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Determining Logistical Strategies to Mitigate Supply Chain Disruptions in Maritime Shipping for a Resilient and Sustainable Global Economy

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Abstract: International trade plays a pivotal role in shaping global supply chains, which are increasingly vulnerable to disruptions caused by geopolitical tensions, pandemics, and environmental disasters. These disturbances, particularly in maritime logistics, can trigger cascading effects across global industries. This study aims to identify and prioritize strategic responses to such disruptions by employing a combined qualitative exploratory approach and the Analytic Hierarchy Process (AHP). Expert judgments were obtained from 32 senior professionals across the maritime logistics and port management sectors during a structured evaluation conducted in the second quarter of 2025. AHP was utilized to systematically assess these inputs and determine the relative importance of resilience strategies. The results emphasize the need for adaptive, proactive, and sustainable logistics approaches to ensure long-term stability in maritime trade. By bridging a gap in the literature concerning integrated assessment of disruption responses, the study offers valuable insights for industry stakeholders and policymakers navigating an increasingly volatile global trade environment.

Keywords: maritime shipping; supply chain disruptions; global economy; sustainable logistics; resilient strategies

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1. Introduction

International trade drives the global economy and shapes supply chains, while supply chains, in turn, influence trade and economic growth. Their success depends on one another.

Disruptions in trade, whether caused by wars, political tensions, pandemics [1], or natural disasters [2], can trigger economic challenges at local, regional, or global levels [3]. Ensuring resilience and sustainability of trade supports economic development, promotes international cooperation, and enhances market stability, because the global competitive pressures have necessitated the development of complex logistics support systems, commonly referred to as supply chains [4].

International trade carried out with the support of global supply chains is largely dependent on maritime logistics. In line with these dynamics, maritime logistics plays a critical role in the logistics network supporting international trade, with almost 80 percent of traded cargo [5] being transported by sea. Therefore, disruptions in maritime logistics present significant challenges across various production processes in all sectors due to the interconnected nature of supply chains [6].

This study focuses on the types and impacts of disruptions in maritime logistics processes, which are crucial for enhancing the durability and sustainability of the global economy and trade. It provides an overview of the current dynamics and key players in the global economy and trade as well as the epistemology of supply chains and their relevance in seeking answers to two fundamental questions:

i. What are the consequences of maritime logistics disruptions, considering the real-life examples discussed in the study, and what strategies can be employed to mitigate them?
ii. What structural changes are necessary in maritime logistics to improve sustainability and resilience in the near future?

The literature review has been conducted under the main headings of Interdependence between the Global Economy, International Trade, and Global Supply Chains; Maritime Logistics as the Backbone of Global Trade; Disruptions in Maritime Logistics; and The Impact of Maritime Disruptions on the Global Economy.

2. Methodology

This study is structured into two primary sections, followed by an analytical discussion that directly addresses research questions introduced at the outset. The first section provides a comprehensive examination of the global economy, international trade, and global supply chains, with particular attention paid to the interdependencies among these domains. The second section focuses on the disruptions impacting global maritime logistics, analyzed through multiple theoretical and practical lenses. By conceptualizing the global economy, trade, and supply chains as an integrated framework within the context of maritime logistics, this research makes a distinctive scholarly contribution. It endeavors to develop a foundational analytical model that can inform policymaking and serve as a critical reference point for academic inquiry in related disciplines. Adopting a qualitative exploratory methodology, the study investigates strategies for enhancing resilience and sustainability in maritime logistics as part of broader supply chain systems. Through a holistic analytical approach, the study aims to address the two central research questions posed in the introduction. From an analytical perspective, this study investigates the nature and implications of disruptions in maritime logistics, organized into two main sections, followed by a comprehensive analysis addressing the core research questions. The first section examines the global economy, international trade, and global supply chains, emphasizing their complex interrelationships. The second section focuses on the disruptions affecting global maritime logistics processes, analyzing them through multiple analytical lenses. This research aims to construct a foundational framework to support decision-making and to serve as a key reference for scholars engaged in related domains. Its distinctiveness lies in its integrative approach, treating the global economy, trade, and supply chains as an interconnected system within the context of maritime logistics. The methodology outlined in Figure 1 was applied to answer the research question.

Literature Review: The literature review is systematically conducted under four key thematic headings: (1) the interdependence between the global economy, international trade, and global supply chains; (2) maritime logistics as the backbone of global trade; (3) disruptions in maritime logistics; and (4) the impact of maritime disruptions on the global economy. To provide comprehensive analysis, the review draws on a variety of academic and professional sources, including reports from leading organizations such as the WTO, IMO, and the UN, peer-reviewed journal articles, books, industry policy papers, and institutional publications.

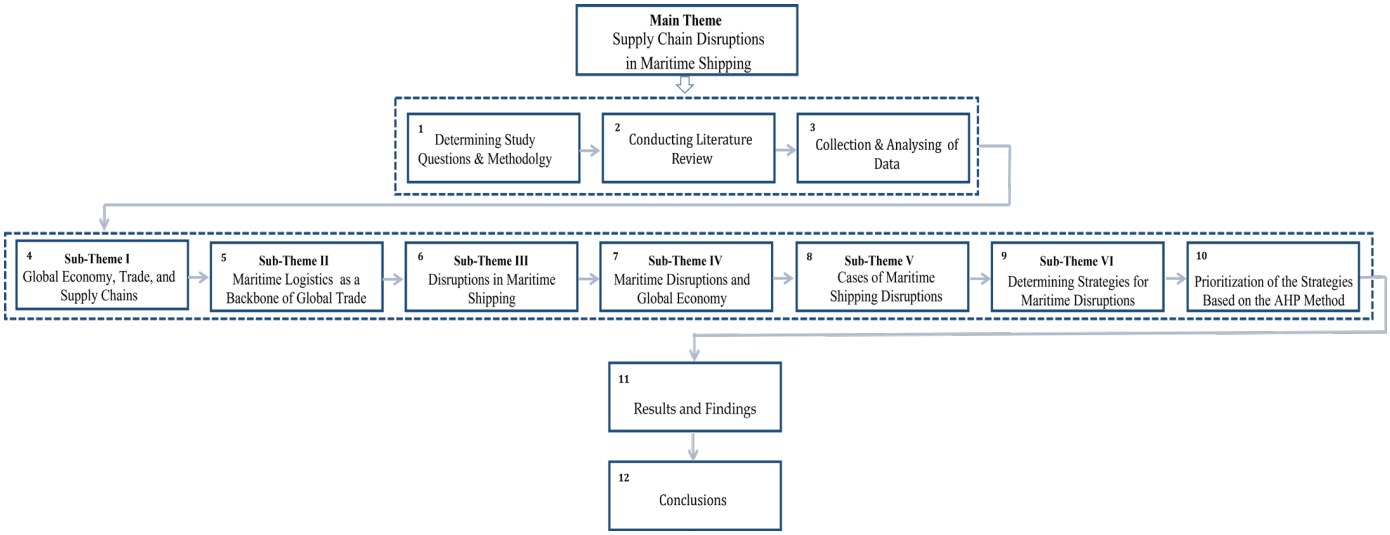


Figure 1. Research methodology for determining logistical strategies.

Both theoretical and empirical studies, as well as data-driven reports and case studies, are included to provide a multi-dimensional understanding of the complex interrelationships between maritime logistics and the global economic systems. The references cited in this study were selected from highly cited, high-impact factor articles published in journals specializing in maritime logistics, supply chains global economy, and international trade with a focus on recent publications within the literature review. All sources were obtained through online databases and institutional and official websites. In addition to that, data was also gathered from academic activities such as focus group discussions, colloquiums, and symposiums, which included participation from representatives and experts from various logistics-focused non-governmental organizations and stakeholder universities. Table 1 provides an overview to facilitate tracking of the relevant literature.

Table 1. Summary of key references regarding theme of the research.

Title/Theme	Main Findings/Opinion	References
Supply Chain Resilience—Conceptual Foundations	Defines resilience as the ability of the supply chain to prepare for, respond to, and recover from disruptions. Emphasizes system-wide coordination and adaptive capacity.	[7,8]
Redundancy and Flexibility in Maritime Logistics	Redundancy in routes and suppliers, as well as flexibility in operations, are shown to improve responsiveness under uncertainty.	[9,10]
Disruption Typologies in Maritime Context	Distinguishes between natural, geopolitical, and operational disruptions affecting maritime supply chains.	[11,12]
Analytic Hierarchy Process (AHP) Methodology	AHP is applied using Saaty's scale for pairwise comparison. Experts rated the relative importance of seven resilience strategies.	[13,14]
Expert Judgment and Geometric Aggregation	32 maritime logistics experts' evaluations were aggregated using geometric mean to construct a consensus matrix.	[15]
Normalization and Priority Vector Derivation	The normalized matrices yield priority weights for each strategy, ensuring consistency ratios are within acceptable thresholds.	[13]

Table 1. *Cont.*

Title/Theme	Main Findings/Opinion	References
Simulation-based Evaluation of Strategic Robustness	Simulation allows for testing strategy effectiveness under different disruption scenarios. Enhances empirical validation of AHP rankings.	[14,16]
Closed-loop Feedback Mechanism	Real-time data and performance metrics enable iterative improvements and dynamic adjustment of resilience strategies.	[17,18]
Original Contribution: Integrated AHP-Simulation Model	Combines expert judgment (AHP) with scenario simulation to provide a robust multi-method framework for resilience strategy evaluation.	Developed by Authors
Policy and Managerial Implications	Recommends prioritizing route diversification, cyber-resilience, and redundancy investments for maritime firms and policymakers.	Synthesized by Authors based on empirical findings

Data Analysis: As detailed in the literature review section, the content of the study is created with the help of data collected from the scanned academic studies in the reference section. Based on insights from subject matter experts, the study examined various strategies to mitigate maritime disruptions. These included diversifying shipping routes, exploring alternative ports, utilizing inland transportation, investing in digitalization and automation, enhancing port efficiency, and strengthening supplier relationships. The strategies are evaluated then based on their relative priority and impact.

Scope and Limitations: Given the broad scope of the topic, which cannot be fully covered in this manuscript, this research specifically focuses on disruptions in maritime transportation, examining their consequences and exploring measures to mitigate these challenges. However, it should be emphasized that maritime transportation, as an integral component of intermodal and multimodal logistics systems, plays a pivotal role in global supply chains. Due to its interconnected nature, any disruption in maritime transport can trigger cascading effects across other modes of transportation, thereby undermining the efficiency and resilience of the overall logistics network.

3. Interdependence Between the Global Economy, International Trade, and Global Supply Chains

International trade plays a crucial role in propelling the global economy and shaping supply chains while, conversely, supply chains influence both trade and economic growth, as shown in Figure 2.

Although simplified in the figure, the impact of maritime disruptions on the global economy represents a broad and multifaceted paradigm, encompassing critical dimensions such as international trade, supply chain resilience, energy security, and geopolitical dynamics. Considering the pivotal role of maritime transport in sustaining global trade logistics, it becomes evident that a comprehensive analysis of these complex interrelations extends beyond the scope of a single study. Capturing the full breadth and depth of these dynamics requires a more expansive approach—one that aligns with the scale and detail typically found across multiple academic volumes or specialized textbooks.

The success of these components is mutually dependent and crucial for a resilient and sustainable global supply chains. Several key factors drive this dynamic.

The global economy, which encompasses the sum total of all economic activity across countries, is a dynamic and interconnected system. The total value of the global economy has changed significantly over time. In the 1500s, it was estimated to be around USD 250–500 billion. The 1950s saw rapid growth due to post-World War II recovery, industri-

alization, and expanding global trade, with the world economy valued at approximately $4 trillion. As of 2025, the global economy is valued at over USD 100 trillion, with significant contributions from various sectors, including services, manufacturing, agriculture, and technology [19].

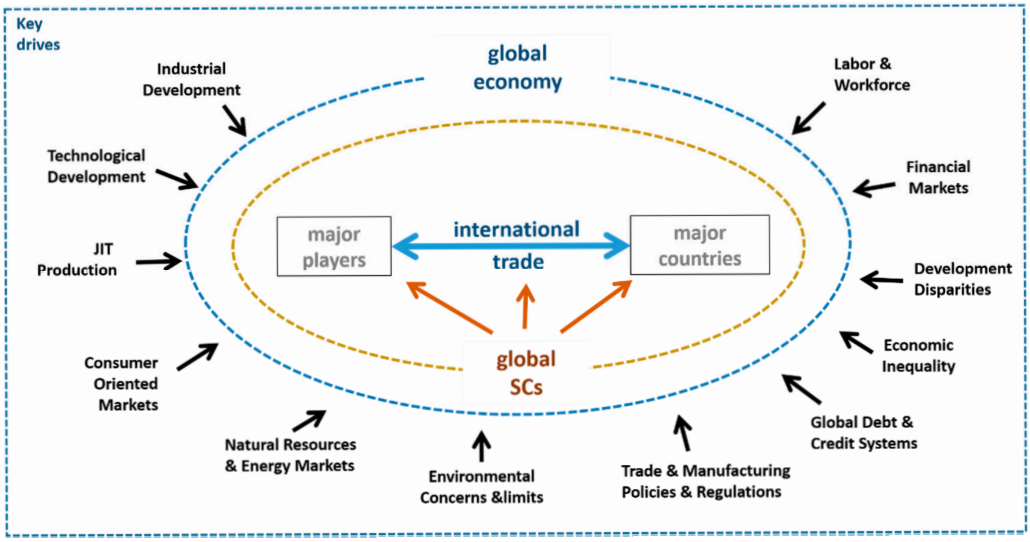


Figure 2. Mutual dependency of global economy, trade, supply chains, and key drivers.

Approximately five centuries later, in the 1950s, the global economy underwent a dramatic shift because of World War II, rapid industrialization, and large-scale reconstruction efforts. During this period, the US became the world's dominant economy, accounting for approximately 30% of global GDP. The Soviet Union (USSR), with its centrally planned economy and rapid industrial growth, emerged as a major rival to the US. The UK remained a significant economic force but experienced a decline from its colonial-era dominance. Germany (West Germany at the time) achieved an impressive post-war recovery—known as the *Wirtschaftswunder* (economic miracle)—which transformed it into an economic powerhouse [20]. Similarly, Japan experienced an astonishing economic resurgence, driven by technology-based industrial recovery and rapid expansion.

As of 2025, the US remains one of the world's largest economies, maintaining its leadership in technology, finance, and consumer markets, largely due to its resilience in the aftermath of World War II and its ability to capitalize on the war's economic consequences. China, once the guardian of the communist system yet also one of the greatest beneficiaries of capitalism, has become the world's second-largest economy, driven by manufacturing and technological advancements [21].

The global economy is characterized by rapid globalization, where markets and economies are increasingly interlinked. International trade involves the movement of goods, services, and capital across national boundaries. It enables nations to focus on producing goods and services where they hold a comparative advantage, resulting in higher efficiency and reduced costs [22]. Over time, trade has transitioned from basic barter exchanges to intricate, technology-driven SC networks that link economies worldwide. The expansion of globalization, trade agreements, and advancements in transportation and digital innovation have significantly increased the speed and efficiency of cross-border transactions. These developments emerged after World War II and accelerated following the collapse of the Berlin Wall, which was seen as a victory for capitalism over its rival ideologies [23]. Institutions like the WTO and regional trade agreements, including the European Union and the now-replaced North American Free Trade Agreement (NAFTA),

succeeded by the US–Mexico–Canada Agreement (USMCA), play a significant role in overseeing and promoting international commerce.

Despite its advantages, international trade encounters several obstacles. Trade restrictions, including tariffs, quotas, and protectionist measures, can hinder the unrestricted movement of goods. Furthermore, global commerce is susceptible to disruptions arising from geopolitical tensions, financial downturns, health crises, and environmental disasters [24]. The COVID-19 pandemic [25], for instance, exposed weaknesses in international supply chains causing shipment delays and escalating costs. Additionally, sustainability concerns present another challenge, as increased trade contributes to greenhouse gas emissions and resource depletion. Looking forward, the future direction of international trade will be influenced by sustainability efforts, digital advancements, and shifting economic dynamics. Emerging trends such as eco-friendly logistics, digital trade systems, and the regionalization of supply networks have been gaining traction.

Supply chains, which have gained significant attention since the 1950s, form a logistical framework that underpins every stage of production, regardless of industry or scale [26]. However, they have evolved beyond mere logistics. In today's highly competitive, customer-driven market [27], having an efficient supply chain and managing it effectively is crucial—not only for profitability but also for long-term sustainability. In essence, supply chains encompass a series of interconnected processes where suppliers, manufacturers, distributors, and retailers collaborate. These processes begin with product design and extend through production, distribution, and even recycling. Despite their complexity and global reach, supply chains operate across three fundamental stages: procurement, production, and distribution, each of which is further divided into smaller components [28].

4. Maritime Logistics: The Backbone of Global Trade

Maritime logistics is a crucial component of global trade, serving as the foundation of international transportation and supply chains. Since about 80% of global trade is conducted by sea, maritime logistics plays a vital role in transporting goods across large distances, linking different continents and driving economic growth. This process encompasses various activities, including the transportation of raw materials, finished products, and everything in between, using different types of vessels such as container ships, bulk carriers, and tankers [29].

A primary advantage of maritime logistics is its cost-efficiency. Sea transport is much more economical compared to other modes, particularly when handling bulk commodities, making it the preferred method for long-haul trade. However, the maritime industry faces a variety of challenges that can disrupt the flow of goods. These challenges include unfavorable weather conditions, port congestion [30], geopolitical instability, and supply chain interruptions, like those triggered by the COVID-19 pandemic [31,32]. Such disruptions can cause delays, a rise in shipping costs, and decreased efficiency in global supply chains. Maritime logistics has adopted technological innovations to address these challenges. The development of smart shipping technologies, automation, and real-time tracking systems has enhanced the efficiency and safety of maritime transport. In addition, improvements in port infrastructure, such as the establishment of mega ports and automated cargo handling systems, have optimized the loading and unloading processes.

In response to environmental concerns, maritime logistics also strives for greater sustainability. The sector is investing in cleaner fuels, technologies to reduce emissions, and energy-efficient vessels to lower its environmental impact. As global trade continues to grow, maritime logistics will remain a key driver of economic success, fostering innovations that improve efficiency, resilience, and sustainability in global goods movement.

4.1. Sea Routes, Passages, and Chokepoints

There are several sea routes, passages, and chokepoints that are vital for global trade, as they enable the efficient transport of goods such as large quantities of oil, raw materials, manufactured products, and food across vast distances. Disruptions to any of these key routes can significantly affect international trade and global supply chains as depicted in Figure 3.

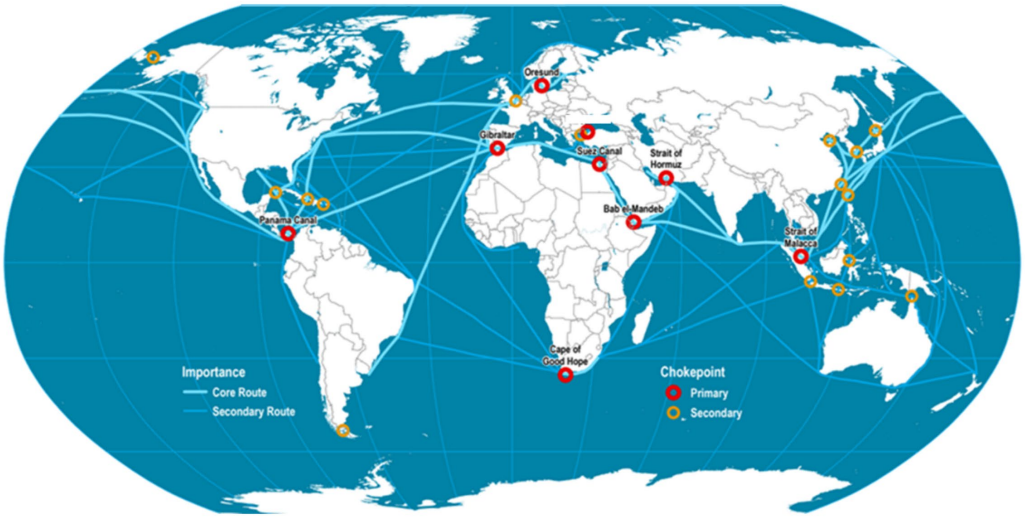


Figure 3. Main maritime shipping routes and chokepoints [33].

Main maritime shipping routes often referred to as major shipping lanes or sea routes are critical navigational pathways utilized by deep-sea vessels for international trade and freight forwarding.

4.2. Key Canal Connections Along Major Maritime Corridors

Canals are pivotal in facilitating global maritime trade by linking major seas and reducing voyage distances for shipping vessels. These canals considerably shorten transit times, enhance trade efficiency, and strengthen global supply chains making them indispensable for the seamless movement of goods across continents.

The Suez Canal, an artificial waterway in Egypt, links the Mediterranean Sea with the Red Sea, offering a direct maritime path between Europe and Asia [34]. It removes the need for ships to navigate around Africa, cutting down travel time, particularly for goods being transported between Europe, the Middle East, and Asia. The Panama Canal, located in Panama, is a vital canal connects the Atlantic and Pacific Oceans, sparing vessels from the long and dangerous route around the southern tip of South America [35]. It is essential for global trade, particularly for commerce between east and west Coasts of the US, as well as trade between the Americas and Asia. Situated between Oman and Iran, the Strait of Hormuz, a narrow waterway, is one of the strategic maritime routes, serving as a primary passage for oil exports from the Persian Gulf. It facilitates the movement of petroleum from countries like Saudi Arabia, Kuwait, and the UAE, linking the Persian Gulf to the Gulf of Oman and the Arabian Sea [36]. The Strait of Malacca is positioned between the Malay Peninsula and the island of Sumatra, Indonesia, this busy passage connects the Pacific and Indian Oceans. It plays a crucial role in the transport of oil and goods between East Asia, the Middle East, and Europe [37]. The English Channel is a narrow waterway between England and France serves as a link between the North Sea and the Atlantic Ocean, but it is one of Europe's most important maritime routes, enabling trade between the European continent and the rest of the world [38]. The Cape of Good Hope, located at Africa's southernmost tip, is a sea route that serves as an alternative to the Suez

Canal. While less frequently used due to the canal's convenience, it remains an important pathway for global trade, particularly for shipments between Europe and East Asia [39].

5. Disruptions in Maritime Logistics

Maritime disruptions refer to interruptions in global shipping and maritime transport systems that hinder the movement of goods across oceans. These disruptions can arise from various factors, including natural disasters [40,41], geopolitical tensions, labor strikes [42], pandemics, accidents [43] and technological failures. Extreme weather events, such as hurricanes and typhoons, are frequent causes, damaging port infrastructure and forcing ships to reroute. Climate change is expected to exacerbate these occurrences, leading to more frequent disruptions in the future. Geopolitical factors, including trade wars, sanctions, and territorial disputes, can disrupt shipping lanes and close key ports, with the 2021 Suez Canal blockage serving as a notable example as mentioned before. This incident caused significant delays and disruptions in international trade, underlining the vulnerability of maritime supply chains.

The COVID-19 pandemic [44] further revealed the fragility of maritime logistics, with labor shortages, lockdowns, and production halts resulting in shipment delays and backlogs at major ports, affecting industries reliant on global supply chains. Labor strikes, especially among dock workers and maritime crews, can halt the flow of goods and delay shipping schedules. Additionally, technological failures, including system outages and cyberattacks [45], can disrupt maritime operations. As industry becomes more dependent on digital systems for navigation and logistics, the risk of technological disruptions increases.

The impact of these disruptions extends far beyond logistics, influencing international trade, consumer prices, and national economies. Consequently, both companies and governments are investing in contingency planning, improved infrastructure, and enhanced resilience strategies to mitigate these risks. Security concerns also play a significant role in maritime operations, as terrorist actions targeting maritime transport can have profound economic and political implications. Piracy and the threat of terrorist groups hijacking ships are major security concerns in regions such as the Gulf of Aden, the Strait of Malacca, and the Horn of Africa. Additionally, cyberattacks on maritime systems, such as the 2017 attack on Maersk, highlight the growing vulnerability of digitalized shipping operations [46].

In response, international organizations like the International Maritime Organization (IMO) have established security standards, including the ISPS Code, and many companies have invested in advanced security technologies. However, terrorism and security concerns continue to challenge the global maritime industry, necessitating enhanced cooperation and investment in new security measures. Furthermore, port congestion [47], geopolitical conflicts [48], and natural disasters like extreme weather events and rising sea levels continue to threaten maritime logistics. Labor shortages, cyberattacks, and fluctuating fuel prices also contribute to delays and inefficiencies. In the face of these challenges, the maritime industry must adapt by investing in innovation, enhancing sustainability practices, and collaborating globally to ensure the resilience of supply chains.

6. Impact of Maritime Disruptions on Global Economy

Given the critical role of maritime transport in international trade, the economic impact of maritime disruptions is significant. Approximately 80 percent of global trade by volume and 70 percent by value is transported by sea, making maritime shipping indispensable to the global economy.

The proposed strategies are complex structures affected by multiple interconnected factors with economic resilience and sustainability. Therefore, creating a well-diversified economic structure can cushion the impact of fluctuations that may arise from sector-

specific maritime logistics. In addition, strong public financial management, together with controlled inflation and interest rates, can act as a hedge in times of economic instability. Maintaining manageable debt levels and implementing prudent fiscal strategies can contribute to the long-term sustainability of the economy. Environmentally sustainable economies that receive marine logistics support tailored to environmental concerns serve the purpose of reducing ecological damage and prioritizing investments in renewable energy, resource conservation and climate resilience. In addition, broad-based and diverse trade partnerships make the economy more resilient to maritime disruptions.

Consequently, disruptions in this sector—whether due to natural disasters, geopolitical tensions [49], piracy, or other issues—can lead to substantial economic losses and ripple effects across various industries. The financial impact of maritime disruptions is immense, often resulting in billions of dollars in losses. Maritime disruptions can cause losses in several ways:

Delivery Delays: When ships are delayed, businesses incur higher costs for storage, warehousing, and additional transportation. These delays can result in product shortages, increased prices, and supply chain bottlenecks, adversely affecting industries that depend on timely deliveries, such as electronics, automotive, and consumer goods. As a result, companies may experience disruptions in production schedules, leading to a cascade of inefficiencies and potentially harming customer satisfaction [50] and profitability. In a market where a customer-focused, ruthless response is paramount and the just-in-time (JIT) philosophy [51] is essential, the cost of these delays can extend beyond financial losses, potentially leading to the loss of customers or contracts. JIT systems depend on prompt delivery and smooth operations, and any disruption can harm a company's reputation for reliability, causing customers to turn to suppliers that are more dependable and leading to the loss of long-term contracts [52].

Increased Shipping Costs: Disruptions often lead to higher insurance premiums for shipping companies, as the risks of delays or accidents increase. Additionally, when shipping routes are closed or rerouted due to geopolitical events such as the closure of the Strait of Hormuz or the Suez Canal [53], shipping companies face additional fuel and operational costs [54]. The trade-disruptive effects of these costs may be difficult to recover. For instance, a disruption at a major shipping port such as Shanghai or Rotterdam can have far-reaching effects on industries in the US, Europe, and other regions. This can result in significant financial losses for manufacturers that rely on JIT production methods. Disruptions can significantly affect port operations, leading to lost revenue from port fees, cargo handling, in addition, ship docking. Shipping companies also face direct losses due to delays, rerouting, and idle ships waiting to reach ports.

Impact on Global Markets: Shipping disruptions often lead to volatility in commodity prices, particularly for goods heavily reliant on transportation, such as oil, gas, and raw materials. For instance, if a major shipping route is obstructed, reduced supply chain drives up oil prices [55], affecting the global economy. Such disruptions can also cause stock market fluctuations [56], as investors respond to uncertainties in supply chains and international trade. As an alternative to maritime transportation, alternative trade routes such as the Middle Corridor or Northern Corridor—modern adaptations of the ancient Silk Road—are increasingly being considered to enhance resilience in global logistics.

7. Notable Cases of Maritime Shipping Disruptions and Long-Term Effects

Maritime shipping remains highly vulnerable to disruptions from various sources, including cyberattacks, piracy, physical blockages, and global crises. Below are some notable cases of maritime shipping disruptions: A cyberattack on Maersk in 2017, one of the world's largest shipping companies, resulted in a massive disruption, costing the

company an estimated $300 million in lost revenue and recovery expenses [57]. The attack severely influenced Maersk's global operations, demonstrating the growing threat of cyber risks in the maritime sector and their potential to cause significant financial losses.

The threat of piracy is another concern regarding disruptions. The Gulf of Aden and the Horn of Africa region have long been hotspots for piracy, posing a persistent challenge to global shipping. In addition to the direct costs of ransoms, piracy has led to increased insurance premiums for ships navigating these waters, adding tens of millions of dollars annually to shipping costs. The threat of piracy not only disrupts maritime trade but also affects the global flow of goods, particularly vital commodities like oil and petroleum products [58].

One of the most infamous maritime disruptions occurred in March 2021 when the *Ever Given*, a massive container ship, became stranded in the Suez Canal, blocking one of the world's busiest shipping lanes for six days. The incident cost the global economy an estimated USD 9–10 billion per day due to delayed goods, increased shipping expenses, and widespread trade disruptions. More than 400 ships were affected, and billions of dollars' worth of goods faced significant delivery delays, highlighting the fragility of global trade routes [59].

The COVID-19 pandemic led to unprecedented disruptions in global maritime trade [60]. Port closures, labor shortages, and lockdown measures caused major delays in shipping schedules, creating severe backlogs at ports across China, Europe, and the US. According to the WTO, global merchandise trade volume declined by 5.3% in 2020, and the global economy contracted by 3.5%. Supply chain disruptions affected critical industries, delaying the delivery of essential goods such as medical supplies and electronics [61]. These cases underscore the vulnerabilities in maritime transportation and the far-reaching consequences of disruptions.

As global trade continues to depend on efficient maritime logistics, strengthening resilience against such challenges remains a priority for businesses and governments worldwide. Beyond immediate financial losses, shipping disruptions can have long-term repercussions on industries and economies worldwide. Prolonged disruptions can reshape international trade patterns as companies seek alternative routes or suppliers to mitigate risks. This shift often leads to increased operational costs for businesses, influences pricing structures in consumer markets, and may even force companies to reassess the viability of certain trade relationships or regions. The financial impact of shipping disruptions also underscores the critical importance of resilience within the global shipping network. Investing in infrastructure, cybersecurity, port modernization, and crisis management strategies is essential to reducing the risks posed by such disruptions. Strengthening these areas can help mitigate potential economic fallout, ensuring stability for businesses and economies across the world.

8. Determining Strategies to Mitigate Maritime Disruptions

There are some proactive strategies to mitigate the impact of maritime disruptions, although its application varies according to the situation and time [62]. One key approach is to diversify shipping routes, exploring alternative ports and transportation networks to avoid bottlenecks in critical shipping lanes. By incorporating secondary ports and utilizing inland transportation options, businesses can enhance their flexibility. Investing in digitalization and automation is also essential. Technologies such as AI, IoT, and blockchain improve supply chain visibility and risk management, while digital twin technology allows companies to simulate logistics scenarios and make decisions that are more informed. Building strong relationships with multiple suppliers and carriers offers businesses alternative options during disruptions. Flexible contracts enable quick adjustments to shipping plans,

ensuring smoother operations during unforeseen challenges. Improving port infrastructure and efficiency is another critical step. Modernizing ports and implementing smart logistics solutions can reduce congestion and expedite cargo handling. Collaboration between governments and private stakeholders is vital in driving infrastructure development to support efficient trade. Strengthening cybersecurity measures is also crucial in today's digitalized shipping environment. Shipping companies should regularly assess risks and adopt robust data management practices to protect against cyber threats. Finally, adopting sustainable and resilient practices can contribute to long-term stability [63]. Green shipping initiatives, alternative fuels, and energy-efficient vessels not only reduce environmental impacts but also help businesses align with sustainability regulations, mitigating potential disruptions [64]. Based on the case analyses, the potential impacts of strategies that can be implemented individually, jointly, or in combination have been evaluated.

8.1. Diversifying Shipping Routes

The methodology for diversifying shipping routes is illustrated in Figure 4. A variety of strategic and operational factors are considered within this framework, including the duration of open-sea transits along existing routes, the presence of Emission Control Areas (ECAs), critical chokepoints and narrow passages, sustainable economic cruising speed, and seasonal, meteorological, and oceanographic variations [65].

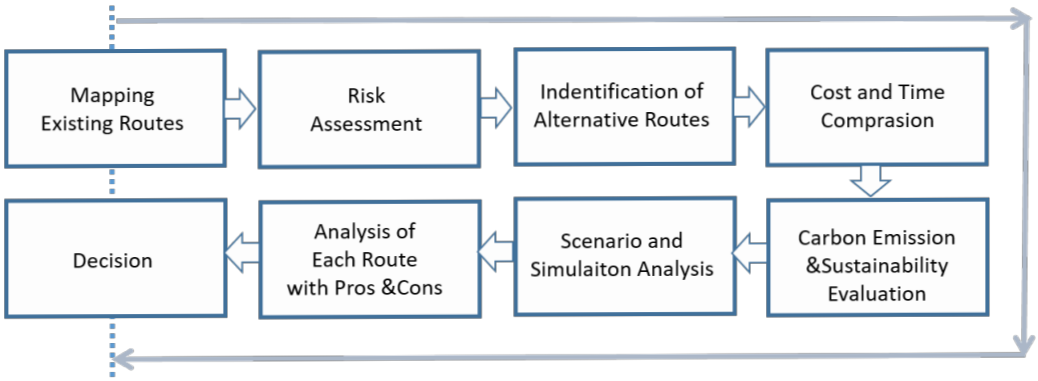
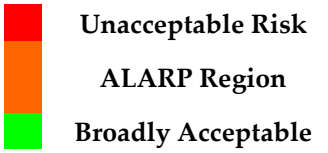


Figure 4. The methodology for diversifying shipping routes.

To ensure a comprehensive evaluation of route feasibility and resilience, the analysis also incorporates geopolitical risks, potential crisis or conflict zones, port accessibility, maritime traffic density, and constraints related to environmental regulations or security threats. However, at each stage, tests for suitability, applicability, and acceptability must be conducted, and the appropriateness of alternative routes should be assessed based on the nature and quantity of the cargo to be transported. Following this, it must be determined—considering time and spatial factors—whether timely delivery to the destination is feasible. Only after this assessment should a decision be made on whether the transport is acceptable in terms of risk level.

Risk is inherent in every phase of the logistics sector. When ALARP (*as low as reasonably practicable*) levels are considered as in Figure 5, it is observed that risks rarely fall within the GREEN category. Therefore, the presence of risk factors typically at the ORANGE or RED levels requires rational and acceptable decision-making strategies.

Intermodal and multimodal transportation should also be considered, and the risk factors from the arrival port to the final delivery destination under last-mile logistics conditions must be carefully evaluated.



Unacceptable Risk	Active War Zones, Embargoed Regions
ALARP Region	Piracy-Prone Waters, Political Instability, Congested Straits, Chronic Port Delays
Broadly Acceptable	Stable Routes, Low Operational Risks

Figure 5. ALARP risk acceptability matrix for maritime route assessment.

8.2. Exploring Alternative Ports

The methodology for exploring alternative ports is demonstrated in Figure 6. The proximity of a port to its final destination plays a critical role in determining transportation costs, delivery times, and carbon emissions. Ports with well-developed road and inland waterway connections increase intermodal efficiency, while those without such infrastructure are more vulnerable to bottlenecks.

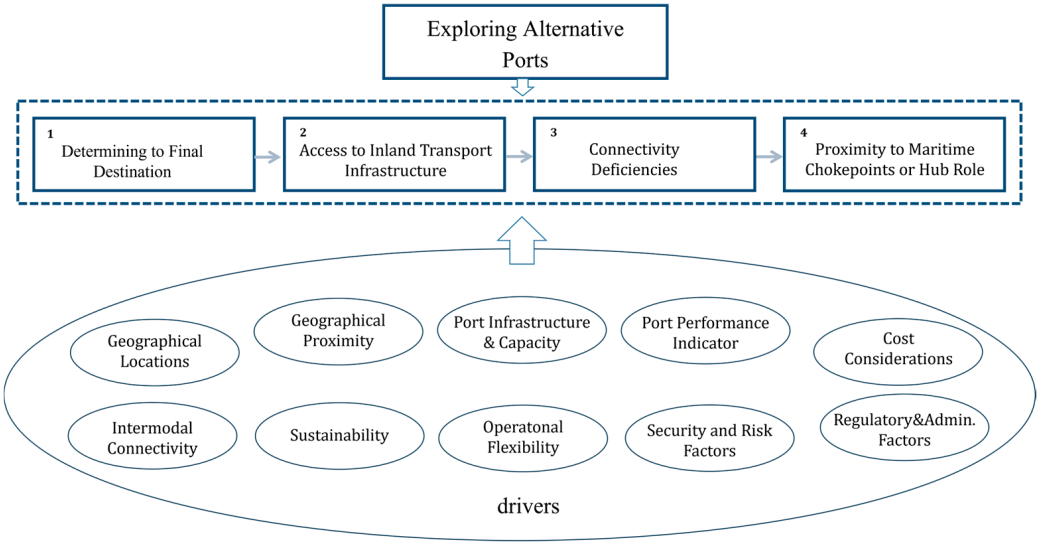


Figure 6. The methodology for exploring alternative ports.

Furthermore, ports located close to strategic maritime bottlenecks or acting as transshipment hubs offer significant advantages in terms of integration into global trade networks and operational flexibility. The criteria and explanations determined considering these considerations are presented in Table 2.

Table 2. Key evaluation criteria for alternative port selection.

Criteria	Explanation
Distance to Final Destination	Shorter distances between the port and final delivery points reduce transportation costs and carbon emissions while improving response time.
Access to Inland Transport Infrastructure	Close proximity to highways, rail lines, or navigable inland waterways facilitates uninterrupted cargo movement and enhances intermodal efficiency.
Connectivity Deficiencies	Ports lacking sufficient infrastructure are prone to bottlenecks and prolonged handling times, which negatively affect overall logistics performance.
Proximity to Maritime Chokepoints or Hub Role	Ports near chokepoints or acting as transshipment hubs enjoy strategic benefits such as better global trade integration and higher network resilience.

Performance indicators like average dwell time, berth productivity, and turnaround times reflect the efficiency and reliability of port operations. Effective intermodal connectivity with logistics hubs or dry ports, as well as efficient last-mile delivery systems, support seamless cargo transitions beyond the port. Cost-related aspects—including port tariffs, handling charges, customs clearance efficiency, and additional fuel costs due to rerouting—must also be factored into the decision-making process. Moreover, ports are evaluated based on security and risk-related considerations, such as geopolitical stability, exposure to piracy, and vulnerability to environmental hazards like typhoons or earthquakes. Regulatory and administrative efficiency, particularly customs procedures, compliance with environmental and safety standards, and the level of digitalization through port community systems, further influence port performance. Lastly, sustainability has become an essential criterion; ports that implement green initiatives, operate near Emission Control Areas (ECAs), and actively work to reduce their carbon footprint contribute to more environmentally responsible supply chain strategies [66].

8.3. Utilizing Inland Transportation Options

By facilitating smooth freight transfers from ports to hinterland locations, the use of inland transportation options—such as railroads, highways, and inland waterways—improves supply chains' flexibility and efficiency. When these modes are successfully integrated, port terminal congestion is decreased, total transportation costs are decreased, and multimodal logistics techniques that enhance sustainability and resilience are supported. Inland transportation increases intermodal efficiency, but it also comes with risks and challenges. Congestion, delays, and decreased dependability can result from inadequate infrastructure, such as antiquated rail networks, underdeveloped inland canal systems, or inadequate road capacity [67]. Inland transportation routes may be hampered by weather, seasonal flooding, or landslides, especially in areas without climate-resilient infrastructure. Regional differences in regulations, such as different weight restrictions on roads or different procedures for border customs, can make planning more difficult and add to administrative workloads. Operational risks are also posed by security issues such cargo theft, vandalism, or mishaps during overland transportation. Finally, yet importantly, long-distance trucking's high emissions and fuel consumption could be at odds with sustainability objectives if they are not compensated for by more environmentally friendly options.

8.4. Investing in Digitalization and Automation

By increasing productivity, visibility, and resilience, investments in automation and digitization [68] generate significant added value in supply chain and maritime logistics operations. Digital tools that enhance transparency, lessen information asymmetry, and facilitate data-driven decision-making include real-time tracking systems, blockchain-based documentation, and predictive analytics. Automation of port operations, such as automated guided vehicles (AGVs), smart warehousing, and autonomous cranes, lowers operating costs, speed up handling, and decreases human error. By reducing emissions and optimizing resource use, these advances also support sustainability. Additionally, digital systems facilitate smooth collaboration amongst stakeholders, speeding up procedures including last-mile distribution, cargo scheduling, and customs processing. Digital transformation is now a strategic necessity for gaining a competitive edge in the increasingly complex global trade market

8.5. Improving Port Efficiency

Resilient and sustainable maritime logistics are made possible in large part by increasing port efficiency [69]. Investments in automation and digitization, which expedite

cargo processing, shorten turnaround times, and enhance terminal operations, are directly linked to efficiency improvements. AI-based scheduling platforms, automated cranes, and terminal operating systems (TOS) are examples of technologies that improve real-time coordination and reduce bottlenecks. Additionally, cost savings, enhanced service dependability, and increased throughput capacity are all closely correlated with port efficiency. Efficient ports provide smooth cargo transportation across supply chain networks and act as vital hubs for intermodal connectivity in an era of more complicated global trade. Through improved traffic flow, energy efficiency, and reduced idle hours for cars and boats, effective port operations help reduce emissions as environmental and regulatory constraints rise.

8.6. Establishing Strong Supplier Relationships

Building solid relationships with suppliers is essential to improving the sustainability, adaptability, and resilience of contemporary supply chains [70]. Businesses may react to disruptions, demand unpredictability, and market uncertainty more skillfully when they have collaborative supplier partnerships that promote mutual trust, information sharing, and long-term strategic alignment. Strong bonds also facilitate collaborative innovation, process improvement, and problem-solving throughout the supply chain. Strong supplier relationships provide visibility into upstream operations and lessen the possibility of opportunistic conduct from the standpoint of risk management. Additionally, since businesses depend more and more on their suppliers' social and environmental performance to satisfy stakeholders and regulations, supplier engagement is essential to reaching sustainability goals.

8.7. Enhancing Cybersecurity

Improving cybersecurity [71] is becoming a top priority in global supply chain management and maritime logistics, especially given the rising reliance on interconnected systems and digital integration. Cyberthreats like ransomware, data breaches, and operational interruptions can cause major financial losses and harm to a company's reputation, making ports, shipping lines, and logistics service providers particularly vulnerable. To prevent unwanted access and guarantee system integrity, strengthening cybersecurity entails putting in place reliable IT infrastructure, network segmentation, real-time monitoring tools, and employee training. Furthermore, reducing digital vulnerabilities requires adherence to international standards, such as the IMO's Maritime Cyber Risk Management recommendations. In this regard, cybersecurity is a strategic asset that supports data protection, operational continuity, and confidence among supply chain partners in addition to being a technological necessity.

9. Prioritization of the Strategies Based on the Analytic Hierarchy Process Method

To identify and prioritize strategic responses to maritime supply chain disruptions, this study employed the Analytic Hierarchy Process (AHP) within a qualitative exploratory framework. Expert input was obtained from 32 professionals actively working in maritime logistics, port operations, ship management, and international freight forwarding. These participants were selected through purposive sampling, based on their minimum 10 years of industry experience and direct involvement in strategic decision-making during previous disruption events. Between February and April 2025, expert data were collected through structured pairwise comparison forms (based on Saaty's 1–9 scale) and semi-structured interviews. The interviews aimed to explore expert insights into disruption types, vulnerabilities, and resilience strategies, and were conducted either in person or online depending

on participant availability. Transcripts were analyzed using thematic analysis, and the emergent themes—such as "flexibility in port operations", "digital infrastructure", and "multi-modal coordination"—informed the construction of the AHP hierarchy. Individual pairwise comparison matrices were developed accordingly, and their consistency ratios (CR) were calculated to ensure reliability; all matrices satisfied the CR < 0.10 threshold. This integrated approach enabled the systematic incorporation of qualitative expert knowledge into the multi-criteria decision-making framework. The valid matrices were then aggregated using the geometric mean method to produce a consolidated group matrix, which forms the basis of Tables 3–8. This integrated approach enabled the systematic incorporation of qualitative expert knowledge into the multi-criteria decision-making framework.

Table 3. Fundamental scale (1–9) for pairwise comparisons.

Numerical Value	Interpretation
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments
1/a	Reciprocal when the second element is more important than the first

Table 4. (**a**) Example of individual pairwise comparison matrix. (**b**) Aggregated pairwise comparison matrix (unrounded geometric means of 32 experts). (**c**) Aggregated pairwise comparison matrix (rounded geometric means of 32 experts).

(a)							
	I	**II**	**III**	**III**	**IV**	**V**	**VI**
I	1	3	4	5	5	5	6
II	1/3	1	2	3	3	3	4
III	1/4	1/2	1	2	2	2	3
IV	1/6	1/6	1/4	1	1	2	2
V	1/6	1/6	1/3	1/2	1	2	2
VI	1/6	1/6	1/4	1/3	1/2	1	1
VII	1/6	1/6	1/2	1/2	1/2	1	1
(b)							
	I	**II**	**III**	**III**	**IV**	**V**	**VI**
I	1.0000	3.0021	4.0134	5.0487	5.1220	6.0001	6.0103
II	0.3332	1.0000	2.0112	3.0045	3.0310	3.9876	4.0054
III	0.2493	0.4973	1.0000	2.0012	2.0010	3.0124	3.0007
IV	0.1980	0.3328	0.4997	1.0000	1.9983	2.0023	2.0088
V	0.1954	0.3301	0.5003	0.5004	1.0000	2.0037	2.0009
VI	0.1667	0.2498	0.3329	0.4998	0.4990	1.0000	1.9985
VII	0.1665	0.2503	0.3331	0.4978	0.4991	0.5004	1.0000

Table 4. *Cont.*

(c)							
	I	**II**	**III**	**III**	**IV**	**V**	**VI**
I	1.0000	3.0000	4.0000	5.0000	5.0000	6.0000	6.0000
II	0.3333	1.0000	2.0000	3.0000	3.0000	4.0000	4.0000
III	0.2500	0.5000	1.0000	2.0000	2.0000	3.0000	3.0000
IV	0.2000	0.3333	0.5000	1.0000	2.0000	2.0000	2.0000
V	0.2000	0.3333	0.5000	0.5000	1.0000	2.0000	2.0000
VI	0.1667	0.2500	0.3333	0.5000	0.5000	1.0000	2.0000
VII	0.1667	0.2500	0.3333	0.5000	0.5000	0.5000	1.0000

Table 5. Column totals of the pairwise comparison matrix.

Criterion	Column Total
Diversifying Shipping Routes	2.3167
Exploring Alternative Ports	5.6667
Utilizing Inland Transportation Options	8.6667
Investing in Digitalization and Automation	12.5000
Improving Port Efficiency	14.0000
Establishing Strong Supplier Relationships	18.5000
Enhancing Cybersecurity	20.0000

Table 6. Column totals of the pairwise comparison matrix—average means.

	I	**II**	**III**	**III**	**IV**	**V**	**VI**
I	0.4317	0.5294	0.4615	0.4000	0.3571	0.3243	0.3000
II	0.1439	0.1765	0.2308	0.2400	0.2143	0.2162	0.2000
III	0.1079	0.0882	0.1154	0.1600	0.1429	0.1622	0.1500
IV	0.0863	0.0588	0.0577	0.0800	0.1429	0.1081	0.1000
V	0.0863	0.0588	0.0577	0.0400	0.0714	0.1081	0.1000
VI	0.0719	0.0441	0.0385	0.0400	0.0357	0.0541	0.1000
VII	0.0719	0.0441	0.0385	0.0400	0.0357	0.0270	0.0500

Table 7. Column totals of the pairwise comparison matrix.

Strategy	Priority Weight
Diversifying Shipping Routes	0.4006
Exploring Alternative Ports	0.2031
Utilizing Inland Transportation Options	0.1324
Investing in Digitalization and Automation	0.0905
Improving Port Efficiency	0.0746
Establishing Strong Supplier Relationships	0.0549
Enhancing Cybersecurity	0.0439

Table 8. The consistency ratio calculation.

λ_max	**7.2204**
Consistency Index (CI)	0.0367
Random Index (RI)	1.32
Consistency Ratio (CR)	0.0278
Consistency Status	Acceptable (CR < 0.10)

The following strategic alternatives were considered for prioritization in the context of maritime logistics and Supply Chain Management:

- Diversifying Shipping Routes (I);
- Exploring Alternative Ports (II);
- Utilizing Inland Transportation Options (III);
- Investing in Digitalization and Automation (IV);
- Improving Port Efficiency (V);
- Establishing Strong Supplier Relationships (VI);
- Enhancing Cybersecurity (VII).

The scale, introduced by Saaty, is demonstrated in Table 4 [13].

The matrix is developed by aggregating individual pairwise comparison matrices completed by 32 maritime logistics experts.

The pairwise comparison matrices used in this study were developed based on evaluations provided by 32 experts in maritime logistics. All participants are senior professionals currently active in the logistics sector. These experts were selected from member companies affiliated with three major Turkish logistics associations:

- The International Transporters Association (UND), representing over 1000-member companies.
- The Association of Logistics Service Providers (LojiDer), comprising 272-member companies and affiliated with the European Logistics Association (ELA).
- UTIKAD (Association of International Forwarding and Logistics Service Providers), which includes 708-member companies.

From this combined pool of approximately 1980 companies, 32 professionals with expertise in maritime logistics were identified and invited to contribute. Their backgrounds in international shipping, freight forwarding, and port operations ensure both the credibility and sectoral relevance of the collected evaluations. In accordance with data protection regulations, the names of the participating companies, associations, and individual experts are not disclosed in the manuscript.

Each expert evaluates the relative importance of the seven strategies using Saaty's 1–9 fundamental scale. After verifying that each matrix satisfies the consistency threshold (CR < 0.10), the valid matrices are combined using the geometric mean method. The resulting values in the matrix represent the consensus-based relative weights assigned to each strategy pair.

Utilizing Saaty's fundamental scale, the pairwise comparison matrix was developed and is displayed in Table 4a,b. Table 4a presents an example of an individual pairwise comparison matrix provided by one of the 32 maritime logistics experts.

Each expert evaluated the relative importance of the seven resilience strategies using Saaty's 1–9 scale, where "1" represents equal importance and "9" represents extreme importance of one element over another. The matrix reflects the expert's judgments on the comparative importance between strategies, providing a basis for later aggregation.

Table 4b shows the aggregated pairwise comparison matrix (Unrounded Geometric Means of 32 Experts), which was constructed by calculating the geometric mean of the corresponding entries from all 32 individual matrices. This method is widely used in Analytic Hierarchy Process (AHP) studies to synthesize group judgments while maintaining the reciprocal property of the matrix. The resulting matrix represents the consensus-based relative importance among the seven strategies, forming the foundation for subsequent normalization and priority weight calculations.

Table 4c presents a rounded version of the aggregated pairwise comparison matrix shown previously in Table 4b. The values were rounded to the nearest standard value from Saaty's 1–9 fundamental scale to enhance readability and facilitate interpretation, especially in practice-oriented settings. While the unrounded matrix (Table 4b) was used for the actual normalization and weight derivation in line with AHP methodology, this simplified version offers a clearer visual reference for stakeholders less familiar with decimal-level comparisons. Aggregated Pairwise Comparison Matrix are depicted in Table 4c.

Each column of the pairwise comparison matrix in Table 4a–c is summed and shown in Table 5. It displays the sum of each column from the aggregated pairwise comparison matrix. These totals are used to normalize the matrix by dividing each element in the matrix by its respective column total. This normalization process enables the calculation of relative priority weights for each criterion, which are essential for determining their final importance rankings within the AHP framework.

Each element of the matrix is divided by its respective column total to form the normalized matrix as is demonstrated in Table 6.

The average of each row in the normalized matrix is computed to obtain the priority weight for each strategy:

To ensure the logical consistency of the pairwise comparisons, the Consistency Ratio (CR) was calculated. The steps involved in this calculation are shown as in Table 7.

$$CR = CI/RI \quad (1)$$

where

- CI (Consistency Index) = $(\lambda\_max - n)/(n - 1)$;
- λ_max is the principal eigenvalue of the pairwise comparison matrix;
- n is the number of criteria;
- RI is the Random Index based on matrix size ($n = 7 \rightarrow RI = 1.32$).

The result of the consistency ratio calculation is demonstrated in Table 8.

The calculated Consistency Ratio (CR) for the comparison matrix is 0.0278. Since this value is well below the acceptable threshold of 0.10, the judgments made during the pairwise comparisons can be considered logically consistent.

10. Results and Findings

The results indicate that Diversifying Shipping Routes and Exploring Alternative Ports are the most critical strategies, receiving the highest priority weights, as shown in Figure 7.

According to Figure 6, it is suggested that enhancing flexibility and resilience in maritime routing is a top concern. Strategies such as "enhancing cybersecurity", and "establishing strong supplier relationships" also hold significant weight, highlighting the growing importance of operational security and collaborative logistics.

In contrast, while still relevant, "utilizing inland transportation options" received a lower relative weight, implying that it may serve as a supporting strategy rather than a primary driver in maritime supply chain resilience initiatives.

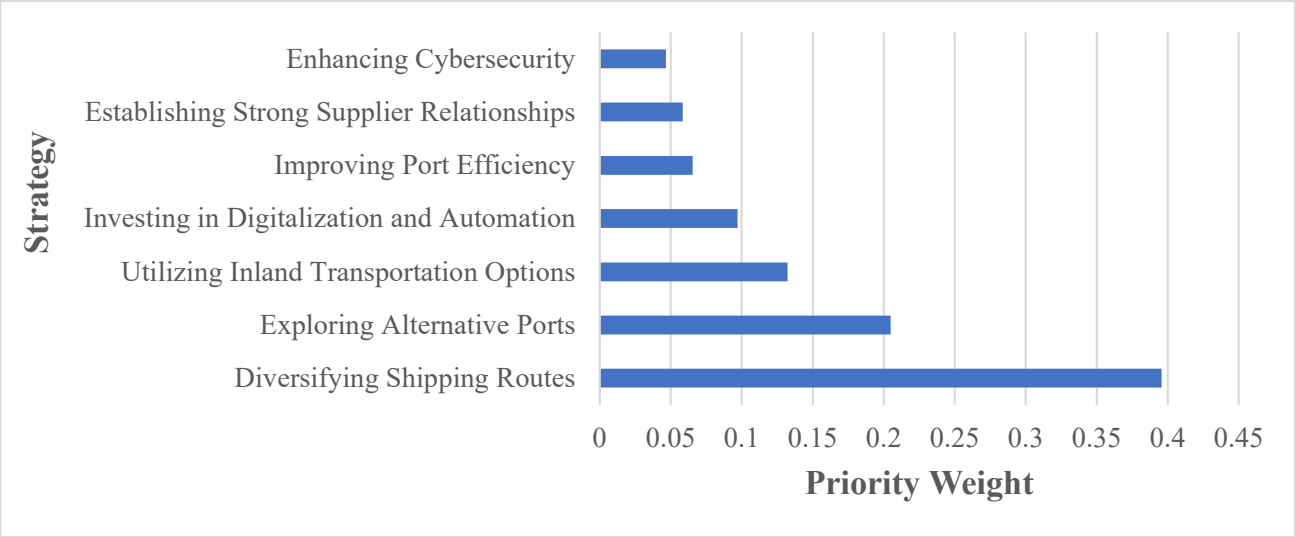


Figure 7. AHP-based priority ranking of strategic measures.

The AHP results revealed a clear hierarchy among the evaluated resilience strategies, reflecting the priorities of maritime logistics professionals based on their operational experiences. Strategies such as flexible port operations, route redundancy, and intermodal coordination ranked highest, likely due to their immediate applicability and direct impact on maintaining supply chain continuity during recent disruptions. In contrast, cybersecurity received a relatively lower ranking. This outcome should not be interpreted as a dismissal of its importance. Rather, it reflects a relative prioritization, where physical and logistical challenges were perceived as more urgent by the participating experts. Given that many of these professionals have recently dealt with tangible disruptions such as port closures, congestion, or rerouting, their emphasis naturally gravitated toward strategies that address such events directly. The results suggest a practical orientation in resilience planning—favoring short-term, operationally visible solutions—while potentially underestimating longer-term or less immediately observable threats. This highlights the importance of ensuring that resilience strategies strike a balance between operational urgency and strategic foresight, integrating both physical and digital risk domains in a comprehensive approach.

11. Conclusions

International trade is a fundamental driver of the global economy, shaping supply chains that, in turn, influence trade and economic growth. The success of both is mutually dependent. Disruptions—whether caused by armed conflict, political instability, pandemics, or natural disasters—can lead to significant economic challenges at the local, regional, or global levels. Strengthening the resilience and sustainability of trade is crucial for fostering economic development, promoting international collaboration, and ensuring market stability. The expansion of economies and the rise of large multinational corporations, supported by a competitive global framework, have created a need for sophisticated logistic support. International trade, which relies heavily on global supply chains, is predominantly dependent on maritime transport. With over 90 percent of traded goods are moved by sea, highlighting the crucial role of maritime logistics within the logistics network that underpins global trade. Consequently, disruptions in maritime logistics pose significant challenges across diverse industries and production processes, given the interconnected nature of supply chains.

Maritime logistics disruptions are handled to address the first research question by examining real-world case studies to assess their effects. Accordingly, the study introduces the tools and strategies for maintaining the resilience and sustainability of the global trade system, which are essential for economic development, international cooperation, and market stability. In this regard the strategic alternatives such as diversifying shipping routes, exploring alternative ports, utilizing inland transportation options, investing in digitalization and automation, improving port efficiency, establishing strong supplier relationships, enhancing cybersecurity, were considered Maprioritization in the context of maritime logistics and supply chain network. For answering the second research question, the structural changes, necessary in maritime logistics to improve sustainability and resilience in the near future, are investigated in detailed. Mitigating the adverse effects of maritime logistics disruptions, several proactive measures—tailored to specific operational contexts—are proposed. These include the diversification of maritime routes, the utilization of alternative port facilities, and the integration of inland transportation networks to alleviate congestion. Additionally, embracing digital transformation through advanced technologies such as AI, IoT, blockchain, and digital twin systems can significantly enhance supply chain visibility and support data-driven decision-making. Establishing strategic partnerships with multiple suppliers and logistics providers further contributes to operational flexibility and risk reduction. Moreover, investing in the modernization and expansion of port infrastructure is essential for improving overall efficiency and resilience within maritime logistics systems.

Implementing proactive strategies in maritime logistics offers several key benefits. Diversifying shipping routes and using alternative ports increases the flexibility of supply chains and increases resilience during crises by reducing reliance on single points of failure. Integrating inland transportation options can further reduce congestion in major ports and facilitate smoother cargo flows. Technological innovations such as AI, IoT, blockchain, and digital twin technologies can significantly improve real-time visibility, predictive analytics, and decision-making capabilities within complex logistics networks. Additionally, encouraging partnerships with multiple suppliers and carriers can strengthen supply chain agility, while investments in port modernization help improve handling capacity and efficiency. However, these measures are not without their limitations. High implementation costs, especially for advanced technologies and infrastructure upgrades, can be prohibitive for small and medium-sized enterprises or emerging economies. Furthermore, relying on digital systems increases exposure to cybersecurity threats. Operational coordination among multiple stakeholders, often with conflicting interests, can also create challenges for smooth execution. Thus, while these strategies together contribute to more resilient and sustainable maritime logistics, their effectiveness depends on context-specific factors such as financial capacity, regulatory frameworks, and technological readiness.

Maritime logistics faces increasing risks from geopolitical, environmental, and technological challenges. By adopting proactive strategies, we can enhance resilience and mitigate the impact of disruptions. In an ever-changing international trade environment, flexibility and innovation will be key to maintaining a stable and efficient maritime logistics system.

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Nomenclature

AGVs	Automated Guided Vehicles
AHP	Analytic Hierarchy Process
ECB	European Central Bank
EU	European Union
Federal Reserve	Central Bank of the United States
Forex	Foreign Exchange
GDP	Gross Domestic Product
IMF	International Monetary Fund
JIT	Just in Time
NAFTA	North American Free Trade Agreement
OPEC	Organization of the Petroleum Exporting Countries
PBOC	People's Bank of China
TOS	Terminal Operating Systems
USMCA	United States Mexico Canada Agreement
USSR	Union of Soviet Socialist Republics (Soviet Union)
WB	World Bank
WTO	World Trade Organization

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