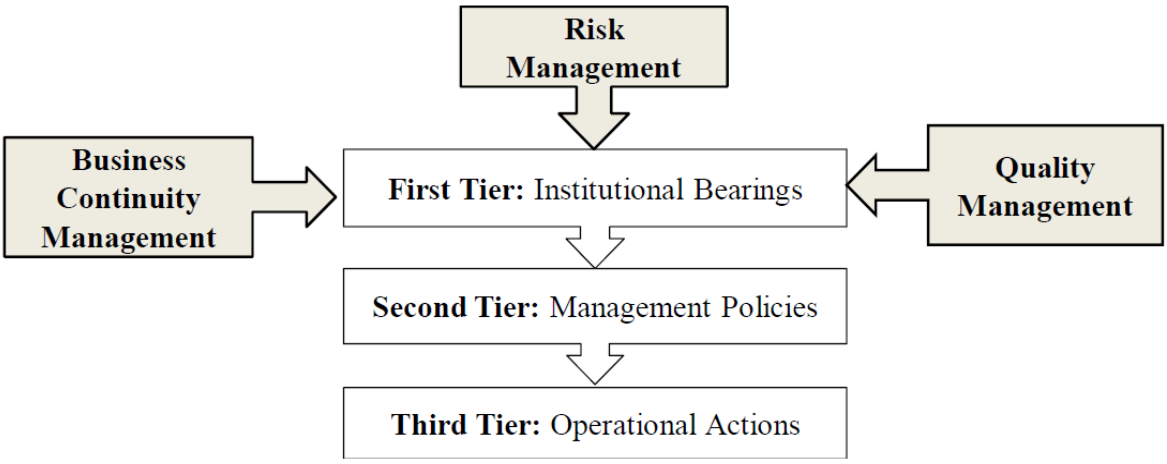

Figure 5 Port-related supply chain disruptions management model (Loh & van Thai, 2014).

Agamez-Arias and Moyano-Fuentes (2017) stated that optimizing intermodal systems mostly pivots around a relationship based on minimizing costs and time and maximizing users' profits in global supply chain management. A dynamic role of the shipping industry is discovered by Huang et al. (2016), where vessel size and numbers are increasing, and new dimensions in port infrastructures (e.g., terminal area, berths, and channel depth) are used to accommodate the latest generations of container ships. However, most previous studies have focused on the IFT system in developed

nations, such as the US, Europe, and Japan, where the infrastructure, technology, and regulations are relatively sophisticated and mature. In developing nations like Bangladesh, where infrastructure, technology, and regulations are limited and immature, research on the IFT system and the supply chain needs to be improved. Chattogram, Bangladesh's most significant and busiest port, handles almost 90 % of the entire seaborne commerce, making marine transit critical to Bangladesh's economy. However, the port of Chattogram faces significant congestion, delays, inefficiency, and vulnerability, due to its small size, aging infrastructure, poor management, and frequent interruptions. These issues have hindered the IFT system's performance and supply chain competitiveness in Bangladesh, slowing economic and social progress, as stated by Siddiqui and Rahman (2018).

The literature review reveals some research gaps that need to be addressed in this research. There needs to be more research into the effects of Bangladesh's inland freight transportation techniques and technologies on the efficiency of the country's ports. Port and terminal development are essential, and intermodal interface must be considered. The opportunities and challenges of multimodal transport and port development in South Asia should be adequately considered from a regional or comparative viewpoint. There needs to be more data and methods for strengthening Bangladesh’s container supply chains and preventing interruptions. Consequently, the Chattogram Port of Bangladesh must explore the potential of establishing an integrated IFT system to avoid container supply chain interruptions. This study aims to help close this knowledge gap to understand the current state of Bangladesh's intermodal freight transportation system, particularly regarding Chattogram Port. Moreover, it aims to investigate to what extent Chattogram Port plays a role, and what the most important considerations are for developing an integrated intermodal freight transportation system for the container supply chain in Bangladesh; specifically, how can an integrated intermodal freight transportation system improve the efficiency and competitiveness of the container supply chain in Bangladesh, particularly in the context of Chattogram Port.

7. Quantitative data analysis

The amount of containers moved through a port in a given time frame is known as its throughput. The intermodal share of container traffic is the proportion of shipments that use more than one mode of transportation to get to or from the port. This section analyzes the port throughput data of Chattogram Port, and forecasts it up to 2045 by time-series analysis. Similar activities are performed in calculating and forecasting the intermodal data of Bangladesh. It is worthwhile noting that only Chattogram Port performs intermodal transport by rail and waterways; the other two ports, Mongla and Payra, are not connected to the intermodal nodes in the country. The first section of the quantitative data analysis focuses on the efficiency of the port of Chattogram. The following graph (**Figure 6**) displays the throughput performance of Chattogram Port from 2010 - 2021, as well as projections for 2022 - 2045.

The graph (**Figure 6**) displays a steady growth in Chattogram Port throughput over time, culminating in a 2019 high of 3.09 m TEUs but a fall in 2020 where handled 2.84 mTEUs as a result of the COVID-19 epidemic. Furthermore, the graph indicates that Chattogram Port throughput will continue to rise, eventually reaching around 7.9 mTEUs in 2045. This indicates that port throughput will increase by more than 100 % in the next 37 years. However, this also means that the port will be subject to increased competition, congestion, and capacity constraints. The chart also demonstrates the importance of improving hinterland and interior transit connectivity to handle more TEUs. The hinterland is the region that the port facilitates trade with. The term “inland transport” refers to the transportation of commodities by land, rather than by water. It also measures how well various forms of inland transportation work together and with one another.

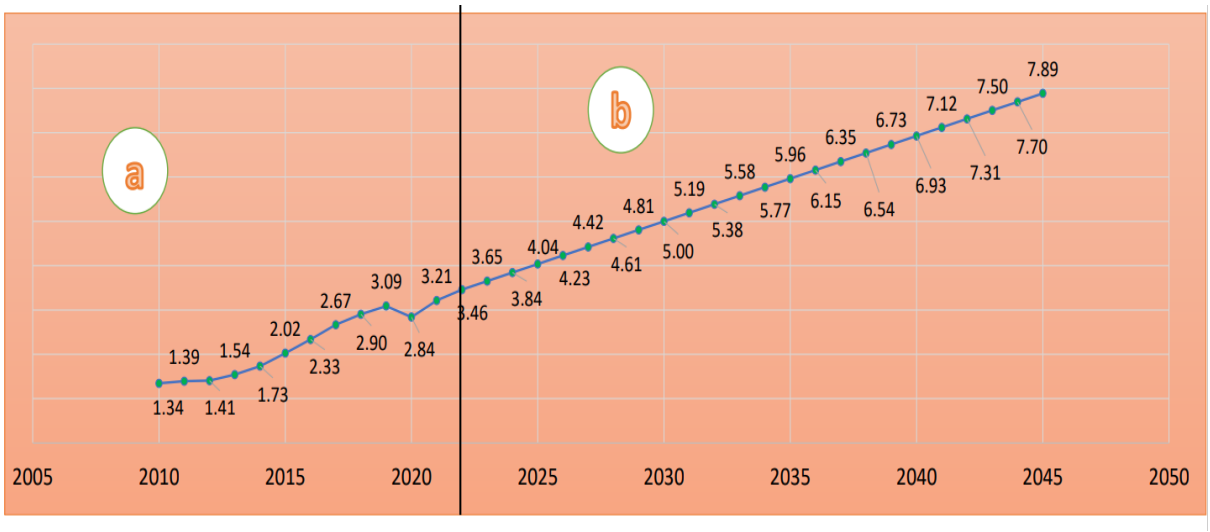

Figure 6 Performance of Chattogram Port a) Actual 2010 - 2021 in mTEUs; b) Forecast 2022 - 2045 in mTEUs.

Furthermore, **Figure 7**, below, displays the percentage of intermodal shipping at Chattogram Port from 2010 to 2021, as well as a forecast for 2022 - 2045:

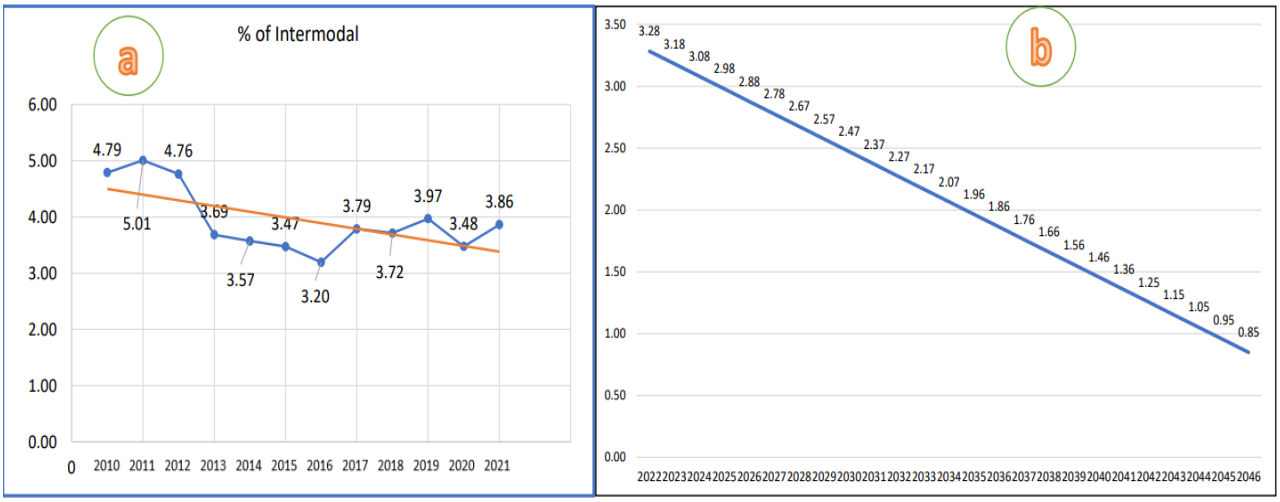

Figure 7 Percentage of intermodal shipping in Chattogram Port a) Actual 2010 - 2021; b) Forecast 2022 - 2045.

According to **Figure 7**, intermodal transport's share of the port's overall throughput is decreasing annually. In 2010, intermodal shipping accounted for around 5 % of port throughput; by 2021, that number had plummeted to approximately 4 %. The percentage of containers transported by rail or river, from or to the port, is thus estimated to be around 5 %. Road transport was used for the remaining containers because it is Bangladesh's most common means of inland transportation. **Figure 7** also indicates an anticipated growth in intermodal transport's share of the port's total throughput. From 2022 to 2045, data forecasts negative trends, and lower or decreased value of intermodal transport from the current 3.86 % to around 1 %. Infrastructure, network, coordination, and regulation are only some of the aspects of inland and hinterland transport links that will be crucial to the expansion of intermodal transportation. Intermodal transport TEUs are on the rise, but the graph shows they need to catch up with the growth of Chattogram Port. Chattogram Port handled over 1.34 million TEUs in 2010, while multimodal transport handled about 0.34 million TEUs. Chattogram

Port handled over 3.21 million TEUs in 2021, while multimodal transport handled roughly 0.48 million TEUs. This indicates that Chattogram Port is expanding at a faster rate than multimodal transport. Moreover, **Figure 7** demonstrates that, in the future, the number of TEUs moving via intermodal transport will rise faster than the number moving through Chattogram Port. The prediction for 2022 - 2045 reveals that intermodal transport will increase from approximately 0.51 million TEUs to about 2.76 million TEUs, while Chattogram Port will increase from about 3.40 million TEUs to about 7.89 million TEUs. If this trend continues, multimodal transportation will expand more quickly than Chattogram Port.

This research yields practical insights and suggestions for advancing intermodal transport and port development in Bangladesh, particularly in the port of Chattogram. These results also offer recommendations for how to strengthen container supply chain resilience in Bangladesh, with a focus on Chattogram Port. However, it is important to recognize the constraints and difficulties associated with these results. Among the restrictions and difficulties that are expected in the coming days, The data used in this study are secondary data, meaning they come from a variety of sources which could have varying definitions, methods, and levels of reliability. This means there is a chance the numbers are wrong, inconsistent, or not directly comparable. Descriptive statistics and visual representations are the primary methods of data analysis in this study, although they may not be enough to capture the intricate interplay, correlation, and causation among the variables. This raises the possibility that the data analysis is not exhaustive, rigorous, or solid. This study's projections are based on guesses and possible outcomes that may not be indicative of future developments. As a result, the prediction might not be entirely accurate, trustworthy, or sound.

8. Major findings and discussions

Maritime disruptions have affected the performance of the port and shipping business. In research, Gurning and Cahoon (2011) ranked 20 major maritime disruptive events in considering the total logistics of commodities from origin to destination.

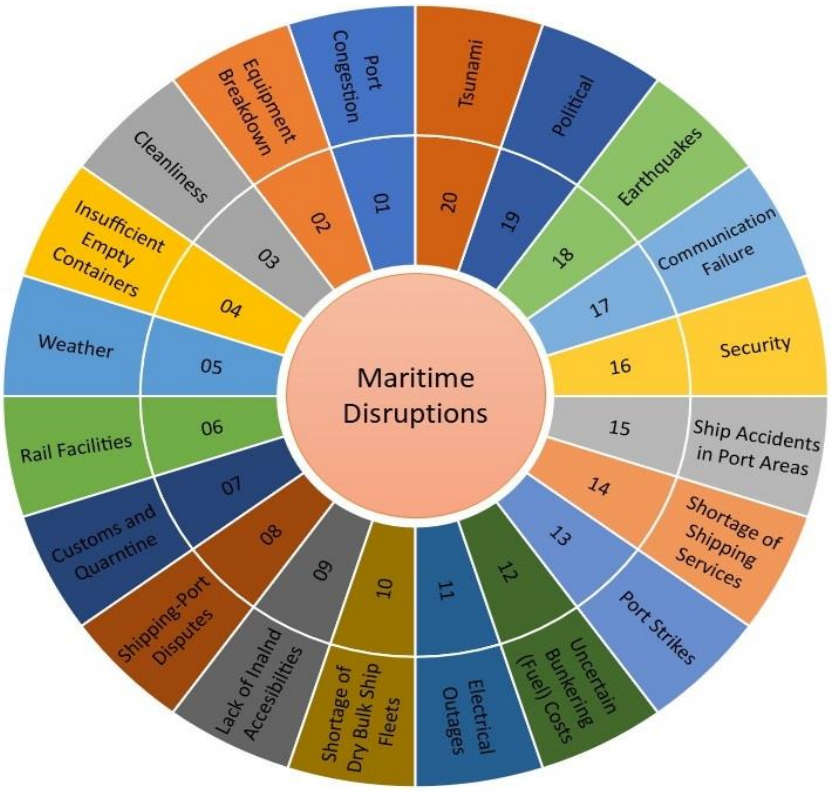

Figure 8 Major maritime disruptive events by Gurning and Cahoon (2011).

Figure 8 shows the 20 maritime disruptive events with scores within 0.40, but only 9 events scored within 0.11 out of 0.40. Gurning and Cahoon (2011) identified that port congestion is the top-ranked disruptive event that killed port performance, productivity, and efficiency. Low-scored but inland accessibility controlled the port volume and vessel's turnaround time. Maximum cargo transfer from/to the port and management to the inland channel will maximize port throughput. Two major findings are attributed to the port ranking of Chattogram Port by Lloyds List (2023) and World Bank (2023). Lloyds List calculated the container port throughput, and the Chattogram Port was positioned at 64th in 2022. On the contrary, the World Bank ranked it in 307th position in terms of efficiency and other facilities. Driven in particular, port infrastructural development is a crucial factor in Bangladesh, especially for Chattogram Port. In the last decade (2012 - 2021), Chattogram Port doubled its port throughput from 1.5 mTEUs to above 3.1 mTEUs, but rail contributed 3.08 %, and inland waterways 0.59 %.

Based on the conceptual framework in the earlier section 3, this research conducted the literature review and collected data, and also analyzed port throughput data (See **Figures 6**, **7**, and **Appendix**) and extracted the major findings as stated below:

The process (Pereira et al., 2016) of economic globalization has become constant and hasty, as the transport network has become increasingly complex because of significant changes in the manner of cargo transport, which leads to satisfying the customer's needs for achieving an effective and efficient low-cost distribution. However, creating a fully-functional multimodal transportation system is far easier said than done. It calls for extensive policymaking, network building, stakeholder coordination, and infrastructure development. According to Siddiqui and Rahman (2018), the Chattogram port in Bangladesh has some intermodal facilities, although they need to be bigger and more. Intermodal transport accounts for a negligible portion of the port's total traffic. Shipping containers typically involves expensive, inefficient, and harmful road haulage. Lack of dry ports, inland terminals, and river and train connections are further issues. This causes regular interruptions in the container supply chain, which lowers Chattogram Port's standing in the area and globally. To help Chattogram Port prevent disruptions in its container supply chain, a proposal for the creation of an integrated intermodal freight transportation system is presented. Specifically, it employs a quantitative research methodology to examine the port's performance and ranking data, and develop an intermodal model for the facility.

Due to COVID-19, the global shipping market has changed, and freight rates have increased significantly. In this changing environment, port or terminal operators have also changed their operations style, and favor direct intermodal transfer instead of port delivery. Osobajo et al. (2021) advised building a relationship with maritime supply chain partners and considering imperatives for organizations to survive and remain competitive. Shi et al. (2023) structured the maritime time supply chain to be kept in the hinterland market with the key performance of logistics service providers in accomplishing the main tasks of cargo and container transfer from/to seaports actively. In the study by the World Bank (2023), it is found that Chattogram Port has a lower performance and ranking than Colombo Port, which is the leading container port in South Asia. The low performance and ranking of Chattogram Port can be attributed to several factors, such as container supply chain disruptions, lack of intermodal infrastructure, poor intermodal network, and weak intermodal coordination. Port (Wendler-Bosco & Nicholson, 2019) resilience and intermodal transportation resilience considering maritime transportation have not yet received significant attention from academic researchers. Nowadays, deep (Agbo et al., 2017) sea terminal operators are putting commercial liaisons with port authorities and mainline or ocean carriers in managing port users and inland transport timely and economically. The business (Loh & van Thai, 2014) environment in which ports are embedded has generally become riskier, as they are more vulnerable to uncertainties attributed to global inter-connected supply chain entities to ensure the delivery of their customer's requirements and become trustworthy. They attributed the port-related supply chain disruptions (**Figure 5**) and prescribed the

management model for operating port business, reducing risk and ensuring quality for developing management policies to set operational actions

Port (Huang et al., 2016) infrastructures need to adapt to future trade volumes well in advance to increase their commercial viability. A large-scale intermodal system for serving the major cities, SEZs, EPZs, and industrial areas is absent due to planning and policy problems, as well as the unavailability of intermodal infrastructure and network. By developing rail and road infrastructure, and utilizing natural river connectivity, it is possible to develop road, rail, and river intermodal systems and shape an integrated intermodal freight transportation system to avoid container supply chain disruptions in Chattogram Port. Rail and inland waterways carry less than 5 % of containers, whereas two ICTs can accommodate more than 7 % of total port throughput. Bangladesh (Saha et al., 2023) is a rapidly developing country, with a population of more than 160 million, and most of this population is highly dependent on land-based freight transport, where inland freight transportation is a significant contributor to the economic growth of Bangladesh. Kordnejad (2014) estimated that intermodal transport saves at least 20 % of costs and space utilization, at 63 %, compared to a unimodal road system (haulage). Lahdeaho et al. (2020) raised the issue of infrastructure constraints that lead to bottlenecks in hinterland operations. In this connection, the role of port authority is appreciable to develop inland port transport connectivity for connecting many modes at a time, and offer synchromodality to port users.

Osobajo et al. (2021) conceptualized that maritime supply chain performance depends on trust, satisfaction, and commitments together, bonding with the port users/customers in providing restless services regularly. Data forecasting of Chattogram Port expects 7.89 mTEUs, and the port needs to develop infrastructures, install capital equipment, and set seamless hinterland connectivity to accommodate the increased volume. Having a nice background on mode selection toward the port, Lahdeaho et al. (2020) accentuated the rail mode as one of the most important factors for environmental sustainability in freight transport chains. Most (Young & Gordon, 2020) international trade is transported as containerized freight that offers fast and efficient services, as well as security from pilferage and obscure contraband and removal of opportunities to tamper with goods in shipment. Due to an improper hinterland intermodal chain, the port faced container supply chain disruptions at the port yard and exceeded port capacity, resulting in container vessel congestion at the outer anchorage of Chattogram Port. In the port data analysis, it was observed that the number of vessels increased significantly (**Figure 3**), and vessel turnaround time decreased drastically from 6.94 to 2.86 within three fiscal years (**Figure 4**). In the negative sense, trends or percentages of intermodal transport will be going down, as new inland nodes are not established and facilities are not planned as per the port throughput of Chattogram Port.

9. Network model for intermodal

Based on the results of a quantitative study of traffic patterns in the port of Chattogram, this research proposes a network model for intermodal transport. Physical geography, cargo movement, and industrial areas are considered in node selection for this network model. Furthermore, it suggests a strategy for expanding and coordinating the port's road, rail, and river intermodal networks, which can boost the port's efficiency and standing. It also explains the network model's accompanying map and table. In addition, it incorporates lessons learned and suggestions for moving forward discovered from the literature, data collections, and dialogue with the respective authority during data collection. Lack of infrastructure, inadequate network, poor coordination, limited acceptance, and strong rivalry are only some of the issues the network model seeks to overcome to advance intermodal transport in Bangladesh. Road, rail, and river intermodal all make up significant parts of Chattogram Port's multimodal transportation network model. The major cities, SEZs, EPZs, and industrial areas in Bangladesh are all within reach, thanks to the network's many components' dedicated routes, services, and facilities. When all of these parts work together, as they should, they prevent disruptions in the container supply chain at Chattogram Port. **Figure 9** represents the route and service network model

for intermodal transport at Chattogram Port. Chattogram Port, along with other significant towns and ports, is indicated on this map of Bangladesh. As part of the network concept, the map also displays the locations of inland container depots (ICDs) and a logistics park (LP). The map's color coding denotes the various paths and offerings in the simulated network.

Figure 9 Map of network model for intermodal transportation system of Bangladesh.

Table 1 summarizes, by component, the network model's planned routes and services, and also includes details on each route's and service's capacity, frequency, reliability, and benefits. Connecting the port of Chattogram to the cities of Dhaka, Khulna, Sylhet, and Rajshahi are the four arteries that make up the road intermodal system. The road intermodal system relies on trucking companies to move containers to and from the port. The road intermodal system also makes use of ICDs and the logistics park to increase security and safety, lessen traffic congestion, and streamline the loading and unloading processes. Due to its speed, adaptability, and frequency, the road intermodal system can accommodate the vast volume of container traffic. Three different train lines connect Chattogram Port to the cities of Dhaka, Khulna, and Sylhet. Shipping containers to and from the port is eased by using the rail intermodal system. In addition to helping with loading and unloading, ICDs and the LP help the rail intermodal system save money on fuel, lessen its impact on the environment, and make its operations more reliable and secure. The rail intermodal system can handle the increasing volume of containers because it provides low-cost, reliable, and high-capacity services. Furthermore, two routes make up the river intermodal system that links the port of Chattogram to the cities of Dhaka and Khulna. The river intermodal system employs barges to get containers to and from the port. With ICDs and the LP, the river intermodal system may speed up the loading and unloading processes, lessen the impact on the environment, and make transportation more adaptable and secure. Utilizing Bangladesh's natural river connectivity, the river intermodal system provides inexpensive, eco-friendly, and less disruptive services.

Table 1 displays the routes and services comprising the multimodal transportation network model serving the Chattogram port, as per **Figure 9**.

Table 1 Mode and loops in the network model.

Mode	Loops	Remarks
Rail	1. Chattogram Port - Akhaura - Ghorasal - Dhaka ICD. 2. Chattogram Port - Akhaura - Ghorasal - Ishwardi - Parbatipur.	1. Ignored Khulna and Barisal divisions that will be served by Mongla and Payra Port. 2. Need to establish Dry Port/ICD in Akhaura, Ghorasal, Ishwardi. 3. Need to construct ICT in Ashuganj, Nagarbari and Ghorasal. 4. Multimodal Logistics Park is proposed in Parbatipur to cover the whole of North Bengal.
River	3. Chattogram Port - Ashuganj. 4. Chattogram Port - Nagarbari. 5. Chattogram Port - Pangaon. 6. Chattogram Port - Ghorasal.	
Road	7. Chattogram Port - Ghorasal. 8. Chattogram Port - Ishwardi. 9. Chattogram Port - Akhaura.	
Multimodal	10. Chattogram Port - Ashuganj (River) - Akhaura (Road). 11. Chattogram Port - Nagarbari (River) - Ishwardi (Rail) - Parbatipur (Rail).	

10. Future directions

Based on the data analysis and results from the previous chapters, a comprehensive future direction for the Chattogram Port is given. It also draws on the best practices and recommendations from the literature review and the stakeholder perspectives. The future direction aims to address the challenges and barriers of intermodal transport development in Bangladesh, such as lack of infrastructure, inadequate network, poor coordination, low acceptance, and high competition.

- Port disruptions can cause cascading effects on the entire supply chain (Wendler-Bosco & Nicholson, 2019). Therefore, to manage the whole supply chain of the country, the government must stabilize the port working environment. This can be done by enhancing the port security, safety, and contingency planning, and fostering a collaborative culture among the port stakeholders, such as port authorities, terminal operators, shipping lines, transport companies, shippers, and logistics providers.
- Establish more transport nodes such as ICDs, RICTs, dry ports, logistics parks, and distribution centers in the major cities and industrial areas. These transport nodes can facilitate loading and unloading operations, reduce road congestion and pollution, improve security and safety issues, and increase the intermodal share of Chattogram Port. These transport nodes can also provide value-added services, such as warehousing, packaging, labeling, sorting, and customs clearance.
- The seaport terminal's design will be intermodal friendly. This means that the seaport terminal will have adequate facilities and equipment to handle different types of containers (standard, reefer, open-top, flat-rack, or tank) with different indicators (volume, weight, value, or density). The seaport terminal will also have sufficient space and layout to accommodate different types of vessels (feeder, liner, or tramp) with different indicators (TEU, tare weight, or payload). The seaport terminal will also have easy access and connectivity to different modes of inland transport (road, rail, or river) with different indicators (distance, time, cost, or reliability).

- The port authority needs to invest in inland node development for quick transfer of containers and increase port capacity accordingly. This means that the port authority will allocate more resources and funds to develop and maintain the inland nodes, such as ICDs, RICTs, dry ports, logistics parks, and distribution centers. The port authority will also coordinate and collaborate with other stakeholders, such as transport companies, shippers, and logistics providers, to ensure the smooth operation and management of the inland nodes. The port authority will also monitor and evaluate the performance and impact of the inland nodes on port throughput, efficiency, productivity, competitiveness, and resilience.

Collaboration should be encouraged among various stakeholders, including transport companies, shippers, and logistics providers. By working together, they can reduce the transportation system's congestion and environmental impact by consolidating loads and optimizing routes to minimize empty runs. They can also improve the transportation system's service level and customer satisfaction, by sharing information and feedback to enhance transparency and trust, and also increase the resilience by supporting each other to cope with disruptions and uncertainties.

11. Conclusions

With the voice of the World Bank (2023) and reception on container shipping "Since the start of maritime trade, ports have played a central role in the economic and social development of countries". The future of intermodal transport in Bangladesh holds excellent promise in developing an integrated freight transportation system in Bangladesh. Intermodal transport is an ever-accelerating force, delivering remarkable savings in time, costs, and environmental impact. Its role as a dependable freight transport system is undeniable, making extending its reach to inland transport nodes imperative. The key to achieving this lies in applying modern freight transport vehicles, enhancing rail freight capacity, and harnessing waterways- a trinity that reduces CO2 emissions and ensures compliance with Sustainable Development Goals. However, with the projection of Chattogram Port's 7.89 mTEUs throughput in 2045, the pressing need for fortified inland freight transport infrastructure becomes crystal clear. In this landscape, research focused on container supply chains and intermodal systems development emerges as a beacon, promising increased port productivity and smoother logistics management. We stand at the threshold of a brighter, eco-friendly, and resilient intermodal future for Bangladesh that will reduce container supply chain disruptions optimistically. Chattogram Port's performance and ranking should improve substantially as a result of implementing the network concept for multimodal transportation that will allow a shorter turnaround time for container ships, meaning lower shipping costs and less fuel used. Port (Saha, 2015) development is essential in Bangladesh, boosting the port's throughput, movements per hour, TEU per hectare (space), and market share to improve efficiency, productivity, and competitiveness. In addition, improving service quality, increasing customer happiness, and promoting teamwork are all ways to make Chattogram Port and the maritime supply chain more resistant to disruptions.

References

Agamez-Arias, A. D. M., & Moyano-Fuentes, J. (2017). Intermodal transport in freight distribution: A literature review. *International Journal of Physical Distribution & Logistics Management, 47*(10), 957-983.

Agbo, A. A., Li, W., Atombo, C., Lodewijks, G., & Zheng, L. (2017). Feasibility study for the introduction of synchromodal freight transportation concept. *Cogent Engineering, 4*(1), 1305649. https://doi.org/10.1080/23311916.2017.1305649

AITD. (2004). *Intermodal Transport Development in South Asia Region*. Asian Institute of Transport Development, New Delhi.

Akter, N., Chhetri, P., & Rahman, S. (2019. Understanding the usage patterns, practices, and decision process of third-party logistics outsourcing in Bangladesh. *Journal of Global*

Operations and Strategic Sourcing, 12(3), 329-354. https://doi.org/10.1108/JGOSS-08-2018-0027

Bhattacharya, A., Kumar, S. A., Tiwari, M. K., & Talluri, S. (2014). An intermodal freight transport system for optimal supply chain logistics. *Transportation Research Part C: Emerging Technologies, 38*, 73-84. https://doi.org/10.1016/j.trc.2013.10.012

Cervinska, J. (2012). *Vulnerability of intermodal logistic networks to sea port disruption*. The University of Texas at El Paso.

CPA. (2021). *CPA overview, 2020*. Chattogram: CPA.

Gurning, S., & Cahoon, S. (2011). Analysis of multi-mitigation scenarios on maritime disruptions. *Maritime Policy & Management, 38*(3), 251-68. https://doi.org/10.1080/03088839.2011.572701

Holguín-Veras, J., Jaller, M., Sánchez-Díaz, I., Campbell, S., & Lawson, C. T. (2014). *Freight generation and freight trip generation models* (pp. 43-63). Elsevier. https://doi.org/10.1016/B978-0-12-410400-6.00003-3

Huang, Y., Rashidi, T. H., & Gardner, L. (2018). Modeling the global maritime container network. *Maritime Economics & Logistics, 20*, 400-420. https://doi.org/10.1057/s41278-016-0047-3

Jeong, Y., Kim, G., & Moon, I. (2022). *Reliable container supply chain under disruption*. Annals of Operations Research. https://doi.org/10.1007/s10479-022-05068-6

Kordnejad, B. (2014). Intermodal transport cost model and intermodal distribution in urban freight. *Procedia-Social and Behavioral Sciences, 125*, 358-372. https://doi.org/10.1016/j.sbspro.2014.01.1480

Lahdeaho, O., Hilmola, O. P., Henttu, V., & Haapasalo, H. (2020). Maritime supply chain sustainability in South East Finland: A mixed-methods research design. *Journal of Cleaner Production, 256*, 120435. https://doi.org/10.1186/s41072-020-00073-z

Lloyd's List. (2023). *Lloyd's List: Maritime Insights & Intelligence: One Hundred Container Ports 2023*. Retrieved from https://lloydslist.com/one-hundred-container-ports-2023

Loh, H. S., & Van Thai, V. (2014). Managing port-related supply chain disruptions: A conceptual paper. *The Asian Journal of Shipping and Logistics, 30*(1), 97-116. https://doi.org/10.1016/j.ajsl.2014.04.005

Luo, M., & Grigalunas, T. A. (2003). A spatial-economic multimodal transportation simulation model for US coastal container ports. *Maritime Economics & Logistics, 5*(2), 158-178. https://doi.org/10.1057/palgrave.mel.9100067

Mathisen, T. A., & Hanssen, T. E. S. (2014). The academic literature on intermodal freight transport. *Transport Reviews, 34*(4), 479-515.

Notteboom, T., Pallis, T., & Rodrigue, J. P. (2021). Disruptions and resilience in global container shipping and ports: The COVID-19 pandemic versus the 2008-2009 financial crisis. *Maritime Economics & Logistics, 23*, 179-210. https://doi.org/10.1057/s41278-020-00180-5

Osobajo, O., Evangelista, P., & Sweeney, E. (2021). Relationship marketing in maritime supply chains: A systematic literature review. *Maritime Policy & Management, 48*(1), 1-25.

Ozpeynirci, Ö., Üçer, K., & Tabaklar, T. (2014). Multimodal freight transportation with ship chartering. *Maritime Economics & Logistics, 16*, 188-206. https://doi.org/10.1057/mel.2013.24

Panwar, R., Pinkse, J., & De Marchi, V. (2022). The future of global supply chains in a post-COVID-19 world. *California Management Review, 64*(2), 5-23. https://doi.org/10.1177/00081256211073355

Pereira, M. T., Ferreirinha, L., Ferreira, F. A., & Oliveira, M. (2022). *A VRP model to support last mile maritime containers* (pp. 360-370). Springer International Publishing. https://doi.org/10.1007/978-3-030-78170-5_31

Prado, R. R., Pereira, D. C., del Rio Vilas, D., Monteil, N. R., & Del Valle, A. G. (2014). A parameterised model of multimodal freight transportation for maritime services

optimization. *International Journal of Simulation and Process Modelling, 9*(1/2), 33-45. https://doi.org/10.1504/IJSPM.2014.061431

Saha, R. C. (2023). Chattogram Port: A dedicated service institution to evolve the country boldly. *Maritime Technology and Research, 5*(1), 258294. https://doi.org/10.33175/mtr.2023.258294

Saha, R. C., Sabur, H. A., & Ruhul, S. T. M. (2023). Environmental sustainability of inland freight transportation systems in Bangladesh. *International Supply Chain Technology Journal, 9*(9), 300. https://doi.org/10.20545/isctj.v9i9.300

Saha, R. C. (2015). Port development in Bangladesh. *European Journal of Business and Management, 7*(7), 392-399.

Shi, X., Liu, Z., Meng, Q., & Wang, S. (2022). Impact of the integration of ports and inland transporters on the resilience of maritime supply chains. *Transportation Research Part E: Logistics and Transportation Review, 149*, 102329.

Siddiqui, M. N., & Rahman, M. M. (2018). *A review of the current state of freight transport in Bangladesh* (pp. 45-60). In Islam, S. M. N., & Ahmed, E. (Eds.). Transportation Systems in Developing Countries. Springer Nature Singapore.

Song, D. (2018). A literature review: Container shipping supply chain: Planning problems and research opportunities. *Transportation Research Part E: Logistics and Transportation Review, 115*, 164-201.

Song, D. W. (2021). Planning problems and research opportunities in container shipping supply chain. *Transportation Research Part E: Logistics and Transportation Review, 147*, 102219.

TBS Report. (2023). *Container handling of import cargos at Chattogram port falls in January. The Business Standard*. Retrieved from https://www.tbsnews.net/bangladesh/container-handling-import-cargos-chattogram-port-falls-january-581614

The Daily Star. (2023). *CTG Port Container handling drops in 2022*. Retrieved from https://www.thedailystar.net/business/economy/news/ctg-port-container-handling-drops-2022-3210516

UNESCAP. (2009). *Policy framework for the development of intermodal interfaces as part of an integrated transport network in Asia*. Retrieved from https://www.unescap.org/resources/study-policy-framework-development-intermodal-interfaces-part-integrated-transport-network

Verschuur, J., Koks, E. E., & Hall, J. W. (2020). Port disruptions due to natural disasters: Insights into port and logistics resilience. *Transportation Research part D: Transport and Environment, 85*, 102393. https://doi.org/10.1016/j.trd.2020.102393

Vilko, J., Ritala, P., & Hallikas, J. (2019). Risk management abilities in multimodal maritime supply chains: Visibility and control perspectives. *Accident Analysis & Prevention, 123*, 244-255. https://doi.org/10.1016/j.aap.2016.11.010

Wang, Z., Zhang, D., Tavasszy, L., & Fazi, S. (2023). Integrated multimodal freight service network design and pricing with a competing service integrator and heterogeneous shipper classes. *Transportation Research Part E: Logistics and Transportation Review, 179*, 103290. https://doi.org/10.1016/j.tre.2023.103290

Wendler-Bosco, V., & Nicholson, C. (2019). Port disruption impact on the maritime supply chain: A literature review. *Sustainable and Resilient Infrastructure, 6*(1-2), 3-18. https://doi.org/10.1080/23789689.2019.1600961

World Bank. (2023). *Transport Global Practice: The Container Port Performance Index 2022 A Comparable Assessment of Performance based on Vessel Time in Port*. Retrieved from https://documents1.worldbank.org/curated/en/099051723134019182/pdf/P1758330d05f3607f09690076fedcf4e71a.pdf

Young, R. R., & Gordon, G. A. (2020). *Intermodal maritime supply chains: Assessing factors for resiliency and security* (pp. 197-213). Routledge. https://doi.org/10.1007/s12198-020-00224-0

Zamparini, L., & Reggiani, A. (2007). Freight transport and the value of travel time savings: A meta-analysis of empirical studies. *Transport Reviews, 27*(5), 621-636. https://doi.org/10.1080/01441640701322834

Appendix

Port throughput of Chattogram Port and inland nodes data and forecasting.

Year	CPA	Intermodal	% of Intermodal	Dhaka ICD/Rail	River (RICT)
2010	1,343,448.00	64,370.00	4.79	64,369	0
2011	1,392,104.00	69,724.00	5.01	69,723	0
2012	1,406,456.00	67,011.00	4.76	67,010	0
2013	1,541,517.00	56,805.00	3.69	56,447	358
2014	1,731,219.00	61,870.00	3.57	60,886	984
2015	2,024,207.00	70,334.00	3.47	69,087	1,247
2016	2,332,892.00	74,577.00	3.20	70,363	4,214
2017	2,667,202.00	101,061.00	3.79	74,907	26,154
2018	2,903,996.00	107,886.00	3.72	83,960	23,926
2019	3,088,187.00	122,640.00	3.97	95,000	27,640
2020	2,839,977.00	98,742.00	3.48	78,242	20,500
2021	3,214,548.00	124,238.00	3.86	96,642	27,596
2022	3,458,896.30	123,263.94	3.28	92,262	31,002
2023	3,651,473.25	129,160.21	3.18	95,088	34,072
2024	3,844,050.21	135,056.48	3.08	97,915	37,141
2025	4,036,627.16	140,952.76	2.98	100,742	40,210
2026	4,229,204.12	146,849.03	2.88	103,569	43,280
2027	4,421,781.07	152,745.30	2.78	106,396	46,349
2028	4,614,358.03	158,641.58	2.67	109,223	49,418
2029	4,806,934.99	164,537.85	2.57	112,050	52,488
2030	4,999,511.94	170,434.12	2.47	114,877	55,557
2031	5,192,088.90	176,330.39	2.37	117,704	58,626
2032	5,384,665.85	182,226.67	2.27	120,531	61,696
2033	5,577,242.81	188,122.94	2.17	123,358	64,765
2034	5,769,819.76	194,019.21	2.07	126,185	67,834
2035	5,962,396.72	199,915.48	1.96	129,012	70,904
2036	6,154,973.68	205,811.76	1.86	131,839	73,973
2037	6,347,550.63	211,708.03	1.76	134,666	77,042
2038	6,540,127.59	217,604.30	1.66	137,493	80,112
2039	6,732,704.54	223,500.58	1.56	140,320	83,181
2040	6,925,281.50	229,396.85	1.46	143,147	86,250
2041	7,117,858.46	235,293.12	1.36	145,974	89,320
2042	7,310,435.41	241,189.39	1.25	148,801	92,389
2043	7,503,012.37	247,085.67	1.15	151,627	95,458
2044	7,695,589.32	252,981.94	1.05	154,454	98,528
2045	7,888,166.28	258,878.21	0.95	157,281	101,597

Note: Data was collected from CPA, PICT, and Dhaka Rail ICD physically.