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The Northern Sea Route as an alternative for enhancing supply chain resilience in a geopolitical disruption

Reflecting on the Case of the Red Sea Crisis

Bachelor's thesis
in International Business

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Abstract

Maritime freight plays an essential role in international trade due to low transportation costs and large cargo volumes transported between continents, often passing through maritime chokepoints. However, these chokepoints, such as the Suez Canal or the Strait of Bab el-Mandeb, are prone to causing disruptions, as demonstrated by the 2021 Suez Canal blockage and the 2023 Red Sea crisis. Materialized chokepoint risks often affect the entire supply chain, causing shipment delays, vessel allocation challenges, and port congestion. Previous research highlights geopolitical risks to be increasingly significant in global trade, yet risk assessment and management remain challenging due to the rapidly and vastly evolving nature of such events.

Both preventive and reactive measures exist to mitigate risks and to maintain supply chain resilience. Previous studies have identified alternative transport routes as one of the centric resilience practices, but most studies reflect on the currently existing routes, such as the Cape Route, under favourable geopolitical environment. Few studies consider the emerging Northern Sea Route, especially under contemporary geopolitical environment. This thesis focuses on assessing the potential of the Northern Sea Route to enhance the resilience of Asia–Europe maritime supply chains in disruptions similar to the Red Sea crisis. The crisis demonstrated how vulnerable Asia–Europe supply chains are to geopolitical disruptions, causing mass ship rerouting around Africa and thus increasing travel time and fuel costs. Evaluating the suitability of the Northern Sea Route requires consideration of the risks and challenges linked with the Arctic, such as the necessary vessel and port infrastructure, Russia’s geopolitical position in the area, and the geographical constraints.

This thesis identifies several prerequisites for the broader adoption of the Northern Sea Route. Under current ice conditions, navigating the Arctic is limited to a few months per year for vessels meeting the requirements for Arctic shipping. Regular connections are not yet economically feasible, but with crucial port and vessel investments, and an effective risk identification model, some traffic could be directed to the Northern Sea Route in the event of a Suez Canal route closure. Nevertheless, the attractiveness of the Arctic is expected to increase as sea ice retreats, extending the navigation season and enabling sailing farther north, away from the Russian coastline.

Keywords: supply chain resilience, maritime transport, geopolitical risks, the Red Sea Crisis, the Northern Sea Route, Asia–Europe trade

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Tiivistelmä

Meritse kuljetettavan rahdin keskeinen merkitys kansainväliselle kaupankäynnille perustuu edullisiin kuljetuskustannuksiin ja suuriin kuljetusvolyymeihin, joita alukset kuljettavat maanosien välillä läpäisten useita maantieteellisiä pullonkauloja. Nämä pullonkaulat, kuten Suezin kanava tai Bab el-Mandebin salmi, ovat kuitenkin alttiita riskeille, kuten 2021 Suezin kanavan sulku ja 2023 Punaisenmeren kriisi ovat osoittaneet. Tärkeiden merireittien sulkujen seuraukset näkyvät koko toimitusketjussa aiheuttaen toimitusviiveitä, alusten allokointiongelmia ja satamien ruuhkautumista. Aiemmat tutkimukset toteavat geopolitiikan olevan yhä merkittävämpi riskitekijä kansainvälisessä kaupassa, mutta riskien arviointi ja hallinta ovat haasteellisia riskien nopean eskaloitumisen ja laajan levinneisyyden takia.

Toimitusketjun resilienssin toiminnan ylläpitämiseksi on olemassa ennaltaehkäiseviä ja reaktiivisia toimia. Aiemmat tutkimukset ovat tunnistaneeet vaihtoehtoiset kuljetusreitit keskeiseksi toimitusketjun resilienssiä parantavaksi toimeksi, mutta Pohjoisesta meritiestä geopoliittisen kriisin tapauksessa on niukasti aiempaa tutkimustietoa. Tässä tutkielmassa keskitytään arvioimaan Pohjoisen meritien edellytyksiä parantaa Aasian ja Euroopan meritoimitusketjujen resilienssiä Punaisenmeren kriisiä vastaavassa häiriötilanteessa. Punaisenmeren kriisi osoitti Aasian ja Euroopan välisten toimitusketjujen häiriöalttiuden, mikä johti kuljetusten uudelleenreititykseen Afrikan ympäri ja kasvatti kuljetusaikaa ja -kustannuksia. Pohjoisen meritien soveltuvuuden arvioinnissa huomioon on otettava Arktisen alueen haasteet ja riskit, kuten vaadittava laiva- ja satamainfrastruktuuri, Venäjän geopoliittinen asema alueella sekä maantieteellisistä syistä johtuvat rajoitukset meriliikenteelle.

Tässä tutkielmassa Pohjoisen merireitin laajemmalle käyttöönotolle tunnistetaan tietyt edellytykset. Tämänhetkisten arktisten jääolosuhteiden puitteissa liikennöinti alueella on rajattu muutamaan kuukauteen vuodessa koko- ja jäänsietostandardit täyttäviltä aluksilta. Säännöllinen reittiliikennöinti ei ole vielä taloudellisesti kannattavaa, mutta tarvittavat satama- ja laivainvestoinnit sekä toimiva riskintunnistusmenetelmä saattaisivat mahdollistaa osan liikenteen hajauttamisen Pohjoiselle meritielle Suezin kanavan reitin sulkutilanteessa. Kuitenkin arktisen alueen houkuttelevuus kasvaa lähivuosikymmeninä napajään vetäytyessä, jolloin liikennöintikausi pitenee ja liikennöinti kauempana valtioiden rajoista mahdollistuu.

Avainsanat: toimitusketjun resilienssi, merikuljetukset, geopoliittiset riskit, Punaisenmeren kriisi, Pohjoinen meritie, Aasia–Eurooppa–kauppa

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1 Introduction

1.1 Background and aim of the thesis

Maritime transport plays a crucial role in global trade as over 80 % of goods are shipped via sea routes (World Bank Group 2023). In terms of the volume transported, the maritime trade between East Asia, especially China, and Europe is globally among the most important trade routes. For instance, container traffic between Europe and East Asia was 26.2 million twenty-foot equivalent units (TEU) in 2025, whereas container movements between Europe and North America were only 8.2 million TEU in the same year (UNCTAD 2025). A twenty-foot equivalent unit is a standardized container measurement used in logistics that enables consolidation in transportation, which is one reason why maritime transport allows companies to buy goods in bulk to achieve economies of scale while also benefiting from low transportation costs. Freight costs have decreased since the 1970s due to several factors, including containerization, improved fuel efficiency and higher reliability, and thus global sea transportation volumes have grown 3% annually on average (Valentine et al. 2013, 3, 16). The increasing importance of this already essential maritime trade is, however, subject to disruptions caused by multiple reasons. These disruptions include geopolitical risks, natural disasters, economic fluctuations and logistical issues, among others.

It is evident that any kind of disruptions in major waterways, such as in the Panama Canal or the Suez Canal, would affect shipping times and the availability of products. A major shock in Asia–Europe sea trade occurred in late 2023, when the Houthi rebels in Yemen began attacking vessels near the Strait of Bab el-Mandeb and the Red Sea as a result of the escalation of the Israel– Hamas war. This geopolitical disruption was particularly important as approximately 12 % of global trade flows pass through the Suez Canal and thus the Strait of Bab el-Mandeb. Some of the biggest shipping companies, such as Maersk, MSC and Evergreen, had to reroute their shipments around the Cape of Good Hope to opt for a more secure yet significantly longer maritime route. (Gallo & Soriano 2024, 14–17.) Disruptions in maritime supply chains are particularly critical because transportation is listed as one of the critical infrastructure sectors on which other industries heavily depend. On the other hand, the impacts of supply chain disruptions are both short-term and long-term but assessing the long-run effects is more challenging due to the limited availability of studies. (Baghersad & Zobel 2021, 2–3.)

The Red Sea crisis of late 2023 falls into the category of geopolitical disruptions, alongside events such as the Russo–Ukrainian War, and the U.S.–China trade war. Caldara and Iacoviello (2022,

1995) suggest that a geopolitical risk is the “threat, realization, and escalation” of events harmful for peaceful international relations linked with wars, terrorism and tensions among countries. In the Red Sea crisis, the geopolitical threat emerged from local tensions across the Middle East, with escalating conflict in Israel and Palestine eventually triggering further escalation in Yemen and the Red Sea. The impacts of geopolitical risks constitute one of the most serious contemporary threats to international business activities, partly due to the increasingly widespread nature of modern geopolitical conflicts (Atacan & Aık 2023, 8; Patsiaouras et al. 2026, 1–2). Moreover, Zhang et al. (2024, 1–2) propose that when evaluating geopolitically more secure transport routes between Asia and Europe, the Arctic routes should be considered as an alternative to the Suez Canal route, especially as climate change enables regional development in the Arctic (Poo & Yang 2022, 16). Out of the few proposed Arctic routes, the main alternative for Asia–Europe trade in terms of commercial potential is the Northern Sea Route (NSR), which runs along the Russian coastline (Rodrigue 2024).

This thesis aims to evaluate geopolitical disruptions and their impacts on maritime supply chain resilience in Asia–Europe trade routes, using the Red Sea crisis as a primary analytical lens. Due to the great importance of maritime transportation in global trade, and in light of the growing threats posed by geopolitical risks (Patsiaouras et al. 2026, 1–2), it seems essential to re-evaluate transportation solutions to maintain resilience. The case study approach for this thesis was chosen because it highlights the practicalities of a contemporary geopolitical event as it unfolds. Given the scope of this thesis, the focus is on two maritime routes, the Suez Canal Route (SCR) and the Northern Sea Route (NSR), while other trade routes, such as the Cape Route or the Eurasian land transport corridors, are not thoroughly examined in this study. Studies on the commercialisation of the Northern Sea Route have been conducted over the years (Zhao et al. 2016; Zhu et al. 2018; Gunnarsson & Moe 2021; Notteboom et al. 2024), but few of them consider geopolitical events and maritime supply chain resilience. Therefore, a research gap exists concerning the Northern Sea Route as an alternative transport corridor in the case of a sudden widespread disruption, such as a geopolitical conflict, especially as Arctic sailing conditions are expected to become more favourable in the future (Lee & Kim 2016, 265; Zhang et al. 2024, 1). With this in mind, the research question for this study is “*What is the significance of the Northern Sea Route for maritime supply chain resilience from the geopolitical perspective? – reflecting on the Red Sea Crisis*” To answer this question thoroughly, three sub-questions have been constructed:

- What are the consequences of geopolitical risks in maritime supply chains, and in Asia–Europe supply chain in particular?

- What is the role of supply chain resilience in disruptions?
- How did the Red Sea Crisis affect Asia–Europe maritime trade?

The first sub-question is addressed in chapter 2, which focuses on supply chain risk factors and risk assessment. Chapter 3 is structured around the second and third sub-questions. The themes from these two chapters are brought together in chapter 4, which evaluates the Northern Sea Route as an alternative route in Asia–Europe trade. This thesis concludes with chapter 5.

1.2 Key concepts

One of the centric theories for evaluating functioning transportation networks is supply chain resilience. Omer et al. (2012, 685–686) define supply chain resilience as the ability to bounce back to normal delivery levels after a disruption, whereas Ponomarov and Holcomb (2009, 124) view resilience as readiness, efficiency, and the capability to recover from disruptions. Furthermore, achieving resilient supply chains require proactive and extensive management decisions that acknowledge social, psychological, and economic levels of resilience (Ponomarov & Holcomb 2009, 127). Understanding supply chain resilience as a concept is essential for this thesis, as global maritime trade involves many entities of a supply chain, and thus potential risk factors.

A characteristic risk factor for maritime transportation is the existence of geographical chokepoints. Marine chokepoints are narrow passageways between land areas that receive heavy traffic flows and are sometimes located in the proximity of politically unstable countries and regions. Marine chokepoint closures cause long-lasting disruptions in supply chains, such as ship rerouting, shipments delays, and port backlogs. Some of the most crucial marine chokepoints for global trade include the Suez Canal, the Strait of Bab el-Mandeb, and the Strait of Malacca. (Pratson 2023, 1–3.) All three of these marine chokepoints are located along the Suez Canal Route from East Asia to Europe as illustrated in Figure 1.

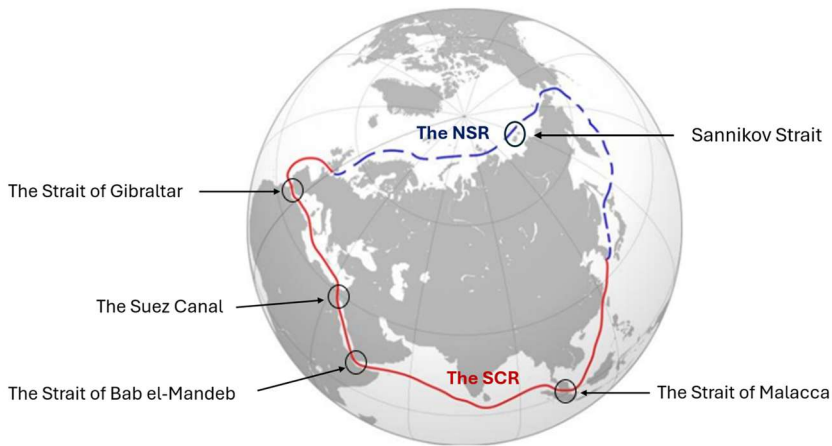


Figure 1 The Suez Canal Route (SCR) and the Northern Sea Route (NSR) (Adapted from Way et al. 2015, 2)

This thesis focuses on two specific maritime sea routes, the Suez Canal Route (SCR) and the Northern Sea Route (NSR). In order to better understand the characteristics of both these routes, Figure 1 presents the geography of the routes highlighting the major chokepoints. Pratson (2023, 1) states that each major maritime chokepoint faces threats, such as regional conflicts, piracy, or shipping accidents. Unlike the other chokepoints depicted in Figure 1, Sannikov Strait is primarily a natural chokepoint due to its draught constraints (Zhu et al. 2018, 461). The original map by Way et al. (2015, 2) included the red and blue lines indicating the two maritime routes. The key chokepoints along the Suez Canal Route appear from left to right as the Strait of Gibraltar, the Suez Canal, the Strait of Bab el-Mandeb, and the Strait of Malacca. Note that the figure shows only the main sections of the routes, not their exact endpoints or precise routing.

2 Maritime supply chain risks

2.1 Risk factors

Supply chains refer to systems that involve people and organizations working to move a product from where it is made to a customer (Cambridge Dictionary 2019). In the maritime context, the network of people and organizations within the supply chain revolves around sea shipments. Maritime supply chain partners can include the exporter, freight forwarder, exporting port, export customs, shipping line, import customs, importing port, and the importer (Liu et al. 2023, 3). Moreover, maritime supply chain risks include risks of a complex nature arising from the international reach of operations (Gao 2024, 175). As a risk can materialize into a disruption at different points of the supply chain, it is crucial to optimize risk management throughout the supply chain. Before assessing the means to handle risks, it is evident that the primary risk factors must be identified.

Supply chain risks can be approached from different angles. Jüttner (2005, 122–123) considers that supply chain risk sources are either environmental or related to problems of supply and demand coordination. Furthermore, political, natural, and social uncertainties are argued to be environmental risk sources that are either amplified or absorbed by internal activities, processes and control mechanisms. Even though the relevance of political risks for supply chain management has been identified, this risk source remains relatively underexplored (Fan & Xiao 2022, 984–985). When taking the maritime aspect into account, Gao (2024, 175–176) presents another classification which lists natural events, transportation failures, worker's strikes, and geopolitical instability as the main causes for disruptions in shipping supply chains.

The third perspective chosen for this thesis regarding maritime risks focuses on chokepoints as chokepoint disruptions can directly hinder traffic in major routes, which makes significant strategic adjustments vital for operations (Yang et al. 2025, 1). Lim and Chiu (2024, 3–5) present three categories for chokepoint disruptions: chokepoint risk, maritime security, and ship loss risk. Chokepoint risk refers to the risk of re-routing or delays due to accessibility issues, whereas maritime security considers criminality issues, and ship loss risk focuses on shipping accidents. Even though the research question of this thesis is to be examined from a geopolitical perspective, it is reasonable to understand other risk factors in order to better understand the gravity of geopolitical risks and potentially discover ways for efficient and broad risk management.

As this thesis explores the opportunities offered by the Northern Sea Route for enhancing maritime supply chain resilience through a geopolitical lens, chokepoint disruptions and other geopolitical risks along the Suez Canal route are the main risks to be evaluated. Gao (2024, 176) argues that geopolitical instability increases supply chain uncertainty and operational costs in addition to direct economic losses. Additionally, both consumers and investors might delay their spending due to geopolitical risks (Atacan & Açık 2023, 2). By applying the definition of geopolitical risk being a harmful event caused by tensions, wars and terrorist acts (Caldara & Iacoviello 2022, 1995) to the geography of the Suez Canal route, it is possible to identify the key geopolitical vulnerabilities associated with the route. Some of the most serious geopolitical threats near the route include the Israel– Hamas war, the civil wars in Sudan and Yemen, and the confrontation over Taiwan (Global Conflict Tracker 2024). Geopolitical risks constitute potential sources of chokepoint disruption (Wan et al. 2023, 1), with Taiwan affecting the South China Sea and the others mentioned influencing the area surrounding the Red Sea.

2.2 Risk assessment and management

After identifying the most prevalent maritime supply chain risks and their characteristics, it becomes essential to understand how to mitigate their impacts and to build a resilient supply chain. Supply chain risks, or vulnerabilities, have a managerial counterpart: supply chain risk management (SCRM). Contrary to risk management in a singular organization, supply chain risk management is an activity that requires coordination of upstream and downstream flows with customers and suppliers. Thus, supply chain risk management requires a broader scope, and an effective risk mitigation strategy is achieved through coordination and joint effort between the entities. (Jüttner 2005, 121–122.) The principal aim of supply chain risk management is to achieve robust and thus resilient supply chains. For this reason, it is crucial both to assess risk factors through key frameworks and to explore ways of enhancing resilience in maritime supply chains.

Due to the diversity of supply chain risks, it is often difficult to accurately assess their actual significance. Prior research identifies several frameworks for evaluating such risks, yet their application typically remains at the organization level, and commonly used methods for the entire supply chain are not necessarily available. Among traditional risk assessment tools, brainstorming and process mapping are used far more frequently than, for example, the Six Sigma method. Brainstorming is a spontaneous problem-solving technique that involves multiple people (Merriam-Webster 2019), whereas process mapping refers to an overview of business operations focusing on the relationships between processes (Malinova et al. 2019, 36). Finally, the Six Sigma method is a

data-based method that defines, measures, analyses, improves and controls processes in pursuit of higher performance (Kowalik 2018, 10). In the supply chain context, the differences in how various risk assessment processes were applied are characterized with even greater variation. (Jüttner 2005, 129, 131; Tang 2006, 35.) This issue also applies to maritime supply chains as multiple frameworks have been established in the sector but no universally and comprehensively adopted method exists (Wan et al. 2019, 224). However, a few established tools can be used for assessing risks relevant to this thesis.

Failure Mode and Effects Analysis (FMEA), fuzzy logic, belief rule base (BRB), and Bayesian networks are presented by Wan et al. (2019, 224–225) as example risk assessment methods in the maritime industry. FMEA method assesses the risk by calculating occurrence likelihood, consequence severity, and the probability of undetected failures, whereas fuzzy logic is based on partial truths in complex situations. Belief rule base is an extension of fuzzy logic where degrees of truth (DoB) are incorporated into IF-THEN rules of a fuzzy logic. Finally, a Bayesian network is a probabilistic graphical model that analyses uncertainty and causal relationships. These four frameworks have their limitations, largely due to the lack of objective data, which is why Wan et al. (2019, 225–226) propose a combination of these methods: a fuzzy belief rule-based Bayesian network (FBRB-BN). This approach integrates fuzzy logic and Bayesian reasoning to model complex relationships between maritime supply chain risk factors and outcomes for more precise risk assessment.

In terms of measuring geopolitical risks Caldara and Iacoviello (2022, 1197–1200) have established the Geopolitical Risk Index (GPR), which measures monthly geopolitical risk levels. The index is constructed by calculating the share of newspaper articles containing specific words related to geopolitical crises, such as “war” and “conflict”. However, because the GPR index is derived from newspaper publications, decision making based on the index may come too late in the case of rapidly unfolding geopolitical crises. The GPR index can still function as a useful tool for examining a country’s historical trajectory, as some geopolitical risks evolve more gradually.

A logical way to apply risk assessment for this thesis is to integrate the fuzzy belief rule-based Bayesian network (FBRB-BN) framework with geopolitical risks. In practice, this could mean that the probability of the escalation of geopolitical risks is evaluated using the Geopolitical Risk Index (GPR). Otherwise, the assessment process would follow the approach proposed by Wan et al. (2019, 225–230), in which the parameters used to evaluate risks include the occurrence likelihood, visibility, consequence severity, additional costs, and quality damage. Each parameter can be given

a qualitative value. For example, likelihood may be categorized as unlikely, occasional, or frequent. Then, the probabilities are represented in a Bayesian network as a probability table, and a Risk Priority Index (RPI) is calculated. Figure 2 illustrates an example of a Bayesian network in the context of the Red Sea crisis, in which delays to Asia–Europe maritime trade are shown as a possible consequence of both the Israel–Hamas war and the 2021 blockage of the Suez Canal. The example network presented is based on the case study applied in this thesis.

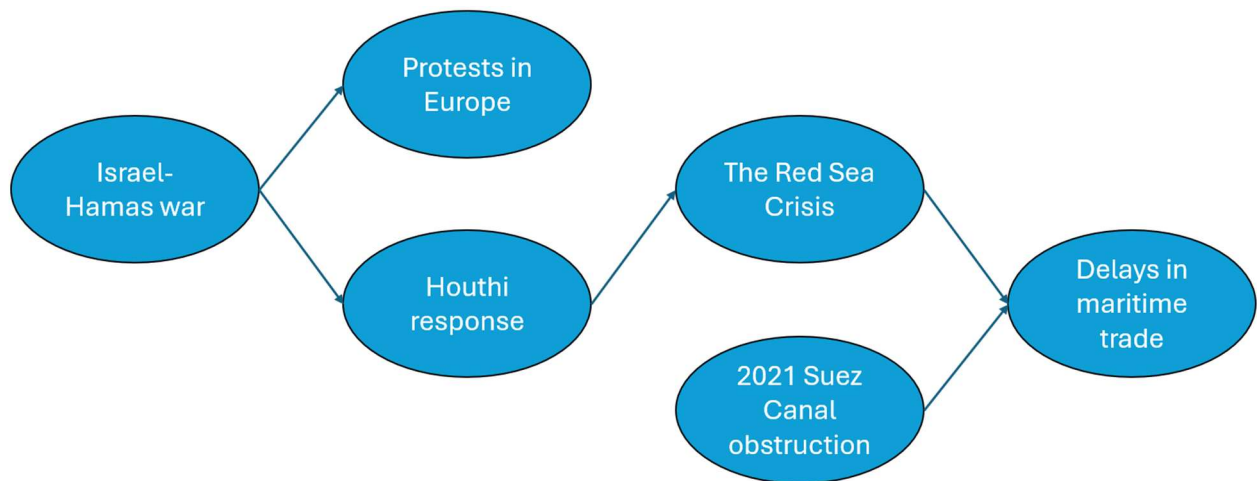


Figure 2 An example Bayesian network in the Red Sea Crisis

Because geopolitical risks are naturally spatial, it is reasonable to analyse each geopolitically relevant sector separately when assessing risks along maritime routes. This approach is used by Baksh et al. (2018, 426) in a Bayesian network-based study of risk assessment along the Northern Sea Route. A Bayesian network is a model that represents possible outcomes of chosen events but also shows how certain scenarios may occur due to several reasons. It should be noted that the simplified model does not take occurrence probabilities into consideration, and an effective implementation of such model would require comprehensive data collection and analysis from multiple sources.

3 Maritime supply chain resilience

3.1 Achieving resilient supply chains

3.1.1 Supply chain resilience elements

A resilient supply chain along with functional risk assessment methods is a key quality for optimal supply chain performance in disruptions. Supply chain resilience as the ability to bounce back from a perturbation consists of two considerations: system vulnerability and adaptive capacity (Omer et al. 2012, 686). In other words, the vulnerability of an entity to end up in a disruption, and the ability to adapt to the situation together define the resilience of an organization or an individual (Dalziell & McManus 2004). Furthermore, Liu et al. (2023, 6) identify agility, robustness, adaptability, and responsiveness as the four core resilience goals of contemporary maritime supply chain resilience. Also, resilience can be examined at many levels within a supply chain. Yang and Lin (2025, 2) argue that resilience is built at the individual, community, and system levels, and that the capabilities of managers and employees contribute significantly to organizational resilience. A comprehensive understanding of the realities of a supply chain resilience, and key factors shaping supply chain resilience is essential when considering geopolitically vulnerable trade routes.

There are many activities and practices that can affect resilience in a supply chain, and therefore it is reasonable to narrow down the most critical factors regarding this thesis. Instead of focusing on generalised factors that enhance resilience, it is more meaningful to focus the analysis on maritime transport and geopolitics, especially regarding chokepoints. Given the scale of maritime transport volumes and low transportation costs, considering alternative transportation modes remains groundless. Ali et al. (2017, 28) have constructed a supply chain resilience concept mapping framework, which consists of elements and practices characteristic for each phase of a disruption. Figure 3 features the elements that have been chosen for this thesis based on their applicability to geopolitical disruptions in maritime supply chains. Consequently, security, visibility, redundancy, market position, and social capital building have been excluded from this thesis. However, security and visibility could be treated as their own resilience elements, but in this context, they are covered under knowledge management.

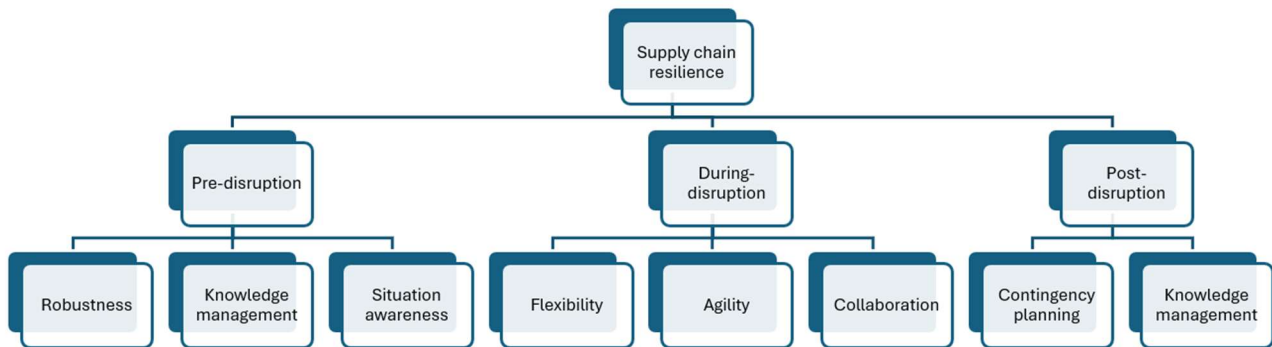


Figure 3 Supply chain resilience elements across disruption phases (Adapted from Ali et al. 2017, 28)

As depicted in Figure 3, supply chain resilience at pre-disruption phase can be achieved through efforts on robustness, knowledge management, and situation awareness, whereas flexibility, agility and collaboration are centric elements for resilience during disruption. Efforts after a disruption should concern contingency planning and post-disruption knowledge management.

3.1.2 Pre-disruption

Building supply chain resilience begins in the pre-disruption phase, when robustness, knowledge management, and situation awareness are the key elements. Robustness can be defined as the ability to resist disturbances and maintain the initial level of operations through proactive decision-making that evaluates the supply chain network complexity, critical locations, and possible scenarios (Ali et al. 2017, 25; Liu et al. 2023, 7). Establishing a proper robustness strategy enables effective execution of contingency planning after a disruption, which enhances supply chain resilience.

Transportation might become a crucial supply chain issue and therefore flexibility measures, such as multi-modal or multi-carrier transportation, or multiple routes, help maintain continuous flows of goods and avoid complete shutdowns. (Tang 2006, 36, 40–41.) Network diversification is especially important for mitigating geopolitical risks along maritime routes and therefore supply chain partners should be evaluated continuously (Zhu et al. 2024, 1057). Especially near chokepoints, the solutions for supply chain network are crucial. One way to enhance robustness and thus mitigate geopolitical risks is through long-term alliance networks as this has several benefits, such as pooling of resources, establishing a safety net, enhancing flexibility, and reducing operational costs (Tang 2006, 43; Liu et al. 2023, 12). Another safety measure for coping with maritime disruptions, especially in container traffic, is the use of time buffers. Long buffers enable shipping lines, such as Maersk, to maintain high levels of schedule reliability. However, some operators use an alternative strategy by opting for shorter buffers to reduce transportation costs. (Notteboom 2006, 33.)

Ali et al. (2017, 25) consider knowledge management in the pre-disruption phase to consist of training practices and human resource capabilities that help create a culture of supply chain resilience. Yang and Lin (2025, 2, 4–7, 14–15) recognize three human resource factors that contribute significantly for organizational resilience: digitalization, leadership, and employee self-efficacy. The study argues that digitalization provides leaders the skills necessary for achieving organizational resilience, and in maritime context digital technologies enable proactive risk management, improved collaboration with other supply chain partners, and automated tasks. Digitalization also plays a critical role in building employee self-efficacy through training programs and online courses, helping employees manage unexpected situations efficiently, such as in port closures and equipment malfunctions. Zhu et al. (2024, 1058) have come across similar findings, showing that an organizational culture encouraging adaptability and innovation helps mitigate geopolitical risks. This aligns with the framework by Omer et al. (2012, 687–688), which presents organizational policy implementation as a way to increase adaptive capacity. Digitalization and technology can also be utilized on risk warning systems to increase situation awareness. The functioning of a supply chain risk warning system is based in continuous, real-time monitoring combined with the utilization of historical risk data, through which the system aims to detect potential risks before they occur (Liu et al. 2023, 12; Gao 2024, 176). For example, the fuzzy belief rule-based Bayesian network presented in chapter 2 would be such digital tool for enhancing supply chain resilience through situation awareness.

3.1.3 During-disruption

Remaining resilient as a disruptive event unfolds requires supply chain managers to act quickly, which requires flexibility, agility, and collaboration among other elements. However, these attributes are particularly important in surviving a rapidly evolving geopolitical disruption in maritime supply chains. Flexibility is the structural ability to adjust operations through available options, such as alternative suppliers, adaptable processes, and multiple transport solutions, enabling swift changes when a disruption occurs. Agility on the other hand refers to the ability to react quickly to uncertainties, and collaboration concentrates on joint efforts in the supply chain to survive a disruption. (Ali et al. 2017, 26–27.)

A reasonable real-time response from shipping companies to mitigate issues caused by disruptions is supply chain reconfiguration (Blackhurst et al. 2005, 4076). One of the primary approaches for achieving flexible and agile maritime supply chains through vessel adjustments is port skipping. Diversifying routes and ports prevent local disruptions from spreading across the supply chain.

Therefore, shipping alliances with capabilities to practice route and port diversification are more resilient to disruptions. (Notteboom 2006, 36; Yang et al. 2025, 3, 11–13). Ports are particularly vulnerable nodes in maritime supply chains, as they are prone to congestion and are attractive targets for terrorist attacks (Omer et al. 2012, 689). In addition to changes in transportation, maritime supply chain flexibility in disruptions can be improved through multiple sourcing and machinery adjustments (Liu et al. 2023, 10).

Both vertical and horizontal collaboration in the supply chain affects positively resilience (Leat & Revoredo-Giha 2013, 228), which is especially crucial when a disruption unfolds. Pricing capabilities, postponement options, and faster reaction times can be achieved through strategic partnerships within the supply chain (Nenavani & Jain 2022, 1002–1003). Furthermore, Li et al. (2015, 91) propose two collaborative strategies to increase resilience. Firstly, risk information sharing refers to the open exchange of information between supply chain entities, especially in long-term partnerships, in order to effectively mitigate further complications. Secondly, risk sharing mechanisms are contracts or other formal arrangements that define responsibilities between supply chain partners. These mechanisms reduce the risk of inadequate decision making under quickly evolving disturbances.

3.1.4 Post-disruption

After a disruptive event contingency planning and post-disruption knowledge management are two important measures for supply chain resilience. Contingency planning practices, such as supply chain, and resource reconfiguration in addition to scenario analysis are essential for establishing resilient practices. (Ali et al. 2017, 27–28). The challenge of creating resilient supply chain practices according to disruption data has been identified by Blackhurst et al. (2005, 4077), as several practices, such as simulation models and game theory, are static and do not fit the dynamic nature of a supply chain. Therefore, robust models are vital in planning these future disruption scenarios. However, due to the great importance of maritime transportation for international trade topped off with the growing frequency and volume of geopolitical disruptions (Patsiaouras et al. 2026, 1–2), transportation network reconfiguration is arguably a distinctive feature for post-disruption resilience analysis. In Asia–Europe maritime trade, port skipping and using the Cape Route around Africa are commonly executed post-disruption reconfiguration practices (Gallo & Soriano 2024, 19–20), yet understudied Arctic routes could offer options (Zhang et al. 2024, 1–2).

Post-disruption knowledge management seeks to improve resilience by learning from disruptions through education, training, feedback, and innovation as these measures enable organizations to

broaden their knowledge and evaluate new opportunities (Blackhurst et al. 2011, 380; Chowdhury & Quaddus 2016, 713; Ali et al. 2017, 27). In practice, managers assessing whether communication was optimal or whether training programs provided the skills necessary to handle situations are two examples of how organizations can learn from disruptions and improve resilience for future disruptions. Post-disruption knowledge management helps establish contingency plans in maritime supply chains. Hence, analysing previous disruptions in detail, such as the Red Sea crisis, provides insights for enhancing future resilience.

3.2 Supply chain resilience in the Red Sea Crisis

3.2.1 Resilience conditions prior to the Red Sea crisis

The Red Sea crisis in late 2023 and early 2024 was a major shock to Asia–Europe maritime supply chains. The Yemen based Houthi movement reacted to the Israel– Hamas war by attacking merchant vessels linked to Israel or its allies, using drones, missiles, and gunmen. The disruption caused notable security issues and put supply chain resilience to the test, as eventually up to 80 % of planned shipments across the Red Sea were rerouted around Africa. (Notteboom et al. 2024, 4, 9; Gallo & Soriano 2024, 15–16.) Rerouting shipments around the Cape of Good Hope has certain implications for supply chains. Assuming unchanged vessel speed, the longer Cape route requires at least two additional vessels to maintain normal shipment schedules. Additionally, longer and adjusted transit times can disrupt container availability, as some containers could end up in the wrong destinations or be transported empty. (Notteboom et al. 2024, 9, 15.) Then, both downstream and upstream flows in the supply chain could be disrupted. Downstream entities of a supply chain might have shortages from materials, whereas upstream operators may face a build-up of goods. Furthermore, factories may have to slow down production, and end product shortages can lead to higher prices for consumers. (Gallo & Soriano 2024, 23.) It is vital to understand how the Red Sea crisis affected maritime supply chain resilience, and what can be learned from it in order to prevent or mitigate similar risks through supply chain resilience practices.

It is important to note a few characteristics of the Suez Canal Route prior to the occurrence of the Red Sea crisis. The importance of the Suez Canal Route is indisputable as 12% to 15% of global trade (UNCTAD 2024), nearly one third of all container traffic, and 8.7% of the world's oil shipments pass through the Red Sea (U.S. Energy Information Administration 2023; Notteboom et al. 2024, 7). Secondly, the Suez Canal Route has already faced major disruptions in the 2000s, such as piracy related hijackings, Covid-19, and the 2021 Suez Canal blockage, which resulted in significant economic losses and a surge in container costs (Pratson, 2023, 1; Wan et al. 2023, 12;

Gallo & Soriano 2024, 22). Considering these features, it seems essential to strengthen supply chain resilience before another major disruption occurs along the Suez Canal Route.

Wan et al. (2023, 12) suggest that after the 2021 Suez Canal blockage, port operators should tailor emergency plans for future disruptions. The benefits from investing in port terminals have been noted by shipping companies, as they have established subsidiaries to operate ports. For instance, Maersk operates APM Terminals, and MSC handles Terminal Investment Limited (TIL) (Gallo & Soriano 2024, 22). As illustrated, shipping companies have aimed to increase pre-disruption resilience through vertical integration to improve the performance of critical maritime supply chain nodes such as ports. On the other hand, the three biggest shipping alliances 2 M, Ocean, and THE Alliance account together for 82.4 % of global shipping market share (Zheng et al. 2022, 1) and therefore are equipped with resources and means to handle crises (Yang et al. 2025, 2). However, the just-in-time (JIT) strategy widely used in Asia–Europe container trade, which is based on low inventory levels, quick response times and a strong reliance on the Suez Canal Route, creates a significant vulnerability in case of a prolonged disruption (Gallo & Soriano 2024, 21). Overall, due to the importance of the Suez Canal Route and the lack of viable alternatives implied by the massive rerouting required during disruptions, pre-emptive measures for improving resilience have been limited in maritime trade between Asia and Europe.

3.2.2 Resilience conditions during and after the Red Sea Crisis

As the Red Sea crisis was unfolding, maritime supply chain managers had to face multiple consequences. The longer Cape route caused 12 days of additional sailing time, increasing voyage costs (Notteboom et al. 2024, 8). In general, transportation costs between Asia and Europe increased 3% to 13% via the Cape Route (Bedoya-Maya et al. 2025, 1, 15), whereas the cost of transporting a container from Shanghai to Rotterdam increased by 800% from October 2023 to July 2024 due to increased fuel and insurance costs (Gallo & Soriano 2024, 23–24; Yang et al. 2025, 2). Some efforts were made to ensure safer passage across the Red Sea. For example, the French navy initially escorted some of the CMA CGM carriers, yet the French shipping company switched to the Cape route in February 2024. Longer travel distances have an impact on emissions as well, and the rerouting of an individual vessel via the Cape route was estimated to increase emissions by 42%. (Notteboom et al. 2024, 8, 10.)

The three shipping alliances used two primary resilience practices during the Red Sea crisis. The 2 M and Ocean alliances were able to adjust their vessel allocations thanks to their vast and flexible resources, whereas the smaller THE Alliance had to cancel some routes due to limited capacity.

However, the more widely implemented practice by shipping alliances to ensure resilient supply chains was port skipping. In practice, this meant that the more vulnerable ports, such as King Abdullah Port in Saudi-Arabia, saw significant traffic decreases, whereas some western Mediterranean ports faced exceptional traffic volumes. (Yang et al. 2025, 8, 11.) Other geographical implications of port skipping and the Red Sea closure were that, as the Mediterranean became a cul-de-sac, traffic flows decreased remarkably in the eastern Mediterranean, whereas African and South American ports experienced surges. Overall, the frequency of port visits in Asia–Europe maritime supply chains decreased as a direct result of the Red Sea crisis. Adjusting vessel allocations and practicing port skipping affected the schedule reliability of the shipping alliances, with 2 M alliance experiencing up to a 20% decrease in reliability. (Notteboom et al. 2024, 10; Yang et al. 2025, 11.)

On the other hand, Liu et al. (2026, 16) observed that the ports with response measures, such as agile berth allocation and rapid hinterland evacuation, maintained resilient during the disruption. Especially methods involving technology and digital tools helped these ports to resist inconveniences. AI-based berth scheduling and automation in yard equipment usage are examples of these used tools. The research findings on the benefits of technology use and cross-training align with the observations of Yang and Lin (2025, 14–15) regarding resilience improvement in supply chains. The geographical areas that handled the Red Sea crisis most effectively, such as the United Kingdom and Western Europe, succeeded partly because their logistics systems were technologically advanced, which enabled rapid cargo movements to the hinterland (Liu et al. 2026, 16).

The Red Sea crisis re-shaped maritime supply chains in several ways and understanding these implications is vital for future supply chain resilience. One significant change concerns the role of Eastern Mediterranean ports as part of Asia–Europe maritime supply chains. Because vessels had to reroute around Africa, the distances to ports relying on the Suez Canal traffic, such as Marsaxlokk in Malta and Piraeus in Greece, increased significantly. As a result, the utilization rates of these ports declined due to the Red Sea crisis, while the importance of certain Spanish ports increased (Yang et al. 2025, 5; Bedoya-Maya et al. 2025, 15). This phenomenon had already emerged after the 2021 Suez Canal blockage. In addition, several other global supply chain disruptions, such as Covid-19 and Russia’s invasion of Ukraine have demonstrated the supply chain vulnerability to geopolitical risks. Gallo and Soriano (2024, 25) predict that shortening supply chains through reshoring and nearshoring will become increasingly attractive to businesses. One proposed option in the research considers relocating operations from East Asia to North Africa and the Middle East, although the current geopolitical situations in these regions limit business opportunities.

Especially after the disruption caused by the Red Sea crisis, Liu et al. (2026, 16) suggest that the parties of Asia–Europe trade should be looking into alternative transportation routes to reduce the dependency on geopolitically critical chokepoints. Even prior to the crisis, efforts to bypass critical chokepoints have been made, for example, through the Belt and Road Initiative (Haralambides & Merk 2020, 7). This project launched in 2013 by China aims to broaden Chinese economic and international influence through connectivity and infrastructure investments. The initiative consists of several projects around the world, including a few aiming to diversify Eurasian trade networks. These projects include the China–Europe land corridor via Central Asia, the Maritime Silk Road (MSR), the India–Middle East–Europe Corridor (IMEC), and the Northern Sea Route (NSR). (Huang 2016, 315; Haralambides & Merk 2020, 4; Notteboom et al. 2024, 11.)

Rail and air transport offer some possibilities for supply chain diversification in trade between Asia and Europe. Both rail and air services from East Asia to Europe are faster than sea transportations, but significantly more expensive. For example, a typical rail freight rate ranges from 7,000 to 15,000 euros per container, and air transport comes with even higher costs. However, including rail and air options in the supply chain can be reasonable for high-value cargo to avoid delays caused by maritime disruptions. Then, the Northern Sea Route could function as an alternative maritime route for the Suez Canal Route. The Northern Sea Route has been seen as a niche route, but the accelerating melting of ice in the Arctic could spike interests over the route. Major shipping companies, such as Cosco and Maersk, have already experimented with the route, which implies that the shorter maritime alternative to the Suez Canal Route could present future options for Asia–Europe trade. (Notteboom et al. 2024, 14, 16–17.)

The non-geographical considerations to improve resilience in the post-disruption phase include several practices. Liu et al. (2026, 16) propose that port resilience can be enhanced through berth capacity expansions, additional staff training, and establishing contingency agreements with inland supply chain partners to boost transportation to the hinterland. Moreover, especially operational measures utilizing digital tools could develop global resilience in the supply chain. Regional data-sharing platforms that detect congestion build-ups in advance, and inter-port coordination to balance vessel movements are presented as two feasible measures to enhance resilience.

Considering these findings concerning supply chain resilience in the Red Sea crisis, it is possible to point out utilized resilience practices for each resilience element as presented in Figure 4. The maritime supply chain entities had prepared for disruptions through vertical integration, implementation of advanced technology, for example, in port efficiency, and emergency plans.

Reactive measures included changes in vessel allocations, port skipping, shipment rerouting, agile port performance, and, to a certain extent, securing vessels through government coordination. Post-disruption tools for enhancing supply chain resilience include improved training, digitalization and coordination, supply chain shortening, and the consideration of alternative routes.

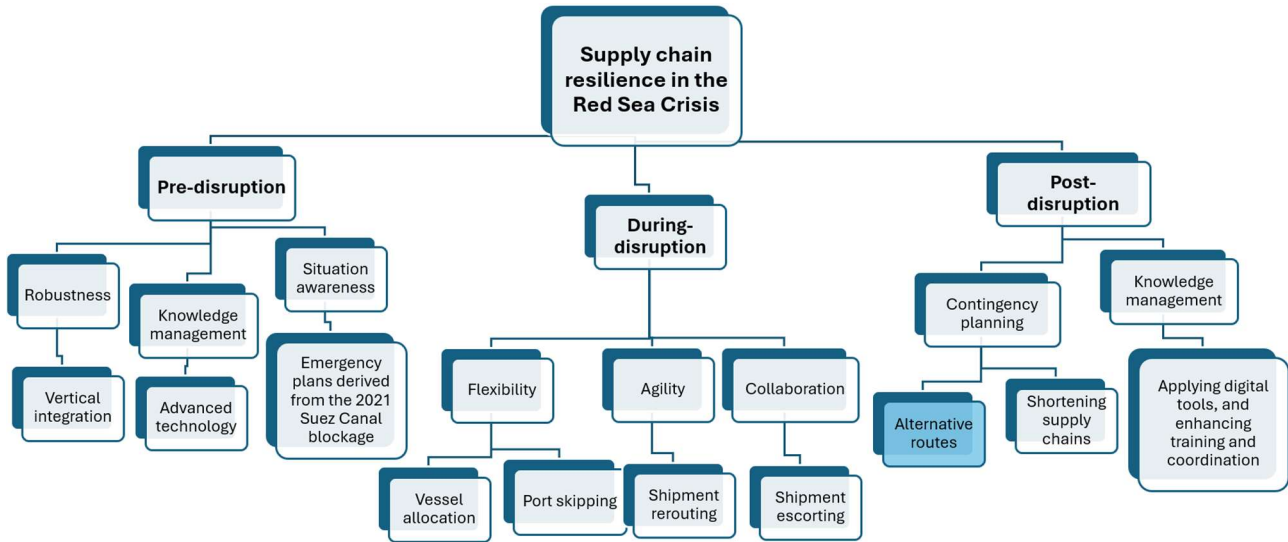


Figure 4 Supply Chain Resilience in the Red Sea Crisis

This thesis focuses on the Northern Sea Route, which is part of the post-disruption resilience practice of alternative routing from the Red Sea crisis perspective. However, when analysing Asia–Europe maritime supply chain resilience in the long-run and considering alternative routing together with the risk assessment tools presented in chapter 2 as resilience improvements, the scope changes from post-disruption to pre-disruption phase.

4 Evaluating the compatibility of the Northern Sea Route

As maritime supply chain resilience can be improved by establishing alternative routes (Poo & Yang 2022, 31; Liu et al. 2026, 16), the Northern Sea Route offers potential for diversifying Asia–Europe transportation. This alternative route connects East Asia to Europe via a maritime passage that goes along the Russian coast, enabling a 40% reduction in distance compared to the congested Suez Canal Route. However, the route has yet to receive major aspirations from shipping companies as mere 71 ships sailed through the Northern Sea Route in 2013, and only one container ship used the route in 2014. (Zhao et al. 2016, 50–51; Zhu et al. 2018, 456–457; Notteboom et al. 2024, 16.) Moreover, infrastructure investments along the route have remained marginal, even though Russia and China have expressed interest in developing the infrastructure in the area (Pruyn & van Hassel 2022, 1). Although the route has not yet attracted significant interest abroad, the retreat of Arctic sea ice due to climate warming has sparked discussion over the route. The Northern Sea Route is projected to be ice-free in the summer in the mid-21st century prolonging the accessibility of the Arctic waters from three to six months (Lee & Kim 2016, 265; Zhang et al. 2024, 1). Thus, Zhao et al. (2016, 51) suggest that the growing demand of container transport could partly be directed to the Northern Sea Route. Apart from transcontinental container transport, the route has already seen growth in other voyages between Arctic and non-Arctic ports during the 2010s (Gunnarsson & Moe 2021, 20).

4.1 Risk assessment of the Northern Sea Route

There are several factors that limit transportation in the Northern Sea Route. Firstly, the challenging geography presents natural barriers for operating in the area, as the existing infrastructure does not meet the requirements for operating under changing ice conditions. Large amounts of sea ice, especially icebergs and moving ice, result in technical challenges and an increased risk for both ships and ground facilities as well equipped refuge ports and communication infrastructure are limited between the major port cities of Vladivostok and Murmansk. (Lee & Kim 2015, 269; Zhu et al. 2018, 457; Pruyn & van Hassel 2022, 1.) Furthermore, Arctic shipping requires ice-strengthened vessels and, to a certain extent, icebreakers, both of which have faced limited or even decreasing capacity (Gunnarsson & Moe 2021, 11; Pruyn & van Hassel 2022, 2). The combination of nature unpredictability and outdated infrastructure increases the risk for an environmental crisis in the Arctic region (Zhu et al. 2018, 457–458). However, as the Eastern Mediterranean appears to be a risky environment for investments due to the dependency on the Suez Canal Route (Yang et al. 2025, 11), Arctic infrastructure could offer potential avenues for the major shipping alliances to

invest in. For example, the resilience practices of vertical integration through acquiring ports and technology solutions, such as AI-based berth allocations, would be significant efforts toward efficient Arctic supply chains.

Another primary limitation for the Northern Sea Route is the impossibility for large ships to navigate through it. Draught limitations along the route, such as the Sannikov Strait, result inevitably in vessel size limitations. A common conception is that a 4,000 to 5,000 TEU ship is the maximum limit for Arctic voyages, which is considerably smaller than the up to 20,000 TEU ships that operate on the Suez Canal Route. (Zhu et al. 2018, 468; Pruyn & van Hassel 2022, 1–2.) Therefore, better economies of scale can be achieved only if vessels sail further north to deeper but more challenging waters (Gunnarsson & Moe 2021, 21). From the environmental perspective, the smaller vessel size may cause greater environmental impacts per TEU compared to the Suez Canal Route (Zhu et al. 2018, 469).

The route seasonality harms especially container shipping as the profits are firmly tied with continuous shipments, and therefore shipping companies would need yet another route for most of the year. On the other hand, the lack of ports, markets and consistent cargo flows along the Northern Sea Route make the route less competitive for container traffic. For example, nearly all transportations along the Northern Sea Route from 2010 to 2019 were filled only one-way. Additionally, the high capital costs due to the construction of ice-resistant ships, maintenance of the hulls, and special crew training topped off with the seasonally restricted access to the Arctic waters raise concerns over profitability. (Lee & Kim 2015, 267, 269; Gunnarsson & Moe 2021, 21–22.) According to Zhao et al. (2016, 59), the ice-breaking costs would have to be reduced to compete with the profitability of the Suez Canal Route. However, Pruyn and van Hassel (2022, 1) suggest that considering the maximum container vessel sizes, potential profits should be carefully evaluated before investments to the Northern Sea Route.

One of the primary geopolitical aspects on the Northern Sea Route concerns Russia, since the maritime transport corridor runs along the Russian coastline for most of its length and is thus mostly under Russian jurisdiction (Lee & Kim 2015, 266). In practice, Russia manages the Arctic waters within 200 miles from the coast (Gunnarsson & Moe 2021, 6; Pruyn & van Hassel 2022, 2), which means that ship safety, marine environment protection, icebreaker fees, and passage permissions are, in the end, under Russia's legislation and its enforcement (Lee & Kim 2015, 267; Zhu et al. 2018, 457). Especially after Russia's invasion of Ukraine, the development of the Northern Sea Route has faced setbacks due to rising tensions, sanctions and countersanctions, disputed regulation

over the Arctic shipping and unwillingness for international cooperation. However, even with reduced tensions the Northern Sea Route would need encouraging policies to attract shipping companies, cargo-owners, and investors. (Gunnarsson & Moe 2021, 6, 25–26; Pruyn & van Hassel 2022, 2.)

Didenko et al. (2022, 30) list military confrontation over shipping regulation, Russia losing control over shipping regulation, and geo-economic confrontation, such as halting technical and scientific cooperation, as potential geopolitical risk factors on the Arctic waters. However, according to Zhang et al. (2024, 12) the potential market share of Arctic routes increased in under geopolitical influence when comparing to the Suez Canal Route and the China–Europe freight trains. The study found that several Chinese cities, especially those in the north, would benefit from the Arctic passages in the current geopolitical environment. For example, Arctic shipping from Shanghai to Europe could account for 39.78% of the total trade between the two. In addition, shipping through the Arctic lowers the risk of piracy (Zhu et al. 2018, 456).

Considering the rising significance of geopolitical risks to maritime transportation (Patsiaouras et al. 2026, 1–2), a comparison between the Northern Sea Route and the Suez Canal Route from a geopolitical perspective could become essential for just-in-time container traffic organizations. In practice, integrating the geopolitical fuzzy belief rule-based Bayesian network in this context could prepare container traffic operators for disruptions and thus enhance robustness. By setting a threshold value for the geopolitical risk index and incorporating it into the fuzzy belief rule-based Bayesian network, shipping companies could assess the probabilities and effects of potential scenarios. This would allow maritime supply chain managers to pre-emptively begin preparing Arctic shipping operations, such as schedules and vessel allocation, if a disruption appears evident and impactful. Further, supply chain managers could then diversify traffic between the Suez Canal Route and the Northern Sea Route flexibly and in an agile manner. However, this is based on the assumption that the occupancy rate of vessels capable of Arctic shipping is low as it has been so far (Gunnarsson & Moe 2021, 22).

4.2 The Northern Sea Route from a resilience perspective

The main factor contributing to the attractiveness of the Northern Sea Route is the distance from East Asia to Europe. The route offers reductions in transport time, and fuel costs compared to the Suez Canal Route, which can be especially beneficial for bulk cargo vessels given the seasonality issues on container transport (Lee & Kim 2015, 269; Zhu et al. 2018, 456, 464; Paardenkooper 2022, 184; Zhang 2023, 164). Moreover, Zhang et al. (2016, 248) state that both container and oil

shipping can save up to 10 sailing days because of the shorter distance, although this might benefit mostly small and medium-sized tankers due to the route seasonality and draught limitations.

However, in the supply chain context not only logistics but also other operations should be considered. Zhao et al. (2016, 59) explain that fewer ships might be needed for scheduled voyages compared to the Suez Canal Route, which results in ship-related cost reduction. As the Red Sea crisis demonstrated, the shift to the Cape Route required additional vessels to maintain normal shipment schedules, yet container availability was still threatened (Notteboom et al. 2024, 9, 15). Therefore, the Northern Sea Route could act as a more resilient option for container traffic to a certain extent in case of a similar disruption. Furthermore, the Northern Sea Route could shorten the delivery cycle, which in the case of suitable demand, price, and holding cost levels would make the whole Northern Sea Route supply chain more time-efficient than the Suez Canal Route (Zhang 2023, 165).

What comes to the sailing conditions on the Northern Sea Route, the Arctic offers a reliable transit route for Arc4 ice class vessels from August to November. However, since 2013 Russia has allowed lower ice class vessels to sail on the Arctic, and less than one third of transiting vessels have been escorted by icebreakers. (Gunnarsson & Moe 2021, 20.) Arc4 is a Russian classification for vessels capable of sailing in Arctic waters during summer facing up to 0.8m ice thickness and year-round in light ice conditions, whereas ships with lower ice classes are generally restricted from Arctic navigation and can handle only up to 0.7m of non-Arctic ice (Russian Maritime Register of Shipping 2019, 14). Moreover, no major accidents have occurred on the Northern Sea Route, and the development of weather-based routing technology support the decentralization of global shipping. Thus, the Northern Sea Route acts as a viable alternative for connecting northern port cities such as Helsinki and Stockholm with Sapporo and Ulsan. (Gunnarsson & Moe 2021, 20; Poo & Yang 2022, 31.)

Regardless of the improved safety along the Northern Sea Route, the remaining constraints should be taken into consideration when evaluating the nature of this maritime passage and the extent to which it could serve as an alternative route. Firstly, further reduction of Arctic ice and decreased toll tariffs would contribute to the competitiveness of the Northern Sea Route. This would enable financially viable operations for certain maritime operators, mainly for either time-sensitive and valuable transports or bulk shipping. High-value cargo, such as high-tech goods, could be transported via the Northern Sea Route as the required transport volumes are comparable to those of the Eurasian land corridor, which primarily carries similar time-sensitive goods. (Pruyn & van

Hassel 2022, 10.) Furthermore, high-value cargo justifies higher transportation costs at lower transportation volumes, and, for example, Cosco has examined the Northern Sea Route in this context since 2016 (Gunnarsson & Moe 2021, 21). When taking the nature of geopolitical risks into account, the ability to switch from the Suez Canal Route or the Eurasian land corridor to the Northern Sea Route, would improve during-disruption resilience through flexibility, which is especially critical in time-sensitive shipping. On the other hand, bulk shipping along the Northern Sea Route seems promising, as just-in-time deliveries are not typical when transporting ore, metals, or chemicals (Gunnarsson & Moe 2021, 22).

Even though regular container shipping on the Northern Sea Route remains problematic, some traffic could be directed from the Suez Canal Route under certain conditions. Pruyn and van Hassel (2022, 9) observed that operating eight 5,300 TEU sized Arc4 class vessels on the Northern Sea Route on a regular basis could account for 42% of the total land corridor transportation volume. Further, total transit time on the Northern Sea Route would be higher than on the land corridor, but 10% shorter compared to the Suez Canal Route in this scenario. Under low sea freight rates, transporting all low-, medium-, and high-value cargo via the Northern Sea Route or the Suez Canal Route is more cost-efficient compared to the land corridor. Moreover, shipments from cities such as Shanghai and Beijing could reach the lowest costs on the Northern Sea Route. However, when sea freight rates are high, rail transport via the land corridor becomes more competitive in some cases, which implies that the wide adoption of Arctic shipping would require financial support. (Zhang et al. 2024, 8, 10, 12.)

Under current natural and geopolitical circumstances concerning the Northern Sea Route, the prerequisites for container traffic are primarily on gathering data and gaining experience (Zhao et al. 2016, 59). Nonetheless, compared to the Eurasian land corridor, the Northern Sea Route can be considered as a viable alternative in the event of a disruption. This is particularly relevant for high-value cargo, for which the Northern Sea Route would enable up to 20% lower total supply chain costs compared to those of the land corridor between Chongqing and Duisburg. This competitive advantage is expected to strengthen as Arctic ice continues to recede, yet even under current conditions the Northern Sea Route can be viewed as a reliable back-up option for Asia–Europe trade. (Pruyn & van Hassel 2022, 2, 10.) Overall, during navigable months, the Northern Sea Route could handle 12.88% of total Asia–Europe transport volumes and take market share from the Suez Canal Route (Zhu et al. 2018, 463).

When comparing the total voyage costs of the Northern Sea Route and the Suez Canal Route, a key difference in cost structure becomes apparent. On the Northern Sea Route, the largest share of expenses comes from icebreaking and pilotage fees, whereas on the Suez Canal Route fuel costs constitute the greatest proportion. Consequently, developing Arctic infrastructure, such as shipbuilding and digital platforms, represents key investment objectives for improving the profitability of the Northern Sea Route. The role of ports is especially important for maritime supply chain efficiency, which can be enhanced through developing digital systems. (Ilin et al. 2022, 7; Zhang 2023, 164.)

5 Conclusions

This thesis examines how a geopolitical disruption, namely the Red Sea crisis, affected maritime supply chain resilience in Asia–Europe trade. Moreover, the main objective for this thesis was to evaluate the Northern Sea Route as an alternative route to the Suez Canal Route for enhancing supply chain resilience in case of a such disruption. Certain concepts were introduced for more precise assessment on the two geographically unique routes. Narrow passageways, or chokepoints, dominate the Suez Canal Route, causing notable geopolitical risks for the uninterrupted flow of goods, as demonstrated by the Red Sea crisis. Meanwhile, the Northern Sea Route as an Arctic corridor is characterized by otherwise challenging features. The challenging nature of an unambiguous risk assessment and management is noted in this thesis, and a maritime risk-related method presented in previous studies and integrated with geopolitical risks is briefly demonstrated. As this thesis is based on a case study approach, the Red Sea crisis is evaluated from a maritime supply chain perspective by comparing theoretical supply chain resilience elements with the actual chronological resilience practices executed by shipping companies, ports, and other supply chain entities. Lastly, the risk characteristics of the Northern Sea Route and its potential through maritime supply chain resilience are considered and compared with the Suez Canal Route.

The Northern Sea Route's potential to enhance maritime supply chain resilience is based on bypassing the chokepoints of the Suez Canal Route. These geopolitically risky chokepoints affect the whole supply chain in case of a disruption by causing availability issues, port congestion, and rising costs. From the Red Sea crisis perspective, evaluating alternative routes falls under post-disruption resilience. However, considering the current limitations of the Northern Sea Route related to Arctic geography and geopolitics, the long-term assessment of the route is centred on enhancing robustness as a pre-disruption resilience practice.

In terms of enhancing resilience in Asia–Europe maritime supply chains in practice, the Northern Sea Route can be used as an alternative maritime passage for the Suez Canal Route in geopolitical disruptions under certain conditions. Key risks and challenges for Arctic operations include vessel size limitations, seasonal constraints, and geopolitical factors, especially the control over the Northern Sea Route amid the current state of world affairs due to the Russia's invasion of Ukraine. Therefore, investments in essential Arctic infrastructure have been conservative, and the entities of maritime supply chains have been cautiously exploring the Northern Sea Route. Especially globally important container traffic, which depends on year-round just-in-time deliveries is considered difficult to integrate with the characteristics of the Northern Sea Route. On the other hand, small-

and medium-sized bulk cargo vessels, and around 5,000 TEU container vessels carrying high-value cargo could operate cost-efficiently on the Northern Sea Route taking market share from the Suez Canal Route, especially under a geopolitical disruption along the Suez Canal Route or the Eurasian land corridor. However, establishing operations requires investment in Arctic infrastructure, such as in ports and ice-class vessels, in addition to Arctic cooperation. The attractiveness of the route is likely to increase in the coming decades as Arctic sea ice declines extending the annual navigation season and enabling shipping farther from the Russian coastline.

Previous research on the Northern Sea Route have concentrated on assessing the route's economic feasibility for regular shipments, whereas few studies evaluate the Northern Sea Route from the perspective of geopolitical disruptions. This study complements existing studies by analysing the Northern Sea Route as a resilience-enhancing alternative in case of a disruption on the Suez Canal Route. The findings of this thesis are consistent with previous research concerning the limited usability of the Northern Sea Route. At the same time, this thesis identifies opportunities for its use in the event of a geopolitical disruption under certain conditions. Required infrastructure investments and an effective geopolitical risk assessment framework, namely the geopolitical fuzzy belief rule-based Bayesian network, are identified as key prerequisites for pre-emptive traffic diversification and thus improved resilience in Asia–Europe supply chains. Moreover, the geopolitical risk assessment tool could enhance preparedness for disruptions in container traffic and improve supply chain robustness through the utilization of the geopolitical risk index (GPR) as a key metric in evaluating potential scenarios and their occurrence probabilities. However, this study has limitations, as it does not assess the feasibility of the Northern Sea Route under current foreign direct investment conditions. Additionally, the practical utility of the proposed geopolitical risk assessment tool should be further examined. Future research could explore financing solutions for Arctic infrastructure and assess the environmental impacts of Arctic shipping.

References

- Ali, A. – Mahfouz, A. – Arisha, A. (2017) Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. *Supply Chain Management: An International Journal*, Vol.22(1), p.16–39.
- Atacan, C. – Açıık, A. (2023) Impact of Geopolitical Risk on International Trade: Evidence from Container Throughputs. *Transactions on Maritime Science*, Vol.12(2), p.1–11.
- Baghersad, M. – Zobel, C.W. (2021) Assessing the extended impacts of supply chain disruptions on firms: An empirical study. *International Journal of Production Economics*, Vol.231, p.1–11.
- Baksh, A.-A. – Abbassi, R. – Garaniya, V. – Khan, F. (2018) Marine transportation risk assessment using Bayesian Network: Application to Arctic waters. *Ocean Engineering*, Vol.159, p.422–436.
- Bedoya-Maya, F. – Beckers, J. – Cant, J. – Martínez-Moya, J. – Hassel, E. van – Vanelander, T. (2025) Container port competitiveness amid disruptions: Insights from the European maritime network during the Red Sea crisis. *Journal of Transport Geography*, Vol.128, p.1–17.
- Blackhurst, J. – Craighead, C.W. – Elkins, D. – Handfield, R.B. (2005) An empirically derived agenda of critical research issues for managing supply-chain disruptions. *International Journal of Production Research*, Vol.43(19), p.4067–4081.
- Blackhurst, J. – Dunn, K. S. – Craighead, C. W. (2011) An Empirically Derived Framework of Global Supply Resiliency. *Journal of Business Logistics*, Vol.32(4), p.374–391.
- Caldara, D. – Iacoviello, M. (2022) Measuring Geopolitical Risk. *The American Economic Review*, Vol.112(4), p.1194-1225
- Cambridge Dictionary (2019) *SUPPLY CHAIN: Meaning in the Cambridge English Dictionary*. Cambridge.org. <<https://dictionary.cambridge.org/dictionary/english/supply-chain>>, retrieved 24.2.2026.
- Chowdhury, M.M.H. – Quaddus, M. (2016) Supply chain readiness, response and recovery for resilience. *Supply Chain Management: An International Journal*, Vol.21(6), p.709–731.
- Dalziell, E. P. – McManus, S. T. (2004) Resilience, Vulnerability, and Adaptive Capacity: Implications for System Performance. In: *International Forum for Engineering Decision Making (IFED)*, Stoos, Switzerland, December 6–8, 2004.
- Didenko, N. – Skripnuk, D. – Kikkas, K. – Kaźmierczyk, J. (2022) Development of Northern Sea Route and Arctic Maritime Logistics. *Contributions to Management Science*, p.17–43.

- Fan, D. – Xiao, C. (2022) Firm-specific political risk: a systematic investigation of its antecedents and implications for vertical integration and diversification strategies. *International Journal of Operations & Production Management*, Vol.43(6), p.984–1007.
- Gallo, A. – Soriano, S. (2024) The geopolitical crisis of the Red Sea - maritime transport dynamics in the reorganisation of logistics chains. *GeoProgress Journal*, Vol. 11(2), p.14–17.
- Gao, Y. (2024) Analysis of Risk Factors for Disruptions in International Maritime Shipping Supply Chains. *Frontiers in Business, Economics and Management*, Vol.17(2), p.175–178.
- Global Conflict Tracker (2024) *Global Conflict Tracker* | Council on Foreign Relations.
<<https://www.cfr.org/global-conflict-tracker>>, retrieved 25.2.2026.
- Gunnarsson, B. – Moe, A. (2021) Ten Years of International Shipping on the Northern Sea Route: Trends and Challenges. *Arctic Review on Law and Politics*, Vol.12, p.4–30.
- Haralambides, H. – Merk, O. (2020) The Belt and Road Initiative: Impacts on Global Maritime Trade Flows. *International Transport Forum*.
https://www.oecd.org/content/dam/oecd/en/publications/reports/2020/06/the-belt-and-road-initiative_e19b8932/2281f06f-en.pdf>, retrieved 14.3.2026.
- Huang, Y. (2016) Understanding China's Belt & Road Initiative: Motivation, Framework and Assessment. *China Economic Review*, Vol.40(1), p.314–321.
- Ilin, I. – Devezas, T.C. – Jahn, C. (2022) *Arctic maritime logistics: The potentials and challenges of the Northern Sea Route*. Springer, Cham.
- Jüttner, U. (2005) Supply chain risk management: Understanding the business requirements from a practitioner perspective. *The International Journal of Logistics Management*, Vol.16(1), p.120–141.
- Kowalik, K. (2018) Six Sigma as a method of improving the quality of service process. *Production Engineering Archives*, Vol.19(19), p.10–15.
- Leat, P. – Revoredo-Giha, C. (2013) Risk and resilience in agri-food supply chains: the case of the ASDA PorkLink supply chain in Scotland. *Supply Chain Management: An International Journal*, 18(2), p.219–231.
- Lee, T. – Kim, H.J. (2015) Barriers of voyaging on the Northern Sea Route: A perspective from shipping Companies. *Marine Policy*, Vol.62, p.264–270.
- Lim, H.K. – Chiu, S.H. (2024) Resilience in maritime chokepoint disruption and its implications. *Continuity & Resilience Review*, p.1–13.
- Liu, J. – Wu, J. – Gong, Y. (2023) Maritime supply chain resilience: From concept to practice. *Computers & Industrial Engineering*, Vol.182, p.1–15.

- Liu, J. – Yu, W. – Fu, X. – Liu, J. (2026) Assessing the port resilience under the Red Sea crisis. *Journal of Transport Geography*, Vol.130, p.1-17.
- Malinova, M. – Leopold, H. – Mendling, J. (2015) An Explorative Study for Process Map Design. In: Proceedings of Information Systems Engineering in Complex Environments, CAiSE Forum 2014, ed. by S. Nurcan – E. Pimenidis, Lecture Notes in Business Information Processing, Vol.204, p. 36–51. Springer, Cham.
- Merriam-Webster (2019) *Definition of BRAINSTORMING*. Merriam-webster.com. <<https://www.merriam-webster.com/dictionary/brainstorming.>>, retrieved 28.3.2026.
- Nenavani, J. – Jain, R.K. (2021) Examining the impact of strategic supplier partnership, customer relationship and supply chain responsiveness on operational performance: the moderating effect of demand uncertainty. *Journal of Business & Industrial Marketing*, Vol.37(5), p.995-1011.
- Notteboom, T. – Haralambides, H. – Cullinane, K. (2024) The Red Sea Crisis: ramifications for vessel operations, shipping networks, and maritime supply chains. *Maritime Economics & Logistics*, Vol.26, p.1-20.
- Notteboom, T.E. (2006) The Time Factor in Liner Shipping Services. *Maritime Economics & Logistics*, Vol.8(1), p.19–39.
- Omer, M. – Mostashari, A. – Nilchiani, R. – Mansouri, M. (2012) A framework for assessing resiliency of maritime transportation systems. *Maritime Policy & Management*, Vol.39(7), p.685–703.
- Paardenkooper, K. (2022) The Role of Data-Driven Logistics in Arctic Shipping. *Contributions to Management Science*, p.173–191.
- Patsiaouras, G. – Saren, M. – Green, W. (2026) Geopolitical risk and international business: a multi-disciplinary review and research agenda. *Multinational Business Review*, p.1–24.
- Ponomarov, S.Y. – Holcomb, M.C. (2009) Understanding the concept of supply chain resilience. *The International Journal of Logistics Management*, Vol.20(1), p.124–143
- Poo, M.C.-P. – Yang, Z. (2022) Optimising the resilience of shipping networks to climate vulnerability. *Maritime Policy & Management*, Vol.51, p.1–20.
- Pratson, L.F. (2023) Assessing impacts to maritime shipping from marine chokepoint closures. *Communications in Transportation Research*, Vol.3, p.1–18.
- Pruyn, J.F.J. – van Hassel, E. (2022) The impact of adding the Northern sea route to the Belt and Road Initiative for Europe: A chain cost approach. *Transportation Research Interdisciplinary Perspectives*, Vol.15, p.1–12.

- Rodrigue, J.-P. (2024) Polar Shipping Routes. *The Geography of Transport Systems*.
<<https://transportgeography.org/contents/chapter1/transportation-and-space/polar-shipping-routes/>>, retrieved 16.2.2026.
- Russian Maritime Register of Shipping (2019) *Rules for the classification and construction of sea-going ships*. Russian Maritime Register of Shipping <https://rs-class.org/upload/iblock/a2b/73513281_E73C_417F_BB15_0EF448302439.pdf>, retrieved 30.3.2026.
- Tang, C.S. (2006) Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics Research and Applications*, Vol.9(1), p.33–45.
- U.S. Energy Information Administration (2023) *Red Sea chokepoints are critical for international oil and natural gas flows*. U.S. Energy Information Administration,
<<https://www.eia.gov/todayinenergy/detail.php?id=61025>>, retrieved 11.3.2026.
- UNCTAD (2024) *Red Sea, Black Sea and Panama Canal: UNCTAD Raises Alarm on Global Trade Disruptions*. UNCTAD. <<https://unctad.org/news/red-sea-black-sea-and-panama-canal-unctad-raises-alarm-global-trade-disruptions>>, retrieved 11.3.2026.
- UNCTAD (2025) *Review of maritime transport: Staying the course in turbulent waters*. UNCTAD. <https://unctad.org/system/files/official-document/rmt2025_en.pdf>, retrieved 12.2.2026.
- Valentine, V. F. – Benamara, H. – Hoffmann, J. (2013) Maritime transport and international seaborne trade. *Maritime Policy & Management*, Vol.40(3), p.226–242.
- Wan, C. – Yan, X. – Zhang, D. – Qu, Z. – Yang, Z. (2019) An advanced fuzzy Bayesian-based FMEA approach for assessing maritime supply chain risks. *Transportation Research Part E: Logistics and Transportation Review*, Vol.125, p.222–240.
- Wan, Z. – Su, Y. – Li, Z. – Zhang, X. – Zhang, Q. – Wan, Z. (2023) Analysis of the impact of Suez Canal blockage on the global shipping network. *Ocean & Coastal Management*, Vol.245.
- Way, B. – Khan, F. – Veitch, B. (2015) The Northern Sea Route vs the Suez Canal Route: An Economic Analysis Incorporating Probabilistic Simulation Optimization of Vessel Speed. In: *Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering*, OMAE2015, May 31–June 5, 2015, p.1–10.
- World Bank Group (2023) *Sustainable Development in Shipping and Ports*. World Bank. <<https://www.worldbank.org/en/topic/transport/brief/sustainable-development-in-shipping-and-ports>>, retrieved 12.2.2026.
- Yang, C.-S. – Lin, M.S.-M. (2025). Boosting resilience of maritime logistics operators: the importance of digitalization, leadership, and employee self-efficacy. *Maritime Policy & Management*, p.1–19.

- Yang, D. – Yue, X. – Yap, W.Y. (2025) Geospatial resilience of shipping alliances: Navigating the Red Sea crisis. *Journal of Transport Geography*, Vol.126, p.1–16
- Zhang, M. – Ding, T. – Ding, C. (2024) Research on the competitiveness of the Arctic transportation route under the belt and road initiative. *Transportation Journal*, Vol.64(1), p.1–14.
- Zhang, Y. (2023) Exploring the Economic Significance of Arctic Routes in the Supply Chain Field by Contrasting with Traditional Route. *Advances in Economics Management and Political Sciences*, Vol.49(1), p.157–165.
- Zhang, Y. – Meng, Q. – Ng, S.H. (2016) Shipping efficiency comparison between Northern Sea Route and the conventional Asia-Europe shipping route via Suez Canal. *Journal of Transport Geography*, Vol.57, p.241–249.
- Zhao, H. – Hu, H. – Lin, Y. (2016) Study on China-EU container shipping network in the context of Northern Sea Route. *Journal of Transport Geography*, Vol.53, p.50–60.
- Zheng, S. – Ge, Y.-E. – Fu, X. (2022) Capacity sharing within a shipping alliance: firm optimization and welfare analysis. *Maritime Policy & Management*, Vol.51(2), p.1–20.
- Zhu, M. – Miao, S. – Lam, H.K.S. – Liang, C. – Yeung, A.C.L. (2024) Navigating through geopolitical risk: the role of supply chain concentration. *International Journal of Operations & Production Management*, p.1032-1065.
- Zhu, S. – Fu, X. – Ng, A.K.Y. – Luo, M. – Ge, Y.-E. (2018) The environmental costs and economic implications of container shipping on the Northern Sea Route. *Maritime Policy & Management*, Vol.45(4), p.456–477.

Appendices

Appendix 1 Use of generative artificial intelligence

Artificial intelligence was used as a supporting tool in this thesis. Initially, ChatGPT version 5 and Microsoft Copilot were used together to narrow down the topic from a broader context to a more suitable lens, but their more relevant role was to check grammar and spelling mistakes. The thesis itself was written by the author, and the modifications suggested by the AI tools were kept minimal. Additionally, Keenious was utilized as a search engine for literature related to the topic of this thesis.

The prompts used with ChatGPT and Microsoft Copilot were:

- ”Etsi lähteitä, joissa selitetään ja tarkastellaan "geopolitical risk" liittyen joko EU yritysten toimintaan, EU-yritysten Aasian kauppaan tai ylipäätään kuljetuksiin (transportation)”
- ”Ehdota sopivia rajoituksia Euroopan ja Aasian välisten toimitusketjujen resilienssin tarkasteluun kandidaatintyössä”
- ”Korjaa kielioppia tarvittaessa muuttamatta asiasisältöä”

The prompts used with Keenious were:

- “give me sources for maritime transportation geopolitics”
- “search supply chain risk assessment”
- “anna tieteellisiä lähteitä, joissa kerrotaan risk warning systeemien käytöstä osana resilienssin säilyttämistä Punaisenmeren kriisissä”