Bibliometric Analysis and Literature Review on Maritime Transport Resilience and its Associated Impacts on Trade

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Abstract

This paper presents a comprehensive bibliometric analysis and literature review on maritime transport resilience and its impact on international trade. It categorizes and benchmarks risks affecting maritime transport resilience, including climate change, geopolitical conflicts, and public health events. Previous research focuses on climate change-related risks, primarily sea-level rise and storms, evolving from qualitative to quantitative methods. Research on public health events, especially pandemics, has emerged, highlighting global supply chain resilience and maritime transport. However, more comprehensive economic evaluations utilizing analytical models and simulations are needed to assess costs and benefits of adaptation strategies. Limited research exists on geopolitical risks and their impact on maritime transport resilience and international trade, with fragmented studies lacking attention in this critical research direction. Recent conflicts like the Sino-US trade conflict, Russia-Ukraine war, and Israeli-Palestinian conflict have profoundly affected maritime transport resilience, international trade, and the global economy. Future studies should prioritize economic implications of maritime transport resilience, particularly regarding geopolitical risks. In-depth economic evaluations, analytical modeling, and numerical simulations are necessary to inform policymakers and industry practitioners for enhancing resilience in the maritime shipping sector. The study offers valuable insights, guiding further investigations and contributing to the development of a robust global supply chain.

Keywords: maritime transport resilience, international trade, bibliometric analysis, collaboration network, semantic analysis

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1. Introduction

Maritime shipping is a pivotal component of international trade and economic

development, facilitating over 80% of global trade in terms of value (Shi and Li 2013). However, this industry encounters various risks and disruptions. For example, the escalating impacts of climate change, ranging from droughts and floods to hurricanes and other disasters, pose a significant threat to maritime infrastructure and transportation. Recent years have witnessed the devastating effects of hurricanes, such as Katrina, Sandy, Harvey, and Irma, along the US coastline, resulting in trillions of dollars in damages (Xiao et al. 2015). Furthermore, the severe drought caused by the El Niño phenomenon in the Panama Canal disrupted the global supply chain. In addition, the grounding of a major container ship in the Suez Canal in 2021 led to shipping congestion and delays, further impacting international trade. Moreover, the COVID-19 pandemic, which emerged in late 2019 and rapidly spread worldwide, severely disrupted international shipping operations, leading to adverse effects on the global supply chain and economy (Chua et al. 2022).

These instances indicate the vulnerability of the maritime shipping industry, emphasizing the critical need to enhance resilience in maritime transport to protect international trade and promote global well-being. The maritime shipping industry encounters not only traditional risks, such as geopolitical uncertainties, but also emerging and unconventional threats, including the impacts of climate change and disruptions caused by public health events. It should be noted that our review concentrates specifically on maritime transport resilience, with a particular emphasis on port resilience rather than the whole supply chain resilience. Therefore, we prioritize examining the three most significant and severe risks for seaports at present, namely climate change, pandemics, and political risks while excluding other risks from our investigation.

Several extant literature reviews have also been conducted in the similar research areas. Table 1 provides a summary of these review articles, including their respective research themes. Notably, the study by Gu and Liu (2023) stands out as a seminal review article that accurately integrates and defines maritime resilience, exploring the state of existing knowledge and future research directions in maritime resilience. Our study however differs from Gu and Liu (2023) in several ways. We focus on three most distinct risks impacting maritime transport resilience in recent years, and explore the literature on the impact of maritime resilience on the international trade, which is overlooked by Gu and Liu (2023). Apart from the review analysis method employed in the referenced article, we also examine the co-authorship network to gain insights into the collaborative patterns among scholars of research and the global involvement of researchers in advancing the relevent knowledge. In terms of findings, we highlight the importance of studying the most recent geopolitical events, not only the impact of the Russia-Ukraine war on maritime resilience, but also the significance of investigating emerging events including the Israeli-Palestinian conflict, piracy, and the politicization of ports on maritime resilience. Furthermore, we draw attention to the dearth of research examining the effects of maritime resilience on the international trade. Moreover, Gu and Liu (2023) specifically highlights the analysis of relevant literature on maritime supply chain resilience and draws corresponding conclusions. Similarly, emphasizing maritime supply chain resilience, Wendler-Bosco and Nicholson (2020) provides a

review of the existing literature in maritime supply chain and port disruptions. The main distinction between our study and this article lies in the research focus. While Wendler-Bosco and Nicholson (2020) primarily examines port disruptions, our study extends its scope to encompass the broader context of maritime transport. To avoid duplicative work, despite the existence of numerous studies on maritime supply chain resilience (Lam and Bai 2016; Liu et al. 2018), the term "supply chain" is not used as a search keyword and is not the primary focus of analysis in this study. The majority of the rest review articles in Table 1 are focused on the impact of climate change on ports (Becker et al. 2018; Loza and Veloso-Gomes 2023; Poo et al. 2018; Portillo Juan et al. 2022; Sánchez-Arcilla et al. 2016). For example, Becker et al. (2018) highlight the findings of an international review that explores the current state of knowledge concerning climate risks and adaptation responses for ports and their supply chains. Loza and Veloso-Gomes (2023) present a systematic literature review on incorporating climate change adaptation measures in the design of new ports and maritime projects, identifying research gaps and trends in the field. Poo et al. (2018) provide a comprehensive review of seaport and airport adaptation to climate change with a focus on sea level rise and flooding. Portillo Juan et al. (2022) present a review of the studies carried out until now on the effects of climate change on Spanish ports, and it identifies research gaps and weaknesses and suggests new research lines. Sánchez-Arcilla et al (2016) review the potential physical impacts of climate change on harbors in the Mediterranean Sea, focusing on climatic variables such as mean sea level and wave storms, and discusses the implications for port operations, infrastructure, and adaptation measures. In contrast, our article takes a broader scope by analyzing climate change as one of the three main risks of interest. Although previous studies examine specific risks affecting maritime transport resilience, systematic reviews comprehensively categorizing and benchmarking the effects of various risks while comparing the corresponding measures used to address them are lacking. Therefore, we fill this critical gap by thoroughly analyzing diverse risks encountered by the maritime shipping industry, shedding light on effective strategies and countermeasures used to mitigate these challenges. This comprehensive review provides valuable insights and enhances our understanding of how the international shipping industry can enhance its resilience in the face of a rapidly evolving risk landscape.

Table 1. Review articles related to maritime resilience

Publication	Journal	Research Theme	Citation
A systematic review of resilience in the maritime transport (Gu and Liu 2023)	International Journal of Logistics Research and Applications	Maritime resilience	18
Port disruption impact on the maritime supply chain: a literature review (Wendler-Bosco and Nicholson 2020)	Sustainable and Resilient Infrastructure	Port disruption impact on maritime supply chain .	36
A systematic literature review of maritime transportation safety management (Xu et al. 2023)	Journal of Marine Science and Engineering	Maritime transportation safety management.	1
Literature review on incorporating climate change adaptation measures in the design of new ports and other	Sustainability	Climate change adaptation in new port	4

maritime projects (Loza and Veloso-Gomes 2023)		design	
Review on seaport and airport adaptation to climate change: A case on sea level rise and flooding (Poo et al. 2018)	Global Warming Focus	Climate change adaptation in seaports and airports	13
Review of the impacts of climate change on ports and harbours and their adaptation in Spain (Portillo Juan et al. 2022)	Sustainability	Climate change impacts and adaptation in Spanish ports	10
Implications of climate change for shipping: Ports and supply chains (Becker et al. 2018)	WIREs Clim Change	Climate change impacts on ports and supply chains	60
A review of potential physical impacts on harbours in the Mediterranean Sea under climate change (Sánchez-Arcilla et al. 2016)	Regional Environmental Change	Climate change impacts on Mediterranean harbours	32
Port city sustainability: A review of its research trends (Zheng et al. 2020)	Sustainability	Port city sustainability	23

Although numerous studies evaluate the impact of maritime shipping development on international trade, particularly in terms of the network structure and its contribution to national and regional economies, limited studies examine the influence of maritime transport resilience on international trade. Disruptions during the COVID-19 pandemic have exerted significant adverse effects on international trade, including slow cargo movements, skyrocketing freight rates, and capacity shortages. Although some studies quantify potential economic losses from a supply chain resilience perspective, direct evaluations specifically focusing on the impact of maritime transport resilience on international trade remain scant. Therefore, a comprehensive review of academic research in this area is necessary to gain a better understanding of this crucial aspect.

The term “resilience” is commonly referred to a system’s capability to recover from a disruptive event and resume its normal operation (IPCC et al. 2007; Notteboom et al. 2021; Wan et al. 2018). Currently, there are a number of different definitions of resilience in various application domains. The definitions of “resilience” applied by previous maritime-related studies are summarised in Appendix A. Currently, the definition of resilience in the maritime transportation can be broadly categorized into two streams. Some studies define resilience as the ability of the system to absorb disturbances while retaining the same basic structure and ways of functioning, along with the capacity for self-organization and adaptation to stress and change. While other articles define resilience as the capacity to endure and recover to an acceptable level of service after encountering disruptive incidents. According to the research on maritime resilience by Gu and Liu (2023), we also define “maritime resilience” as the ability of the organization or segment in maritime transport to withstand disruption and return to a desirable performance level following disruptive events.

In light of the above, we conduct a comprehensive literature review using bibliometric analysis approaches. This review analyzes previous academic articles based on their titles, keywords, and abstracts and examines the major findings and research methods employed. We address two main research questions regarding maritime transport resilience: (1) What is the current state of research on maritime transport resilience? What are the main research methods and findings? Specifically, our review categorizes different types of risks, including geopolitical, climate change-related, and public health events, and examine the evolution of the research paradigm in addressing these risks. (2) To what extent does maritime transport resilience affect international trade? How does the risk of maritime transport resilience impact cargo flow and modal shifts among different transport modes? While addressing each research question, we identify the limitations of current research and suggest potential future research directions.

Our systematic literature review indicates that previous studies thoroughly examine the impacts of climate change-related risks on maritime transport resilience. Risks such as sea-level rise and storms have received significant attention, with earlier research primarily employing qualitative methods and later studies also incorporating quantitative approaches, such as economic modeling and numerical simulations. Research in this area is centered around a few key scholars. Research on risks posed by public health events, such as pandemics, has emerged in recent years, with a focus on global supply chain resilience, which includes maritime transport. However, there is still a need for more comprehensive economic evaluations using analytical models or numerical simulations to assess the costs and benefits of related adaptations. Conversely, research on geopolitical risks and their impact on maritime transport resilience and, thus, international trade, is limited. The topics and corresponding research groups within this area are fragmented, indicating insufficient attention to this important research direction and a lack of international cooperation. The recent outbreaks of significant geopolitical conflicts, such as the Sino–US trade conflict, Russia–Ukraine war, and Israeli–Palestinian conflict, have had serious consequences for maritime transport resilience, international trade and transport, supply chain functioning, and the global economy. Future research to address these gaps is warranted.

The remainder of this study is structured as follows: Section 2 introduces the research methodology and data used. Section 3 analyzes the selected research papers, describing our investigation findings and providing interpretations of maritime transport resilience. Finally, Section 4 concludes the study.

2. Methods of Literature Search and Database Construction

2.1 Elaboration of a corpus on maritime transport resilience

In accordance with the systematic literature review process, we use the following procedure to construct an article database for our analysis. To focus on relatively recent research developments, we define our search period from 2003 to 2023. We begin by searching papers' "title," "abstract," and "keywords" on the Web of Science Core Collection (hereafter referred to as WOS) and Scopus databases using keywords related

to “maritime resilience,” “transport resilience,” and “international trade.” Based on the search results from WOS and Scopus, we exclude books and conference papers, retaining only journal papers written in English. Table 2 presents the detailed syntax used for our search.[1] In addition, we use Google Scholar to supplement our search for the relevant literature not found in the WOS and Scopus databases. We initially find 250 articles on WOS, 385 articles on Scopus, and 4 additional articles from Google Scholar. However, considering that such preliminary search may not be sufficient, we apply further refinement. Table 3 provides an overview of our literature search results, and Figure 1 presents the framework of our review process, including the steps and outcomes of our literature search. The following major exclusion standards are also implemented: (1) articles lacking sufficient information and the full text, and (2) articles that do not discuss the resilience of maritime transport, including the resilience of marine ecosystems or the fishing industry. After thorough examination and elimination of duplicate articles and unrelated papers, 307 articles published between 2006 and 2023 are selected to construct our database. These articles are published in 138 journals across various disciplines, including maritime, transportation, and economics, indexed in the SSCI, SCI, SCIE, and ESCI. Appendix A lists the top 20 journals in our database, ranked by the number of articles included, along with their categories.

Table 2. Syntax to compile research on maritime transport resilience

Data source	**Syntax**
Web of Science Core Collection www.webofscience.com	First layer: TS = ((“maritime transport*” OR “marine transport*” OR shipping OR seaport$ OR port$) AND (resilien* OR adaptation)) NOT TS = (ecosystem OR biodiversity OR fish*) Second layer: 1) TS = (“Climate change” OR disaster)); 2) TS = (pandemic OR COVID-19 OR coronavirus OR corona-virus); 3) TS = (politic* OR Geopolitic* OR piracy OR “China-US” OR “Israeli-Palestinian” OR “Russia-Ukraine”); 4) AK = (trade NOT “trade-off$”) OR KP = (trade NOT “trade-off$”)
Scopus www.scopus.com	First layer: TITLE-ABS-KEY ((maritime OR marine OR shipping OR seaport$ OR "port$") AND (resilien* OR adaptation)) AND NOT TITLE-ABS-KEY(ecosystem OR biodiversity OR fish*) Second layer: 1) TITLE-ABS-KEY (“Climate change” OR disaster); 2) TITLE-ABS-KEY (pandemic OR COVID-19 OR coronavirus OR corona-virus); 3) TITLE-ABS-KEY (politic* OR Geopolitic* OR piracy OR “China-US” OR “Israeli-Palestinian” OR “Russia-Ukraine”); 4) KEY(trade AND NOT “trade-off$”)

Table 3. Overview of literature search results

Period		**Type**	**Number of Research Articles**

[1] Although some papers mention “trade” in their abstracts, their primary focus is not international trade. Indeed, they only use the term “trade” once in the background or introduction section of the abstract. Thus, while searching for relevant studies on the impact of maritime transport resilience on international trade, we specifically focus on keyword searches, limiting the search to the list of keywords and only including the term “trade.”

2021–2023	**Risks**	**Pandemic** COVID-19	**WOS + Scopus + Google Scholar**: 42 + 63 + 1→**51** (Duplicate: 26, Irrelevant: 29)
2006–2023		**Climate change** Water shortage, disaster, and sea-level rise	**WOS + Scopus**: 182 + 213→**244** (Duplicate: 93, Irrelevant: 58)
2010–2023		**Political risks** Trade war, geopolitics, piracy, and political conflict	**WOS + Scopus + Google Scholar**: 19 + 47 + 3→**13** (Duplicate: 12, Irrelevant: 44)
2013–2023	**Trade**	International trade, trade performance, and maritime trade	**WOS** + **Scopus**: 7 + 34→**22** (Duplicate: 4, Irrelevant: 15)
			TOTAL: 611 − 135 − 146 = 330→**<u>307</u>** (Duplicate: 23)

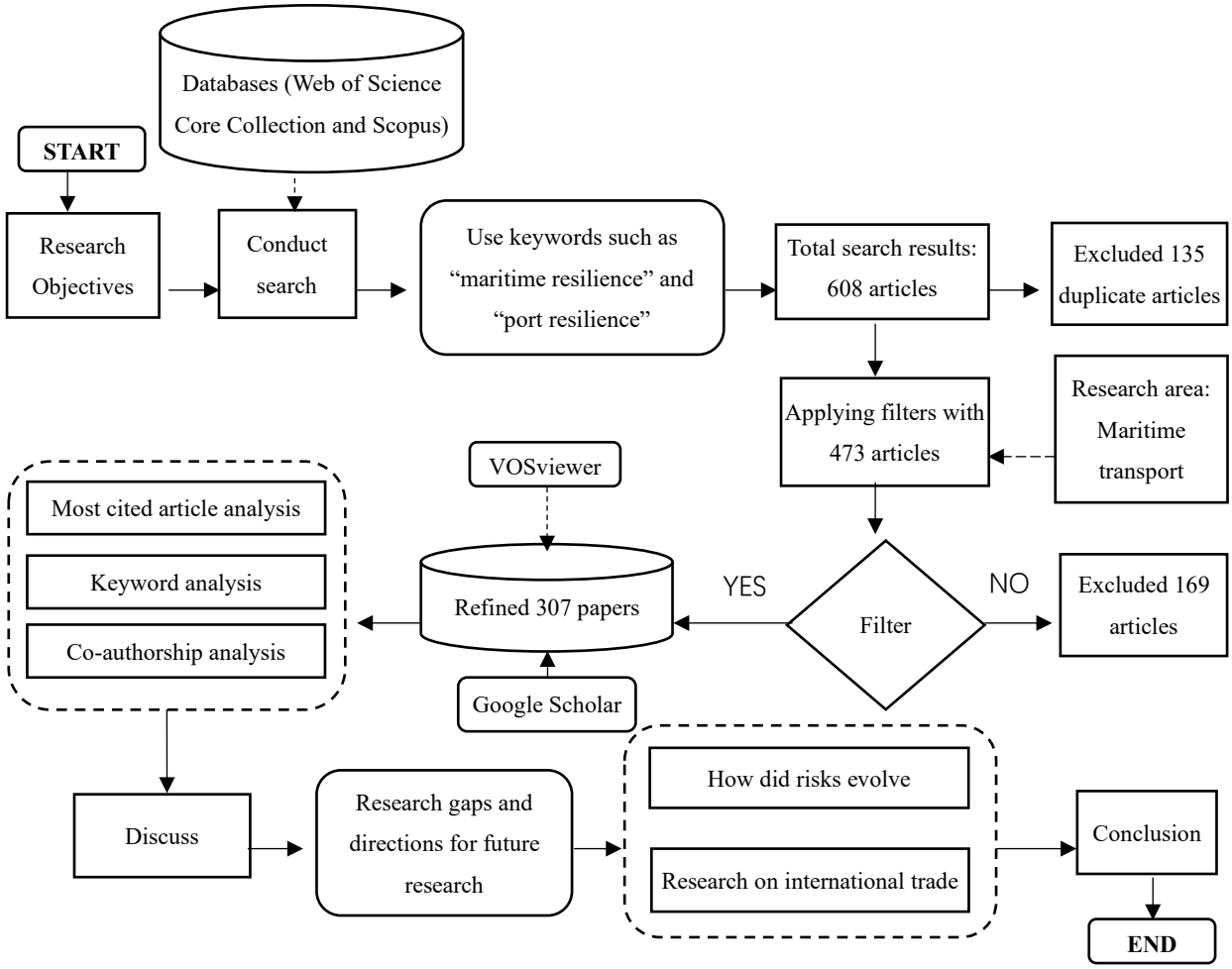

Figure 1. Flowchart illustrating the review procedure and database construction process

2.2 Most cited papers

On the basis of citation count statistics obtained from WOS, Scopus, and Google Scholar, we rank research papers examining different types of risks associated with maritime transport resilience and their impact on international trade. In addition, we provide a summary of the research methodologies and key findings of these highly cited papers. Because of the large number of papers examining the risks of maritime transport resilience, we select the top 10 most cited papers for climate change and pandemic-related risks and include all articles on geopolitical-related risks. However, studies focusing on the impact of maritime transport resilience on international trade are relatively limited, resulting in the identification of only 22 papers on this topic. For a more detailed analysis, please refer to subsection 3.1. This organization of the literature enables us to highlight the most influential research articles for each specific risk that poses a threat to maritime transport resilience. It also provides valuable insights into the diverse research methodologies used and their corresponding findings.

2.3 Semantics

Semantic analysis falls within the scope of co-occurrence network analysis, where researchers identify the emergence of ideas and trends in large corpuses (Cancho and Solé 2001; Knuth 1993; Lau et al. 2017). Semantic analysis plays a crucial role in uncovering intricate relationships and interactions between different research topics, as well as identifying emerging trends in the field. In this study, we perform a co-occurrence analysis of keywords in articles to track the evolving research landscape of maritime transport resilience. By examining patterns of keyword co-occurrence, we obtain valuable insights into prevailing themes, connections, and advancements in this field.

During semantic analysis, it is essential to address words that have the same meaning but are expressed in different ways because they can lead to knowledge split (e.g., "coronavirus and COVID-19," "pandemics and pandemic," and "ports and port"). This variability in words, referring essentially to the same objects, necessitates careful harmonization to prevent the splitting of knowledge (Lau et al. 2017). Thus, we eliminate some basic words (e.g., article) from our analysis.

We use VOSviewer graph visualization software to generate undirected weighted graphs. This software is used to construct a keyword co-occurrence network that enables us to visualize relationships between keywords and derive insights from their co-occurrence patterns. In the graphs generated, nodes represent keywords listed in the articles and edges indicate relationships between pairs of nodes. Using occurrences as weights, the diameter of the nodes and the thickness of the edges between the nodes represent the weights assigned to them, which are determined by the frequency of the occurrence of a keyword and the co-occurrence of two keywords in the same article. The detailed results of this semantic analysis are presented in subsection 3.2.

2.4 Science collaborations

Co-authorship in research not only fosters collaboration but also serves as a powerful tool for highlighting the research paradigm and the evolving focus among

diverse groups of researchers worldwide. By analyzing co-authorship patterns within and across papers, we obtain valuable insights into the dynamics of research communities and the active participation of scholars in specific topics. VOSviewer, is used to conduct and visualize these investigation results.

In co-authorship networks, researchers are interconnected based on their joint publications, creating a web of collaborative relationships. Nodes within these network represent the names of researchers, whereas edges depict connections between pairs of nodes. By assigning weights based on occurrences, we can determine nodes' diameters, which reflect the number of articles published by an author. This measure shows an author's research output and influence within the field. In addition, the thickness of the edges represents the frequency of collaboration between two authors, revealing the strength and extent of their collaborative relationships.

This comprehensive analysis of co-authorship networks allows us to understand the collaborative nature of research and global participation of researchers in advancing knowledge. Furthermore, this analysis highlights the evolving research focus within different groups worldwide and emphasizes their active engagement in specific topics. By visualizing these collaborative dynamics, we can gain valuable insights into the research paradigm and the collective efforts of researchers in pushing the boundaries of their respective fields. The detailed results of our co-authorship analysis are presented in subsection 3.3.

3. Results and Discussion

3.1 Results of the most cited articles

On the basis of citation counts, we organize the articles examining different types of risks. We select the top 10 most cited papers for climate change- and pandemic-related risks. In addition, we include all papers focusing on geopolitical-related risks (Tables 4–6). The 22 papers investigating the impact of maritime transport resilience on international trade are listed in Table 7. As shown in these tables, the total citation counts for the top 10 articles focusing on climate change-related disasters, pandemics, and geopolitics are 833, 297, and 145, respectively. Furthermore, the total citation count for the top 10 articles focusing on international trade is 405.

The tables also contain information on the research methods used, the specific regions targeted by the studies, and key research findings. In particular, the table related to international trade articles presents the risks addressed by each paper. Although the majority of articles discuss the three types of risks examined in this review, two papers specifically focus on economic risks. Heijman et al. (2017) illustrate how the global business cycle drives port activities and connects the regional economy to the global business cycle. Przekota (2022) demonstrates the resilience of the Polish economy to fuel market turbulence, suggesting that higher fuel prices should not trigger panic because technological advancements enable development despite increased fuel costs, whereas panicking only exacerbates inflationary pressures.

Table 4 provides a comprehensive overview of the top 10 most cited research

articles focusing on climate change-related risks in maritime transport resilience. These articles cover research areas on a global scale, including regions such as the United States, China, and Australia. This indicates extensive research on the resilience of various regions and sectors to the impacts of climate change, highlighting the global nature of climate change-related threats. Specifically, several of the most cited articles (Table 4) focus on studying the resilience of specific ports. For example, Rose and Wei (2013) examine the ports of Beaumont and Port Arthur in the United States, whereas Lawrence et al. (2020) analyze Puerto Rico, also located in the United States. Verschuur et al. (2020) examine 74 ports in the United States and Australia, and Yang et al. (2018) evaluate 14 ports in China. Conversely, the remaining articles adopt a broader scope, considering global perspectives or all ports on a larger scale in terms of regions.

Various research methods are employed in these articles, including questionnaire surveys, qualitative analysis, quantitative analysis, Bayesian analysis, risk modeling, and case studies. Among them, qualitative analysis emerges as the most frequently used method, as evidenced by the high citation of qualitative analysis–based articles. This finding suggests that researchers predominantly perform qualitative analysis to study the adaptability and planning efforts of ports in the context of climate change. However, despite the prevalence of qualitative analysis, there is a need for more research incorporating economic analysis, especially as more data become available. Such an approach would enable a comprehensive assessment of the economic consequences of port disruptions and enhance our understanding of effective adaptation strategies. The qualitative research is necessary and essential at the early stage of the research paradigm by framing research questions and establishing research areas. Subsequently, by incorporating economic analysis (both analytical and empirical), researchers can gain insights into the financial impacts of port disruptions and accordingly develop robust strategies for climate change adaptation in port systems.

Table 5 presents the top 10 most cited research articles on the effect of the COVID-19 pandemic on maritime resilience. These studies focus on specific regions, companies, or global ports and shipping networks. For example, Praharsi et al. (2021b) examine a shipping company in Surabaya, Indonesia, whereas Gibson et al. (2021) focus on Port Kembla in Australia. Other articles consider a broader scope. For instance, Marobhe (2022) examines 49 shipping companies across Asia, North America, and Europe, highlighting a global perspective in analyzing maritime resilience during the pandemic.

These studies on maritime transport resilience during the pandemic primarily use network analysis as a prominent research method. This approach enables the analysis of the complexity and connectivity of transportation networks, providing insights into the key features and resilience performance of container transport systems. In addition, complementary research methods, such as qualitative analysis, simulations, and case studies, are used to enhance our understanding of the adaptability and response strategies of maritime shipping to the pandemic. By incorporating diverse research methods, these studies provide a comprehensive perspective on maritime resilience during the pandemic. However, establishing and maintaining resilience in the face of global public health crises, such as the COVID-19 pandemic, remain challenging. Further research and interdisciplinary collaborations are necessary to deepen our

understanding of the resilience of the maritime transportation system. These efforts can provide targeted recommendations and facilitate the development of effective strategies for addressing similar crises in the future.

Table 6 presents 13 research articles examining the effect of geopolitical-related risks on maritime resilience. These articles cover various regions, including Germany, Sweden, the United States, New Zealand, the Netherlands, China, and Somalia. For instance, Fu et al. (2010) address the issue of piracy in Somalia. Mou et al. (2020) examine regions traversed by the Maritime Silk Road, China's initiative for large-scale cooperation in the Euro-Asian continent, which encountered resistance from Western countries. Ringsberg and Cole (2020) study 47% of ports in Sweden, and Notteboom (2016) examines the Hamburg region in Germany, among others. These regions reflect unique contributions, vulnerabilities, and regional dynamics within maritime trade. These studies focusing on geopolitical aspects do not consider specific individual ports but instead examine specific regions facing different geopolitical threats. More comprehensive discussions on these geopolitical risks are presented in subsection 3.2.1.

In terms of research methods used in studies of geopolitical risks, the combination of qualitative and quantitative analyses offers a comprehensive perspective for understanding and addressing complex issues. Qualitative analysis delves into stakeholders' perspectives, motivations, and viewpoints, whereas quantitative analysis provides data and patterns to understand geopolitical phenomena. By considering contextual factors, such as history, culture, economy, and geography, qualitative analysis enhances the comprehension of events and decision-making processes. Conversely, quantitative analysis employs data analysis and modeling to uncover interrelationships and impacts among these factors. Furthermore, qualitative analysis captures viewpoints through interviews, observations, and text analysis, whereas quantitative analysis quantifies perspectives through surveys and statistical analysis. The integration of both approaches leads to a holistic understanding of geopolitical issues, facilitating informed decision-making.

Table 7 presents the most cited research articles examining the impact of maritime transport resilience on international trade. Approximately half of the 21 reviewed articles focus on a global scale, highlighting the universal concern for the impact of maritime transport resilience on international trade. The remaining articles examine specific regions, including China, India, Sweden, the United States, and New Zealand, which reflect their unique contributions and vulnerabilities. For instance, Chen et al. (2017) examine the Port of Gothenburg in Sweden, whereas Rose et al. (2018) focus on the Beaumont and Port Arthur ports in the United States. Heijman et al. (2017) examine the Port of Rotterdam in the Netherlands. In addition, several articles explore multiple ports or specific regions, with some adopting a global perspective. For example, Jiang et al. (2021b) investigate five important ports in China, Popovich et al. (2021) study 13 ports in New Zealand, and Kuhla et al. (2023) examine ports in countries across the West Pacific region.

Studies investigating the impact of maritime transport resilience on international trade use various research methods, with mathematical modeling and simulations being the most commonly used approaches. This indicates a strong emphasis on quantitative

analysis to understand the dynamic nature of maritime transport resilience. In addition, qualitative analysis is recognized as an important method, as evidenced by its high citation rate. This finding highlights the importance of considering subjective factors and contextual nuances in analyzing maritime resilience and its effects on international trade.

Regarding the sources of risks affecting maritime transport resilience and, thus, international trade, many articles (7 out of 22) focus on risks related to climate change. These studies examine how climate change threats impact maritime transport resilience and, in turn, affect international trade. In addition, three articles examine the impact of the COVID-19 pandemic and two articles investigate economic risks in the shipping market (e.g., the shipping cycle) that pose a threat to maritime transport resilience. This demonstrates an awareness of the complex financial dynamics and market volatility that affect the stability and resilience of the industry. Furthermore, one article delves into geopolitical risks associated with piracy, highlighting security challenges encountered by the shipping industry in certain regions. Some articles do not explicitly restrict their research to specific risk types but instead conduct a more comprehensive analysis covering various types of risks affecting maritime transport resilience when discussing their impact on international trade. This approach indicates a broader perspective on maritime resilience, recognizing the interactions of various risk factors and the need for a comprehensive understanding when addressing industry challenges.

Table 4. The most cited articles related to climate change-related risks

No.	Authors	Year	Title	Methods	Area	Results	Citations
1	Becker et al.	2012	Climate change impacts on international seaports: Knowledge, perceptions, and planning efforts among port administrators	Questionnaire Survey	Global	Identifies opportunities for the scientific community to collaborate with port practitioners to proactively prepare for the impacts of climate change on this sector.	169
2	Rose and Wei	2013	Estimating the economic consequences of a port shutdown: The special role of resilience	Input–Output Analysis Data Analysis	The United States (Beaumont and Port Arthur)	Develops a methodology to estimate the total economic consequences of a seaport disruption. The finding reveals that regional gross output can decline but resilience can reduce these impacts by nearly 70%.	115
3	Becker et al.	2013	A note on climate change adaptation for seaports: A challenge for global ports, a challenge for global society	Qualitative Analysis	Global	Suggests a way forward through the adoption of some initial measures and a need to shift to more holistic planning, investments, and operations.	107
4	Verschuur et al.	2020	Port disruptions due to natural disasters: Insights into port and logistics resilience	Empirical Study	The United States and Australia (74 ports)	Provides insights for future modeling studies to approximate the extent of the disruption and resilience of maritime networks.	74
5	Yang et al.	2018	Risk and cost evaluation of port adaptation measures to climate change impacts	Fuzzy-Bayesian Analysis	China (14 ports)	Introduces a methodology to evaluate port climate change adaptation measures in scenarios with high data uncertainty and offers insights into developing efficient adaptation measures in a supply chain context.	72
6	Lawrence et al.	2020	Leveraging a Bayesian network approach to model and analyze supplier vulnerability to severe weather risk: A case study of the U.S. pharmaceutical supply chain following Hurricane Maria	Bayesian Network	The United States (Puerto Rico)	Investigates key events leading to risk propagation and disruptions in the US pharmaceutical supply chain post-Hurricane Maria and emphasizes the importance of port resilience for maintaining pharmaceutical supply chain performance.	67
7	Izaguirre et al.	2021	Climate change risk to global port operations	Risk-Modeling Framework	Global	Estimates that ports located in Pacific Islands will be at extremely high risks by 2100, whereas those in the African Mediterranean and the Arabian Peninsula will have a very high risk.	62
8	Ng et al.	2013	Climate change and the adaptation strategies of ports: The Australian experiences	Case Study	Australia	Demonstrates that although port managers recognize climate change as an issue that requires close attention, adaptation strategies have remained segregated and piecemeal.	60
9	Wang and Zhang	2018	Climate change, natural disasters and adaptation investments: Inter- and intra-port competition and cooperation	Mathematical Modeling	Global	Demonstrates that inter-port competition stimulates increased investments, whereas a “free-riding effect” occurs within ports, highlighting implications for maritime transportation.	55

10	Asadabadi and Miller-Hooks	2018	Co-opetition in enhancing global port network resiliency: A multi-leader, common-follower game theoretic approach	Game Theory	East Asia Europe	Shows that the proposed co-opetition approach leads to increased served total demand, significantly increasing market share for many ports and improving services for shippers.	52

Table 5. The most cited articles related to pandemic risks

No.	Authors	Year	Title	Methods	Area	Results	Citations
1	Notteboom et al.	2021	Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis	Qualitative Analysis	Global	Demonstrates that further adaptation mechanisms, such as slow steaming, economies of scale, and capacity management, are applied differently between the financial crisis and COVID-19.	172
2	Guerrero et al.	2022	The container transport system during Covid-19: An analysis through the prism of complex networks	Complex Networks	Global	Finds that COVID-19 mitigation measures implemented by governments exert differential impacts on port hierarchies, with larger and densely interconnected ports demonstrating greater resilience.	26
3	Praharsi et al.	2021	The application of Lean Six Sigma and supply chain resilience in maritime industry during the era of COVID-19	Lean Six Sigma Framework	Indonesia (companies in Surabaya)	Develops a suitable continuous improvement method for the maritime industry by applying Lean Six Sigma and supply chain resilience concepts to ensure the maintenance of a resilient supply chain during the COVID-19 pandemic.	22
4	Dirzka and Acciaro	2022	Global shipping network dynamics during the COVID-19 pandemic's initial phases	Network Theory	Global	Applies a three-stage approach and provides insights into operator behaviors when under distress.	17
5	Jin et al.	2022	Impact of COVID-19 on China's international liner shipping network based on AIS data	Complex Network	China	Demonstrates an increase in the scale of China’s international liner shipping network, with more routes converging at fewer hub ports, but the overall connectivity and connection strength have declined.	14
6	Panahi et al.	2022	Developing a resilience assessment model for critical infrastructures: The case of port in tackling the impacts posed by the Covid-19 pandemic	Bayesian Network	Global	Proposes a resilience assessment model for critical port systems to maintain strategic relationships among key stakeholders, including terminal operators, logistics service providers, port decision-makers, and port authorities.	13
7	Gibson et al.	2021	COVID-19 and the shifting industrial landscape	Qualitative Analysis	Australia (Port Kembla)	Catalogues five themes warranting geographical analysis and global comparison in light of the COVID-19 pandemic.	11
8	Zhang and Sun	2021	The coevolutionary process of maritime management of shipping industry in the context of the covid-19 pandemic	Test Analysis	Global	Discovers an MM progression mechanism developed between stakeholders in conjunction with the post-crisis period and presents the “MM-as-	8

						process" vision to emphasize the time-varying dynamic nature of MM development.	
9	Bai et al.	2023	Data-driven static and dynamic resilience assessment of the global liner shipping network	Simulation	Global	Demonstrates that both overlapping community structure and traffic flow significantly impact the resilience evaluation of the GLSN and proposes a simulation model with tailored, locally weighted flow redistribution rules.	7
10	Marobhe	2022	Investors' reactions to COVID-19 related announcements: evidence from the cargo shipping industry	Case Study	Asia, North America, Europe (49 Companies)	Demonstrates an overall negative overreaction to WHO's declaration of COVID-19 a pandemic.	7

Table 6. The most cited articles regarding geopolitical risks

No.	Authors	Year	Title	Methods	Area	Results	Citation
1	Fu et al.	2010	The impacts of maritime piracy on global economic development: the case of Somalia	Empirical Studies Simulation	Somalia	Demonstrates that even from the perspective of economic interests, more efforts from the international community should be dedicated to tackling maritime piracy.	62
2	Notteboom	2016	The adaptive capacity of container ports in an era of mega vessels: The case of upstream seaports Antwerp and Hamburg	Case Study	Germany (Hamburg)	Links the development path of upstream seaports to diverse economic, technological, social, and political factors and demonstrates that the discussion on the future of upstream seaports cannot be detached from broader public policy and stakeholder management concerns and the influences of retention mechanisms, power, politics and collective action by the port community.	40
3	Mou et al.	2020	Assessment of the Resilience of a Complex Network for Crude Oil Transportation on the Maritime Silk Road	Complex Network	Maritime Silk Road	Constructs a crude oil transportation network, designs a resilience assessment framework, and assesses the resilience of the network, demonstrating that the resilience of crude oil transportation networks declines at a steady rate under random attacks but declines sharply under intentional attacks.	16
4	Min	2011	Modern maritime piracy in supply chain risk management	Qualitative Analysis	Global	Assesses the impact of piracy on global supply chain operations and proposes potential remedies.	14
5	Ringsberg and Cole	2020	Maritime security guidelines: a study of Swedish ports' perceived barriers to compliance	Questionnaire Survey	Swedish (47% ports)	Considering the risks of piracy and terrorist attacks, they create a conceptual framework to explore perceived barriers that prevent compliance with maritime security guards and present a general conceptual framework.	5
6	Burns	2018	Participatory Operational & Security Assessment on homeland security risks: an empirical research method for improving security beyond the borders through public/private partnerships	Empirical Studies	The United States (Port of Entry)	Considering political terrorism and geopolitical threats, they demonstrate the development of a "Participatory Operational Assessment" instrument, where homeland security officials and industry stakeholders form a think-tank to resolve security and operational challenges on both sides of the border.	3
7	Ažman Momirski	2021	The Resilience of the Port Cities of Trieste, Rijeka, and Koper	Qualitative Analysis	Northern Adriatic (Trieste,	Considering that countries, cities, and ports are always struggling for political and economic dominance in the Northern Adriatic area, this study identifies factors in cities' resilience and shows how these notions are visible in the more recent past and present of each port city.	3

					Rijeka, Koper)		
8	Rabbani et al.	2015	Designing a resilient oil supply network with an intelligent solution algorithm	Mathematical Modeling	Saudi Arabia Persian Gulf etc.	This study is the first to provide a flexible multi-objective mathematical model that not only mitigates catastrophic risks by filtering and considering plausible oil-supply disruption scenarios but also reduces oil-supply disruption probability by considering and optimizing political, economic, and financial dimensions of oil procurement.	2
9	He et al.	2023	Assessment of global shipping risk caused by maritime piracy	Qualitative Analysis	Global	Analyzes the evolutionary characteristics of risks caused by piracy and highlights three high-risk regions globally.	0
10	Ibrahim	2022	The impact of neurotechnology on maritime port security-hypothetical port	Descriptive Analytical Approach	Global	Considering maritime piracy as a significant threat, this study presents a descriptive analytical approach to demonstrate the advantages of neurotechnology in fostering a deeper recognition of threatening intruders' activities to maritime ports' security.	0
11	Nicolaisen and Hansen	2023	Humor, transparency, and the management of distrust among business rivals: a case study of berthing meetings at the Port of Tema in Ghana	Qualitative Analysis	Africa	Demonstrates that the humorous atmosphere at regularly held physical berthing meetings fosters a sense of community and that the meetings can serve as a pragmatic local stakeholder adaptation to the challenges posed by universally perceived politicized, opaque, and corrupt business practices at the Port of Tema and beyond.	0
12	Muradian et al.	2023	Logistics of Smart Port in Ukraine: Problems and Prospects in the Conditions of Sustainable Development	Game theory	Ukraine	Considering the Russian invasion of Ukraine, they propose an optimization management model for logistics processes, employing a gaming approach concept, to effectively implement the strategy for the development of Ukrainian seaports until 2038.	0
13	Fan et al.	2023	Resilience assessment of strait/canal: A rule-based Bayesian network framework	Game theory Bayesian network	Maritime Silk Road, Strait of Malacca	Considering account piracy and military conflicts in the Strait of Malacca, they propose a framework to assess resilience performance and identify crucial influencing factors, demonstrating that the Strait of Malacca achieves higher resiliency scores and the inconsistency in the weakness of each strait.	0

Table 7. All articles examining the influence of maritime transport resilience on international trade

No.	Authors	Year	Title	Method	Risks	Area	Results	Citation
1	Becker et al.	2013	A note on climate change adaptation for seaports: A challenge for global ports, a challenge for global society	Qualitative Analysis	Climate Change	Global	Emphasizes the significance of ports and maritime shipping for international trade while highlighting the challenges posed by climate change and the necessity to transition toward comprehensive planning, investments, and operations.	107
2	Chen et al.	2017	Developing a model for measuring the resilience of a port-hinterland container transport network	Simulation Mathematical Modeling	ALL	Sweden (Port of Gothenburg)	Constructs an integer programming model to obtain a quantitative measure of resilience from the perspective of shippers, using the Port of Gothenburg as a case study.	61
3	Narasimha et al.	2021	Impact of COVID-19 on the Indian seaport transportation and maritime supply chain	Quantitative Analysis	COVID-19	India	Highlights the ongoing crisis and encourages interdisciplinary research on the global maritime supply chain's response to COVID-19.	54
4	Loh et al.	2017	Fuzzy comprehensive evaluation of port-centric supply chain disruption threats	Questionnaire Survey Fuzzy Evaluation	ALL	Global	Assesses port-centric supply chain disruption threats, finding that port operators rate the overall risk level as low to medium.	49
5	Rose et al.	2018	Economic consequences of and resilience to a disruption of petroleum trade: The role of seaports in U.S. energy security	Case Study	ALL	The United States (Beaumont, Port Arthur)	Proposes a methodology to estimate the economic consequences of resilience to disruptions, highlighting the enhanced effectiveness of resilience tactics.	36
6	Jiang et al.	2021	Port vulnerability assessment from a supply Chain perspective	Fuzzy Theory Uncertainty Analysis	ALL	China (5 ports)	Proposes a novel port vulnerability assessment framework that can guide and demonstrate a standardized vulnerability analysis process for ports from different geographical areas. The findings can be used for rationally allocating safety resources from a supply chain perspective.	28
7	Hanson and Nicholls	2020	Demand for Ports to 2050: Climate Policy, Growing Trade and the Impacts of Sea-Level Rise	Case Study	Climate Change	Global	Considering potential changes until 2050 under four climate-based scenarios, they explore changes in international maritime trade consistent with global temperature increases and the implications of associated sea-level rise.	28

8	Shepard and Pratson	2020	Maritime piracy in the Strait of Hormuz and implications of energy export security	Empirical Studies	Geopolitical Risks (piracy)	Strait of Hormuz	Considering petroleum trade, they demonstrate that tanker transit declines 2 years after piracy attacks and identify the drivers of this heterogeneity and policy implications	15
9	Heijman et al.	2017	The impact of world trade on the Port of Rotterdam and the wider region of Rotterdam-Rijnmond	Case Study	Economics Risk	Netherlands (Port of Rotterdam)	Analyzes the economic impact of world trade on the throughput of the Port of Rotterdam and the regional economy of Rotterdam-Rijnmond and demonstrates the crucial relationship between port activities and regional economic development.	7
10	Fahim et al.	2021	The Physical Internet and Maritime Ports: Ready for the Future?	Qualitative Analysis	ALL	Global	Emphasizes the role of maritime ports within the global freight transportation logistics system to mitigate shock effects on international trade and manufacturing caused by the lack of resilience in the system, addressing the challenges and outlining the necessary requirements for ports.	7
11	Shi et al.	2023	Construction of resilience mechanisms in response to container shipping market volatility during the pandemic period: From the perspective of market supervision	Mathematical Modeling Simulation Game Theory	COVID-19	China	Emphasizes the necessity of government interventions to counter deliberate congestion strategies by liner companies, leading to increased container capacity, stable freight rates, and reduced supply chain disruptions, ultimately enhancing the resilience of the container transport system.	7
12	Friedt	2021	Natural disasters, aggregate trade resilience, and local disruptions: Evidence from Hurricane Katrina	Case Study	Climate Change	The United States	Demonstrates that the calamity causes lasting trade reductions in affected ports, with nearby ports experiencing significant shipment increases; this effect persists for 8 years.	7
13	Przekota	2022	Do High Fuel Prices Pose an Obstacle to Economic Growth? A Study for Poland	Mathematical Modeling; Case Study	Economics Risk	Poland	Demonstrates the resilience of the Polish economy to fuel market turbulence, suggesting that higher fuel prices should not trigger panic.	6
14	Qiao et al.	2021	Cognitive gap and correlation of safety-i and safety-ii: A case of maritime shipping safety management	Empirical Studies Fuzzy Mathematics	ALL	China	Demonstrates that safety issues are combined with maritime trade and identifies dominant factors influencing safety-I and safety-II perspectives, emphasizing the need for organizational resilience.	5
15	Gu and Liu	2023	Port resilience analysis based on the HHM-FCM approach under COVID-19	Simulation Graph theory	COVID-19	Global	Considering that port disruptions significantly impact the economy, trade, and global supply chains, they reveal that supply and demand balance, along with schedule reliability, are the most influential factors contributing to port resilience during the COVID-19 pandemic.	5

16	Verschuur et al.	2023	Multi-hazard risk to global port infrastructure and resulting trade and logistics losses	Mathematical Modeling Simulation	Climate Change	Global	Considering the maritime trade risk triggered by natural disasters, they conclude that port resilience relies on distinct factors, such as engineering standards, which differ among ports, emphasizing the need for tailored solutions.	2
17	Popovich et al.	2021	An assessment of subduction zone-generated tsunami hazards in New Zealand Ports	Simulation	Climate Change	New Zealand (13 ports)	Considering the impact of earthquakes on international trade capacity, regional recovery, and domestic inter-island transport, they highlight the importance of a broader national and international transport system perspective to inform potential resilience investments.	1
18	Tai and Yang	2016	A Policy-Making Framework for Enhancing the Kaohsiung Port'S Economic Resilience	Mathematical Modeling	ALL	China Taiwan (Kaohsiung)	Proposes a policy-making framework for enhancing Kaohsiung port's economic resilience and indicates that adjusting the shipping policy is perceived as the most critical strategic dimension to enhance container port resilience.	1
19	Olapoju	2022	Cross examinations of maritime trade disruptions in Africa during COVID-19 pandemic	Data Analysis	COVID-19	Africa	Demonstrates that Africa has the potential to boost resilience and competitiveness by integrating into the global supply chain.	0
20	Kuhla et al.	2023	Resilience of international trade to typhoon-related supply disruptions	Numerical Analysis	Climate Change	West Pacific	Demonstrates that annual median export volumes are projected to rise in all trade blocs due to lower export prices, revealing significant regional disparities and the resilience of export to increased typhoon-induced perturbations in China, ASEAN, East Asia, and Europe.	0
21	Sheikh et al.	2023	A comprehensive performance measurement model for maritime Logistics: Sustainability and policy approach	Questionnaire Survey Data analysis	ALL	Global	Proposes a comprehensive performance measurement model for maritime logistics, providing policymakers with insights to enhance maritime logistics performance and facilitate international trade.	0

3.2 Semantic analysis results

3.2.1 Semantic analysis of risks

When constructing a co-occurrence network for keyword co-occurrence analysis, we set a weight threshold (i.e., the minimum number of occurrences of a keyword individually) to ensure that only keywords with a weight greater than or equal to this threshold value are included in the co-occurrence network. This approach reduces the number of keywords in the network, allowing us to focus on the most important keywords and their connections with other keywords. As shown in Figures 4–7, the color of the nodes represents the average duration (history) of appearance of each keyword. Keywords that have appeared more recently are depicted by lighter shades of yellow, whereas keywords that appeared earlier are depicted by darker shades of purple. This color scheme provides a visual representation of the chronological distribution of keywords in the analyzed literature.

We create a bar chart illustrating the publication timeline of research related to three types of risks, namely climate change, public health events, and geopolitical risks, and the impact of maritime transport resilience on international trade, as shown in Figures 2 and 3, respectively. Research on climate change-related risks continues to attract the attention of scholars, with the number of related studies steadily increasing over the past two decades. Research on pandemic-related risks emerged in 2021 and increased in terms of the number of publications in the past 2 years. Although the COVID-19 pandemic ended in 2023, the number of publications in 2023 is higher than those in 2021 and 2022, because of the time lag between research completion and publication. Research on geopolitical risks is limited. From 2010 to 2022, fewer than two papers are published each year in this stream, with some years lacking any relevant studies published. For 2023, only four papers are published on this topic. In addition, studies analyzing the impact of maritime transport resilience on international trade are considerably limited. From 2013 to 2020, only three or fewer articles are published each year. Despite a slight increase in the number of studies in the past 3 years, the quantity of research remains low, with only single-digit numbers of relevant studies.

In Figure 4, the keyword co-occurrence network includes all keywords related to climate change risks concerning maritime transport resilience, encompassing author keywords and index keywords. A total of 1,800 keywords appear in these papers. The network is constructed using the full-counting method, and a keyword should have a minimum of 6 occurrences to meet the threshold for inclusion. Thus, 45 keywords meet this threshold and are included in the network.

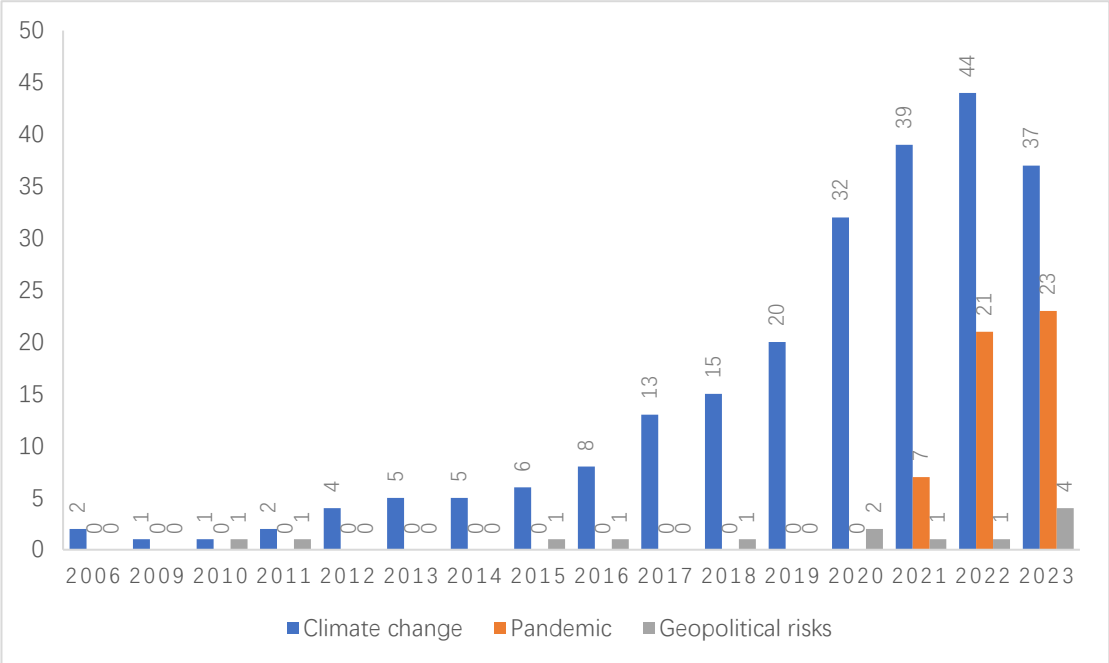

Figure 2. An overview of the timeline of research on three types of risks affecting maritime transport resilience

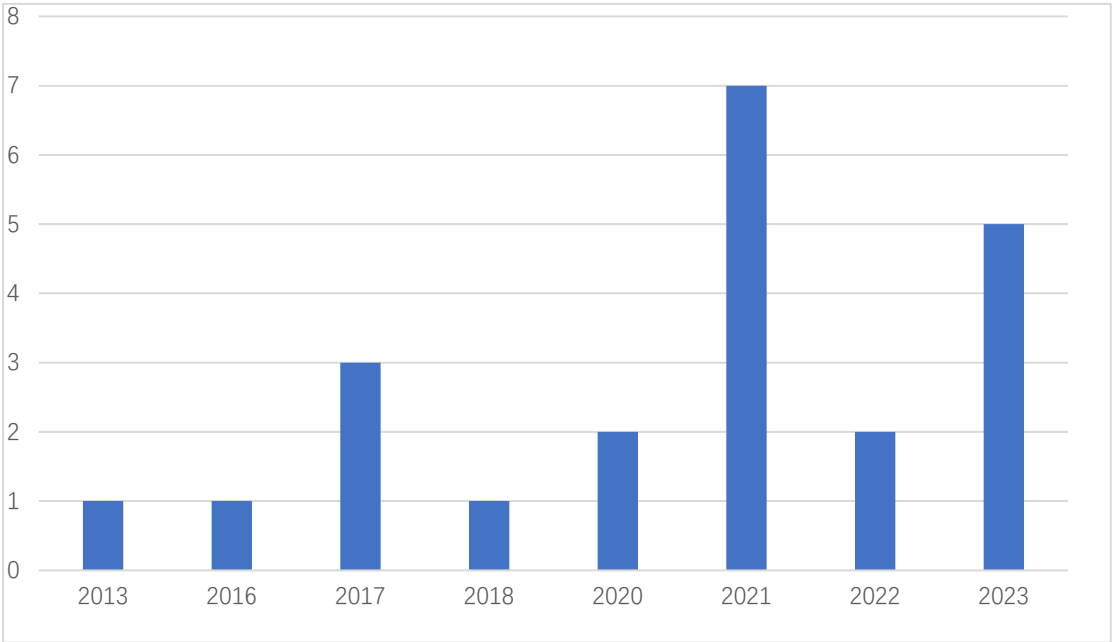

Figure 3. An overview of the timeline of research on the impact of maritime transport resilience on international trade

In Figure 4, the keywords "climate change," "port," "adaptation," and "maritime transportation" are at the center of the image, indicating their central importance in this stream of research. These keywords are closely connected to each other compared with other keywords in the figure. As we move outward in the network, we can observe that research related to sea-level rise and flooding appears relatively more frequently, whereas other types of climate change-related disasters have fewer occurrences and are not represented in the figure. For instance, Becker et al. (2012)

highlight the importance of proactive planning and adaptation by port administrators to mitigate the adverse effects of sea-level rise and flooding on port operations and infrastructure. Becker et al. (2017) demonstrate the efficacy of "boundary objects" in facilitating dialogue among stakeholders on long-term storm resilience challenges in the Port of Providence during sea-level rise (Becker 2017). Furthermore, DiSegni et al. (2017) indicate the importance of cost-adjustment analysis and adaptation policies to mitigate risks associated with sea-level rise. Implementing these strategies offers economic benefits and ensures the sustainability of marine sectors and public well-being.

In recent years, there has been a growing presence of various keywords, such as "competition," "modeling," and "decision making" in the literature, indicating an increasing focus on economic research examining the impact of climate change-related risks on maritime transport resilience. For example, Yang et al. (2018) introduce a methodology to evaluate port climate change adaptation measures in scenarios with high data uncertainty, providing insights into the development of efficient adaptation measures in a supply chain context to enhance sustainability and adaptation for ports, intermodal transport, and urban planning. Balakrishnan et al. (2022) propose a framework and methodology to analyze the economic risks of hurricane-related shutdowns in ports, emphasizing the significant threat hurricanes pose to port infrastructure and the importance of ensuring operational continuity for domestic and international transportation. Wang and Zhang (2018) demonstrate that climate change and natural disasters considerably influence adaptation investments in ports. Inter-port competition stimulates increased investments, whereas a "free-riding effect" occurs within ports, highlighting their implications for maritime transportation. Zheng et al. (2021a) report that inter-port competition and adaptation trading play significant roles in shaping adaptation investments in seaports encountering asymmetric disaster losses, highlighting the need for a comprehensive evaluation of adaptation policies beyond competition effects. Zheng et al. (2021c) demonstrate that the choice between minimum requirement regulations and subsidies in port adaptation depends on ambiguity, risk attitudes, and market failures. Zheng et al. (2021b) explore how competing shipping lines make timing-based decisions in terminal investments under demand ambiguity, emphasizing the importance of subsidies and government regulations and the impact of incomplete information on resilience outcomes.

Among studies examining the impact of climate change-related risks on maritime transport resilience, there is a discernible gap in research specifically focusing on the perspectives of the supply chain, with only 19 papers related to this area. A notable study in this field is that conducted by Yang et al. (2018) who introduce a methodology to evaluate port climate change adaptation measures in scenarios with high data uncertainty. Their work provides valuable insights into developing effective adaptation strategies within the context of supply chains. In addition, Lawrence et al. (2020) investigate key events leading to risk propagation and disruption in the US pharmaceutical supply chain following Hurricane Maria, highlighting the importance of port resilience in maintaining the performance of the pharmaceutical supply chain.

In our keyword co-occurrence network (Figure 5), all keywords related to

pandemic risks in the context of maritime transport resilience are counted, including author keywords and index keywords. A total of 382 keywords appear in these papers. The network is constructed using the full-counting method, with a minimum threshold of 2 occurrences required for a keyword to be included in the network. A total of 42 keywords meet this threshold and are included in the network. As shown in Figure 5, except for the keyword "COVID-19," the other central themes of research are similar to those in Figure 4, including maritime transportation, resilience, and ports. However, the node of the keyword "supply chain" has a larger diameter and is more closely connected to other keywords. Among the 51 pandemic-related articles, 11 are related to the supply chain. The most cited study is by Notteboom et al. (2021) who compare the impacts of COVID-19 with those of the 2008–2009 financial crisis; explore the short-term effects, differences, and reasons for changes in the supply chain; and examine the evolution of adaptive capacity and resilience among ports, terminal operators, and carriers. In addition, Shi et al. (2023a) investigate the adverse impact of the COVID-19 outbreak on port operational efficiency and the time lost due to the independent and challenging collaboration between ports and inland logistics providers.

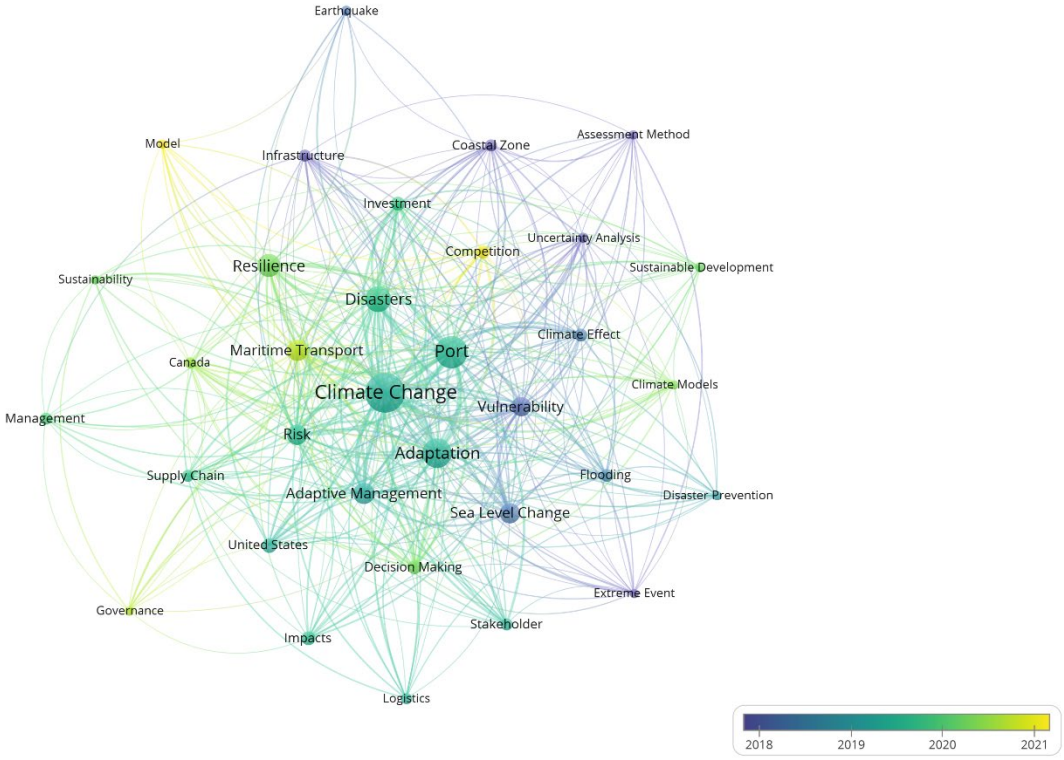

Figure 4. Co-occurrence network of research on climate change-related risks

As shown in Figure 5, the terms "port congestion," "government approach," and "global trade" have emerged more recently, whereas the terms "principles" and "complexity" have appeared relatively later. However, considering that the pandemic began toward the end of 2019, we do not need to consider specific time ranges for this topic. The time span for the appearance of these keywords does not exceed 2 years. Therefore, we consider them collectively. Notteboom et al. (2021) find that further

adaptation mechanisms, such as slow steaming, economies of scale, and capacity management, are differently applied between the financial crisis and COVID-19. Guerrero et al. (2022) suggest that pandemic mitigation measures implemented by governments have varying effects on regional port hierarchies. Very large ports and small but densely inter-connected ports exhibit better resistance to the crisis than other types of ports, whereas small transshipment hubs and bridges are more negatively impacted. Praharsi et al. (2021a) develop a continuous improvement method for the maritime industry by combining Lean Six Sigma and supply chain resilience concepts. This approach ensures the maintenance of a resilient supply chain during the pandemic. Dirzka and Acciaro (2022) use a three-stage approach and provide insights into operator behaviors during periods of distress. The pandemic disrupted service network integrity, with initial disruptions clustering in Asia before spreading along main trade routes. Jin et al. (2022) demonstrate an increase in the scale of China's international liner shipping network, with more routes converging at fewer hub ports. However, decreases in overall connectivity and connection strength are noted. Panahi et al. (2022) propose a resilience assessment model for critical port infrastructure systems to maintain strategic relationships among key stakeholders, including terminal operators, shipping firms, logistics service providers, port decision-makers, and port authorities. Gibson et al. (2021) report five themes warranting geographical analysis and global comparison in light of the pandemic. Zhang and Sun (2021) discover an MM progression mechanism developed between stakeholders during the post-crisis period. They present the "MM-as-process" vision to emphasize the time-varying dynamic nature of MM development during disruptions. Bai et al. (2023) demonstrate that both overlapping community structure and traffic flow significantly impact the resilience evaluation of the global liner shipping network and propose a simulation model with tailored, locally weighted flow redistribution rules. Marobhe (2022) demonstrates an overall negative overreaction to WHO's declaration of COVID-19 a pandemic. The Greek, Singaporean, and Taiwanese shipping stocks were the least affected because their respective shipping industries remained resilient in 2020.

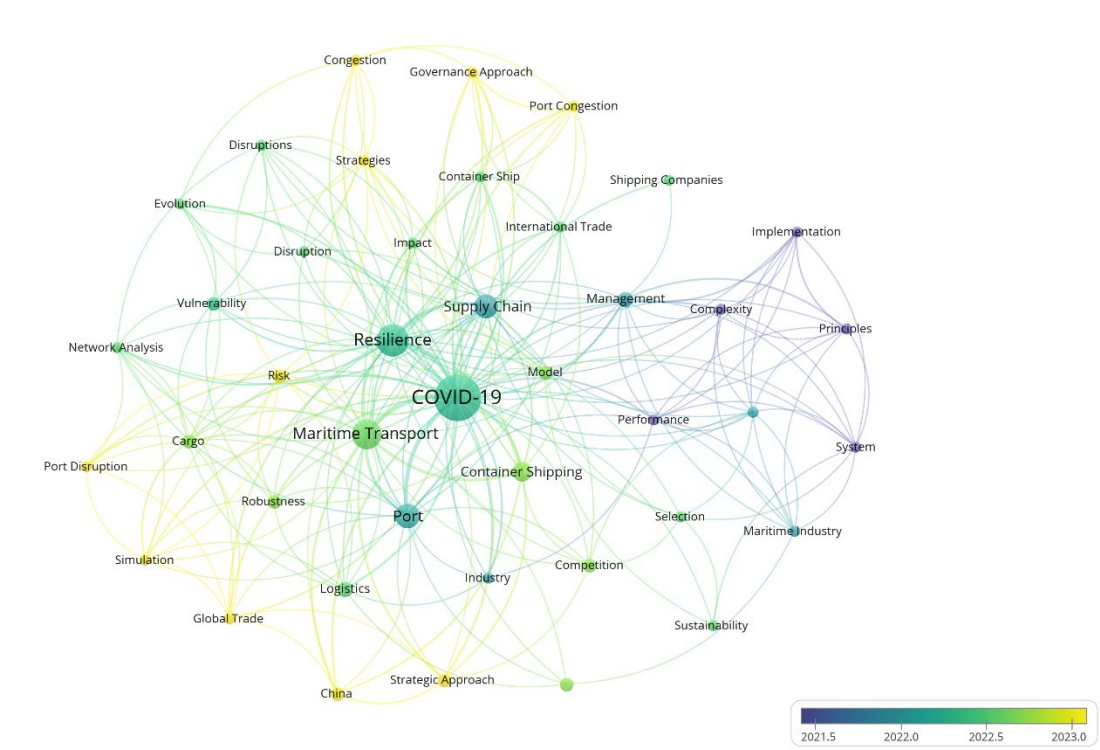

Figure 5. Co-occurrence network of research on pandemic-related risks

In the keyword co-occurrence network shown in Figure 6, all keywords related to geopolitical risks, including author and index keywords, are counted. A total of 160 keywords appear in these papers. The network is constructed using the full-counting method, with a minimum threshold of 2 occurrences required for a keyword to be included in the network. A total of 13 keywords meet this threshold and are included in the network.

As shown in Figure 6, maritime transport and ports still hold central positions. Because of the limited number of relevant research articles on this topic (only 13 articles meet our criteria), we do not conduct an analysis based on the temporal stages of the studies. Figure 6 shows fewer nodes and edges because of the limited number of studies on geopolitical risks, indicating that the academic focus in this area is currently insufficient. The figure reveals that among the few existing studies, there is a notable emphasis on the impact of piracy on maritime transport resilience. Specifically, Fu et al. (2010) highlight the importance of addressing maritime piracy from the perspective of economic interests, emphasizing the need for increased international efforts to tackle this problem. Min (2011) identifies the major sources of maritime piracy, investigates its impact on global supply chain operations, and proposes potential remedies that can mitigate supply chain risks associated with maritime piracy. Considering the risks of piracy and terrorist attacks, Ringsberg and Cole (2020) develop a conceptual framework to explore perceived barriers that prevent compliance with maritime security guidelines. He et al. (2023) analyze the types and evolutionary characteristics of shipping risks caused by piracy and piracy behavior patterns in different seas, emphasizing that maritime piracy poses varying levels of risks in different seas, with

three high-risk regions globally, and their centers of activity change over time. Considering maritime piracy as a significant threat, Ibrahim (2022) presents a descriptive analytical approach to demonstrate the advantages of using neurotechnology to enhance the recognition of threatening intruders' activities at maritime ports.

Some studies discuss security issues resulting from terrorist attacks or wars and evaluate their effects on maritime transport resilience. For example, considering political terrorism and geopolitical threats, Notteboom (2016) indicates that the development path of upstream seaports is linked to various economic, technological, social, and political factors. In addition, the author demonstrates that the discussion on the future of upstream seaports cannot be detached from broader public policy considerations; stakeholder management concerns; and the influence of retention mechanisms, power, politics, and collective action by the port community. Burns (2018) introduces a "Participatory Operational Assessment" instrument designed to address security and operational challenges. This instrument involves collaboration between homeland security officials and industry stakeholders, creating a think-tank to resolve such challenges. Rabbani et al. (2015) are the first to provide a flexible multi-objective mathematical model that not only mitigates catastrophic risks by filtering and considering plausible oil-supply disruption scenarios but also reduces oil-supply disruption probability by considering and optimizing political, economic, and financial dimensions of oil procurement. Mou et al. (2020) construct a crude oil transport network and design a resilience assessment framework to examine the resilience of the network. They show that the resilience of crude oil transportation networks declines at a steady rate under random disruptions but decline sharply during some intentional attacks. This highlights the vulnerability of the crude oil transport network to potential terrorism and war attacks. Given that countries, cities, and ports are always struggling for political and economic dominance in Northern Adriatic area, Momirski (2021) identifies resilience factors in cities, shedding light on how these factors are visible in the more recent past and present of each port city. Nicolaisen and Hansen (2023) demonstrate that the humorous atmosphere at regularly held physical berthing meetings fosters a sense of community. They indicate that these meetings serve as a pragmatic adaptation strategy for local stakeholders to address challenges posed by universally perceived politicized, opaque, and corrupt business practices at the Port of Tema and beyond. Considering piracy and military conflicts in the Strait of Malacca, Fan et al. (2023) propose a framework to examine resilience performance and identify crucial influencing factors. They find that the Strait of Malacca achieve higher resiliency scores and observe inconsistency in the weakness of each strait.

China proposed the Belt-and-Road Initiative (BRI) to strengthen economic and political cooperation with Asia-Euro countries, including the Eastern coastal African countries. China has helped construct or finance infrastructure constructions in the developing countries involved in the BRI. This strategy is viewed as a threat that can diminish the economic and political influence of Western countries in these regions, leading to resistance from the United States and some European countries. Some reviewed studies (Fan et al. 2023; Mou et al. 2020) mention such risks related to the

BRI for maritime transport resilience, but their analyses are not in-depth. Some significant geopolitical events in recent years, such as the Sino–US trade conflict and Russia–Ukraine war, have exerted considerable adverse impacts on international shipping transport. However, these recent geopolitical disputes have not been explored in terms of their potential impacts on maritime transport resilience. One exception is Muradian et al. (2023) who consider the Russia–Ukraine war, proposing an optimization management model for reconfiguring logistics processes. They use a gaming approach concept to effectively implement the strategy for the development of Ukrainian seaports until 2038. However, the paper is very recent and has not been cited by other studies.

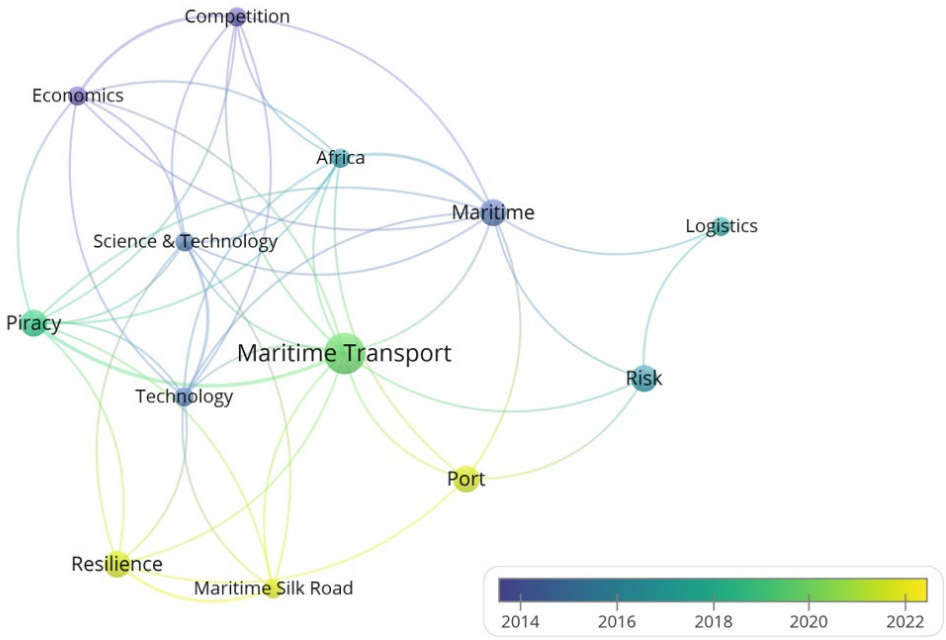

Figure 6. Co-occurrence network of research on geopolitical risks

3.2.2 Semantic analysis of the impact of maritime transport resilience on international trade

In the keyword co-occurrence network shown in Figure 7, all keywords related to the impact of maritime transport resilience on international trade, including author keywords and index keywords, are counted. A total of 250 keywords appear in these papers. The network is constructed using the full-counting method, with the minimum number of occurrences required for a keyword to be included in the network being 2. The number of keywords that meet this threshold is 35.

As shown in Figure 7, early research in this stream primarily focuses on investigating the impact of maritime transport resilience resulting from climate change-related risks on international trade. However, in recent years, there has been an increase in research on the impact of the COVID-19 pandemic on international trade through its

direct effect on maritime transport resilience. The figure also shows a relatively higher weight for the "supply chain" node. Among the 21 relevant articles, seven are related to the general context or perspective of the supply chain. For example, Narasimha et al. (2021) highlight the ongoing crisis and call for interdisciplinary research on the response of the global maritime supply chain to the pandemic. Loh et al. (2017) assess port-centric supply chain disruption threats and find that port operators rate the overall risk level as low to medium. Jiang et al. (2021c) propose a novel port vulnerability assessment framework that can guide and facilitate a standardized vulnerability analysis process for ports from different geographical areas. Their findings can be applied to rationally allocate safety resources from a supply chain perspective. Shi et al. (2023b) emphasize the necessity of government intervention to counter deliberate congestion strategies by liner companies, leading to increased container capacity, stable freight rates, and decreased supply chain disruptions, ultimately enhancing the resilience of the container transport system. Given that port disruptions significantly impact the economy, trade, and global supply chains, Gu et al. (2023) reveal that supply and demand balance, along with schedule reliability, are the most influential factors contributing to port resilience during the COVID-19 pandemic. They also discuss how disruptions in maritime shipping can adversely slow the trade flow. Olapoju et al. (2022) demonstrate that Africa has the potential to boost transport resilience and competitiveness by integrating its seaports into the global supply chain. With a more resilient maritime shipping transport system, Africa can play a more important role in international trade.

In addition to the aforementioned studies that discuss the impact of maritime transport resilience on international trade from a supply chain perspective, the remaining reviewed studies (Figure 7) examine the topic more directly by focusing on ports or the shipping network. Becker et al. (2013) highlight climate change-related risks for ports and suggest a way forward through the adoption of some initial measures to improve resilience for well-functioning international trade flow. Addressing the need to shift toward more holistic planning, investments, and operations, Chen et al. (2017) develop an integer programming model to quantitatively measure port resilience from the perspective of shippers, using the Port of Gothenburg as a case study to demonstrate the benefits for trade. Rose et al. (2018) propose a methodology to estimate the total economic consequences of resilience to disruptions in crude oil and refined petroleum product trade and examine the effects of mitigating these impacts through various resilience tactics. They conclude that factors associated with the recent surge in the extraction of shale and tight oil resources have significantly enhanced the potential effectiveness of some resilience tactics. Hanson and Nicholls (2020) consider potential changes in 2050 under four climate-based scenarios to explore changes in international maritime trade consistent with global temperature increases and associated sea-level rise implications. In terms of petroleum trade, Shepard and Pratson (2020) show that tanker transit declines 2 years after piracy attacks and only refined petroleum exports from Bahrain and Kuwait are significantly impacted. They discuss the drivers of this heterogeneity and the policy implications of this risk for global energy security. Heijman et al. (2017) analyze the economic impact of world trade on the throughput of

the Port of Rotterdam and the regional economy of Rotterdam-Rijnmond, demonstrating the crucial relationship between port activities and regional economic development. Fahim et al. (2021) emphasize the role of maritime ports in the global freight transportation logistics system to mitigate shock effects on international trade and manufacturing resulting from the lack of resilience in the system. They also address the challenges and outline the necessary requirements for ports in this context. Friedt (2021) demonstrates that calamities lead to lasting trade reductions in affected ports, with nearby ports experiencing significant shipment increases, and this effect persists for 8 years. Przekota (2022) corroborates this finding, showing that calamities cause lasting trade reductions in affected ports, with nearby ports experiencing significant shipment increases, and this effect persists for 8 years. Qiao et al. (2021) demonstrate that safety issues are combined with maritime trade and identify dominant factors influencing safety-I and safety-II perspectives, emphasizing the need for organizational resilience in ports. In view of the maritime trade risk triggered by natural disasters, Verschuur et al. (2023) conclude that port resilience relies on diverse factors, such as engineering standards, which differ among ports, emphasizing the need for tailored solutions. Considering the impact of earthquakes on international trade capacity, regional recovery, and domestic inter-island transport, Popovich et al. (2021) highlight the importance of a broader national and international transport system perspective to inform potential resilience investments. Tai and Yang (2016) propose a policy-making framework to enhance Kaohsiung port's economic resilience and indicate that adjusting the shipping policy is perceived as the most critical strategic dimension to enhance container port resilience. Kuhla et al. (2023) demonstrate that annual median export volumes are projected to increase in all trade blocs due to lower export prices, revealing significant regional disparities. They show that the resilience of exports to typhoon-induced perturbations increases in China, ASEAN, East Asia, and Europe. Sheikh et al. (2023) propose a comprehensive performance measurement model for maritime logistics, providing policymakers with insights to enhance maritime logistics performance and facilitate international trade.

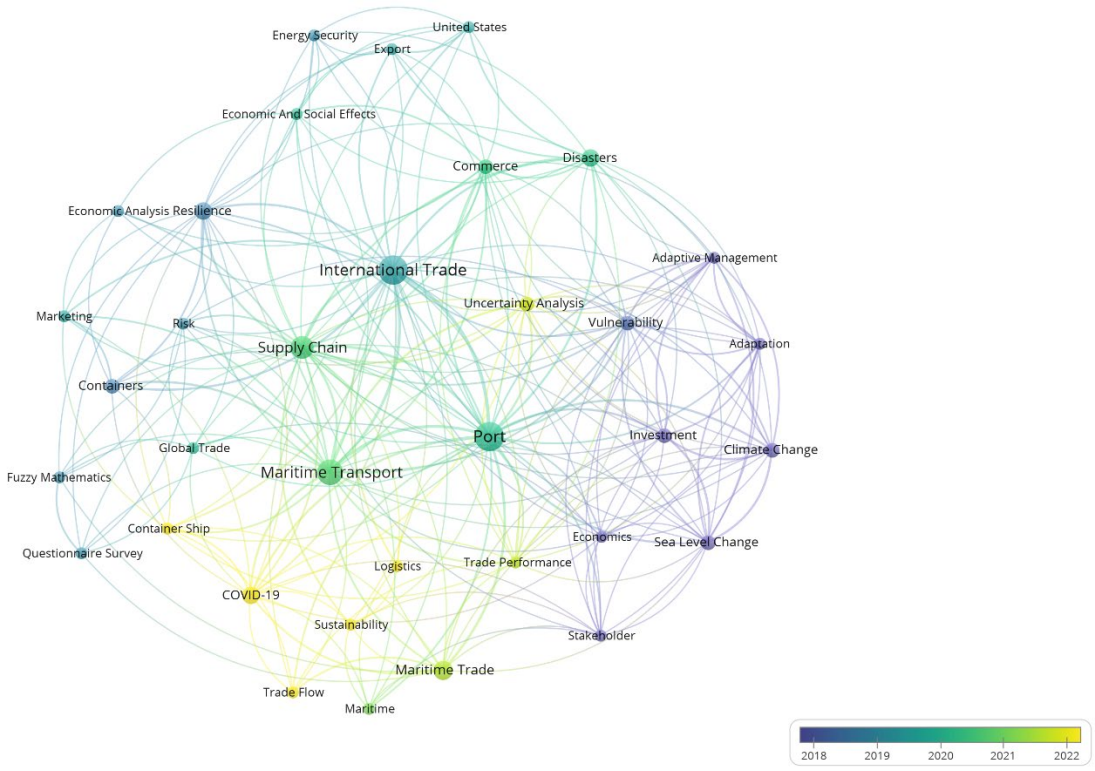

Figure 7. Co-occurrence network of articles examining the impact of maritime transport resilience on international trade

3.3 Science collaborations

3.3.1 Science collaboration analysis for three types of risks

Figures 8–11 depict the bibliographic coupling network of authors in our database, offering insights into the co-authorship relationships among researchers in the field of maritime transport resilience. In the graph, each solid circle represents an author, with the size of the circle corresponding to the number of papers published by that author. Lines connecting authors represent their co-authorship, and the line thickness reflects the corresponding co-authorship intensity. To construct this co-authorship network, we introduce a weight threshold for individual nodes, requiring authors to have a minimum number of published articles. Only authors whose weight exceeds or is equal to this threshold are included in the co-authorship network. Similar to the co-occurrence network for keywords, this approach aims to reduce the number of authors in the network, allowing us to focus on key research communities and scholars of significance.

The co-authorship network analyses for research on climate change-related risks, pandemic risks (public health events), and geopolitical risks are conducted using the full-counting method, which allows the inclusion of a maximum of 25 authors per article. However, the minimum article requirements per author differ for each type of risk. For climate change-related risks, a minimum of 3 articles per author is required, resulting in 36 authors meeting the threshold. For pandemic risks, only 1 article per author is required, leading to 165 authors meeting the threshold. Similarly, for

geopolitical risks, a minimum of 1 article per author is required, resulting in 32 authors meeting the threshold. Except for the co-authorship analysis related to climate change-related risks where a minimum of 3 articles per author is required, for the other risk types, either all authors have only published one relevant article or setting a weight threshold of greater than or equal to 2 would result in a considerably limited number of authors. This would impede our analysis and discussion.

Research collaborations related to geopolitical risks are relatively scattered, lacking a substantial research community. Conversely, significant collaborations exist for research on the other types of risks. In particular, research on climate change-related risks exhibits notable collaboration closeness. In each co-authorship network, scattered research teams/groups are observed in every field, with team sizes of 3 or fewer individuals, without establishing connections with other research teams.

As shown in Figure 8, in the co-authorship network of research on climate change-related risks, the early research team is centered around Ng and Becker who play a critical role in the establishment and development of a larger and continuous research community. Ng and Becker have closely aligned research interests centered around the effects of climate change on ports. They investigate the vulnerabilities of ports to climate-related factors, such as rising sea levels and intensified storms, and focus on developing adaptation strategies for port infrastructure. Their research underscores the importance of proactive planning and decision-making by port administrators to effectively address challenges posed by climate change and ensure the resilience and sustainability of seaport operations (Becker et al. 2013; Ng et al. 2013; Ng et al. 2019; Ng et al. 2018a; Ng et al. 2018b). The research group led by Zhang, Fu, Wang, Zheng, and Jiang has emerged recently and focuses on various areas within the economics analysis of port adaptation investments to climate change-related disasters. Their studies cover a broad spectrum of economic topics, including the impacts of market competition, disaster and demand uncertainty (complete and incomplete information), inter- and intra-port structure, capacity investment in adaptation strategies for ports, and joint investment in the resilience of cross-country maritime infrastructure (Jiang et al. 2021a; Wang and Zhang 2018; Zheng et al. 2022a; Zheng et al. 2023; Zheng et al. 2021b; Zheng et al. 2022b; Zheng et al. 2022c). Figure 8 presents the results after weighting and filtering. In addition to the depicted research group, there are several smaller research teams consisting of two or three researchers who work independently without collaborations with other research groups.

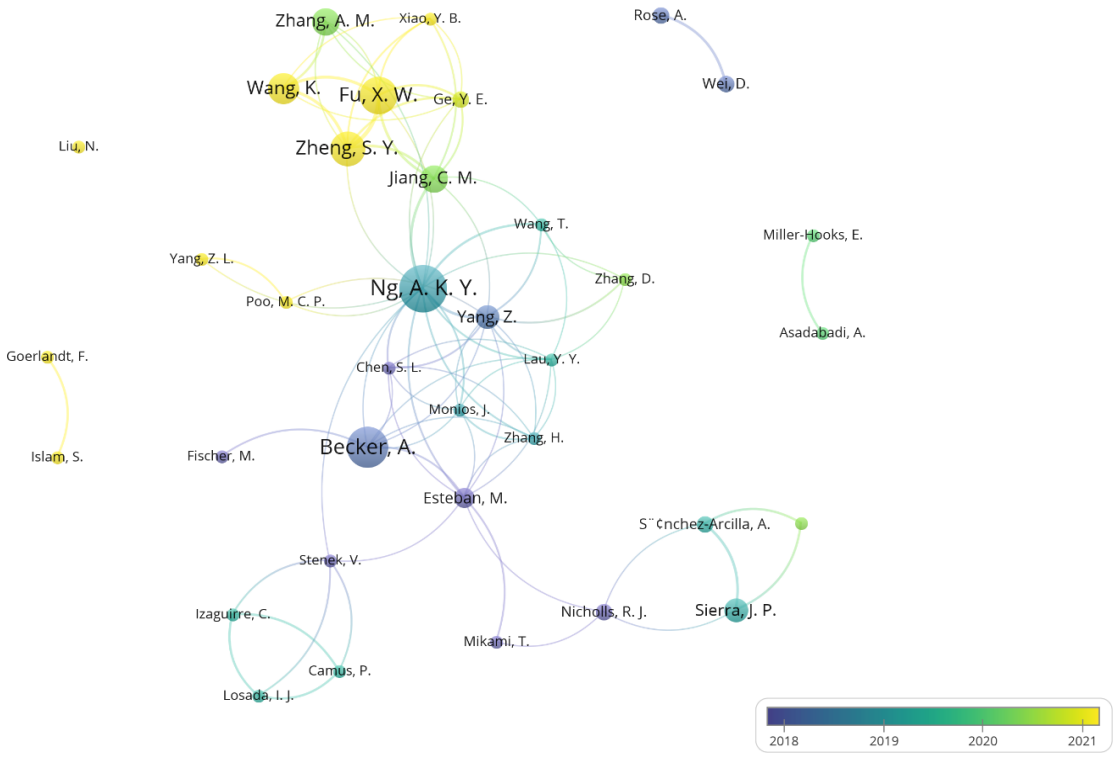

Figure 8. Co-authorship network of research on climate change-related risks

As shown in Figure 9, in the co-authorship network of research on pandemic-related (public health) risks, there is a closely connected research group centered around Chen. In the database of 51 articles on this stream, Chen publishes five articles. The team's research primarily focuses on enhancing the resilience of "maritime supply chains" during the pandemic. Their studies identify factors determining maritime transport resilience by using an integrated multi-criteria decision-making approach, examine the spatial-temporal heterogeneity of the resilience of global ports during the pandemic, construct mechanisms to address container shipping market volatility, integrate ports and inland transporters to improve supply chain resilience, and enhance the resilience of inland river transportation through flexible freight consolidation strategies (Liu et al. 2023; Shi et al. 2023a; Shi et al. 2023b; Wang et al. 2023; Xu et al. 2023). In addition, as shown in the lower left corner of Figure 9, a larger research team consisting of members such as Klein, Belz, and Baklr collaborate on a study examining the Port of Hamburg's capability to respond to mass casualty incidents resulting from the outbreaks of infectious diseases, such as COVID-19 (Klein et al. 2021). Conversely, other research teams appear to be more fragmented and have limited or no collaborations across different research groups.

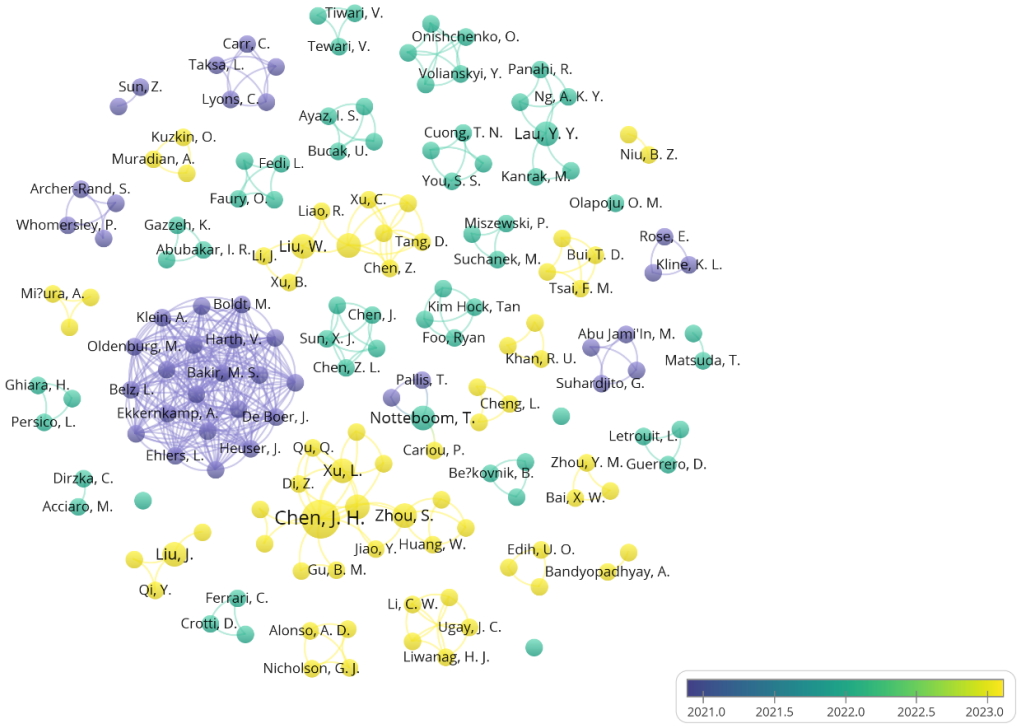

Figure 9. Co-authorship network of research on pandemic-related risks

As presented in Figure 10, in the co-authorship network of research on geopolitical risks, the number of studies is considerably limited as depicted earlier in the semantic analysis. This limited research output results in fragmented and scattered research teams focusing on this topic. All research teams have only one article included in the database. Most teams consist of fewer than four researchers, whereas five independent researchers have published their own papers. As shown in the lower left corner of Figure 10, a larger research team composed of members such as Mou and Sun collaborates on a publication. They construct a crude oil transportation network, design a resilience assessment framework, and assess the resilience of the network, indicating that the resilience of crude oil transportation networks declines at a steady rate under random attacks but declines sharply under intentional attacks (Mou et al. 2020). In addition, six research teams conduct maritime resilience studies specifically related to piracy. For instance, Fu et al. (2010) demonstrate that addressing maritime piracy requires dedicated efforts from the international community, even when solely considering economic interests.

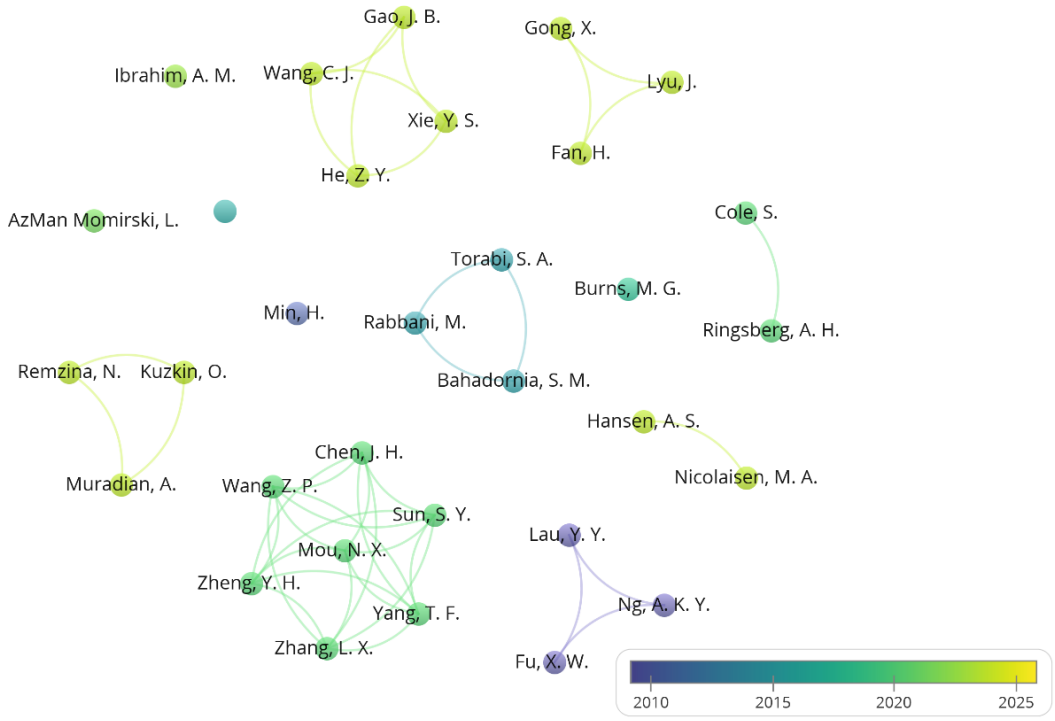

Figure 10. Co-authorship network of research on geopolitical risks

3.3.2 Science collaboration for examining the impact of maritime transport resilience on international trade

The network representing international trade is constructed using the full-counting method, allowing for a maximum of 25 authors per article. The minimum threshold for an author's inclusion in the network is their contribution to at least one article. A total of 78 authors who meet this threshold are included in the network analysis. In the co-authorship network shown in Figure 11, a prominent research team on this topic is visible on the right side. This team comprises individuals such as Becker and Ng who collaborate on a publication highlighting the climate change challenges faced by ports. Their work emphasizes the necessity of adopting a more holistic approach encompassing planning, investments, and operations to mitigate risks and minimize their impact on international trade (Becker et al. 2013). On the opposite end, the left side depicts a research team consisting of six researchers, including Fahim. Their study underscores the vital role played by maritime ports in facilitating a significant portion of global international trade within the Port Index. They address the challenges faced by ports and provide a comprehensive outline of factors necessary to overcome these obstacles (Fahim et al. 2021).

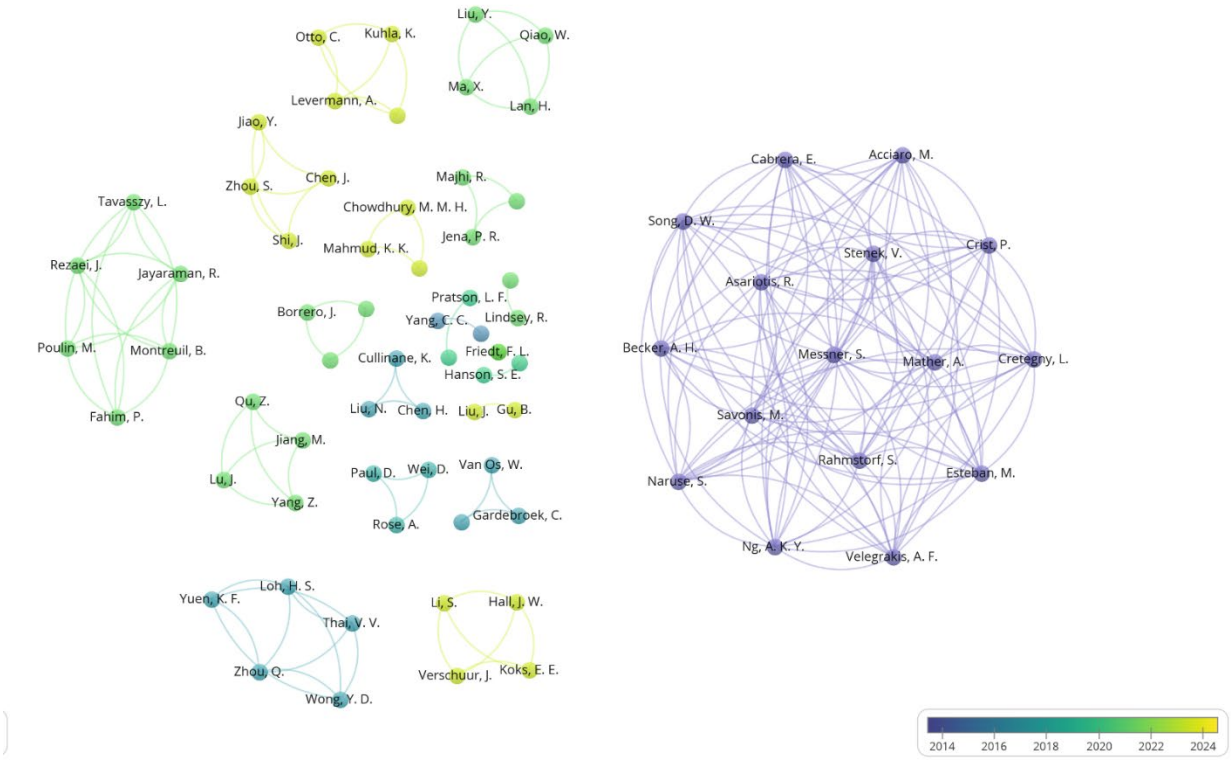

Figure 11. Co-authorship network of research on the influence of maritime transport resilience on international trade

3.4 Future research directions

Our analysis (Figure 2) provides valuable insights into the evolving trends of risks that threaten maritime transport resilience. Research on climate change-related risks has steadily increased since 2006, whereas studies related to pandemic risks emerged in 2021 and gained significant attention from scholars. However, research on geopolitical risks remains relatively limited compared with that on other areas. For 2023, only four papers are found to be related to geopolitical risks, exploring topics such as the Maritime Silk Road, piracy, the Russia–Ukraine conflict, and the politicization of ports. Despite limited research in this area, these geopolitical events adversely impact international shipping transport and thus the global economy. For instance, the number of weekly port calls in Ukraine, the Russian Federation, and Turkey has drastically declined due to the war in Ukraine. In addition, the Israeli–Palestinian conflict has led to significant reductions in the imports of various commodities in Israeli ports. Moreover, the potential spillover of the conflict can severely impact critical global shipping routes, such as the Suez Canal, with implications for the shipping market, commodity prices, and the global economy. However, despite these potential consequences, studies have not thoroughly investigated the impacts of these conflicts on maritime transport resilience and international trade.

The Suez Canal and Panama Canal have crucial impacts on the stability and resilience of the global shipping network. Some recent events have had substantial impacts on these two canals. Since November 2023, the Houthi armed forces in Yemen

have frequently attacked merchant ships, leading many shipping companies to suspend their services through the Suez Canal. These events have devastating outcomes for global shipping and international trade, similar to those of the blockage in the Suez Canal in 2021. In addition, the Panama Canal is facing significant challenges because of a lasting drought, resulting in severe congestion for vessels crossing it. Future studies should pay more attention to the impacts of key nodes, especially these two important canals, on the resilience of the global maritime network. Detailed quantitative analysis of the impacts of the blockage of these two canals on maritime resilience is warranted.

In addition to these exogenous shocks, attention should be directed to recent endogenous developments in the shipping industry. For example, the potential dissolution of the 2M alliance in 2024 could lead to a reorganization of shipping alliances and the entire shipping industry. The reformation and reconstruction of the structure of the shipping market will affect the strategies of the top shipping companies and thereby maritime resilience. Therefore, future studies could explore the link between maritime resilience and changes in the shipping market structure and analyze them quantitatively.

In our constructed article database, the reviewed studies on maritime transport resilience predominantly rely on qualitative methods, such as surveys, conceptual arguments, and network analysis using complex network theories. However, there is a lack of more sophisticated quantitative methods, including economic modeling analysis, econometrics, and numerical simulations. This gap becomes apparent when examining the impacts of pandemic and geopolitical risks on maritime transport resilience. Although qualitative and network analyses provide valuable insights into various aspects of maritime resilience, the incorporation of economic analysis methods can offer a more comprehensive perspective. By integrating economic analysis, researchers can assess financial implications, supply chain dynamics, and trade patterns associated with maritime resilience. Future research should consider incorporating economic analysis methods to examine the economic dimensions of maritime resilience. This approach will contribute to a more nuanced understanding of the economic consequences and enable policymakers and industry practitioners to develop targeted strategies for enhancing resilience in the maritime shipping sector.

In recent years, data analysis technology has undergone unprecedented development, providing researchers with access to new technologies and abundant data sources. This progress has significantly enhanced our analytical capabilities in the field of maritime resilience. Technologies such as artificial intelligence, machine learning, blockchain, and big data from the automatic identification system, along with the application of complex network theory, offer valuable tools for studying maritime resilience and generating comprehensive management insights in this area.

In conclusion, our findings highlight the pressing need for future research to focus on analyzing the impact of geopolitical risks on maritime transport resilience and the influence of maritime transport resilience on international trade. In terms of research methods, there is a compelling need to use more sophisticated quantitative approaches, such as economic modeling, econometric estimations, and numerical simulations. These methods are essential for evaluating the economic losses and benefits of

adaptation investments that promote maritime transport resilience to various risks and their implications for international trade. Notably, there exists a gap in quantitative analysis, particularly in relation to pandemic and geopolitical risks. Addressing these research gaps is crucial for deepening our understanding of potential challenges and developing effective strategies to mitigate risks, benefiting not only the maritime shipping industry but also the overall economy.

4. Conclusion

This study conducts a comprehensive analysis of maritime transport resilience and its impact on international trade. It is important to note that our study does not primarily focus on analyzing supply chain resilience, as there is already an extensive body of research available on the topic, including articles specifically examining the resilience of maritime supply chains. Through bibliometric analysis and a literature review, we categorize and benchmark various risks that threaten maritime transport resilience, including climate change, geopolitical factors, and public health events (mainly the COVID-19 pandemic). By using standard methods such as the analysis of the most cited articles, semantic analysis, and collaboration network analysis for each stream of research, we gain valuable insights into the current research landscape and identify key factors influencing maritime transport resilience.

Specifically, our systematic literature review suggests that the impact of climate change-related risks on maritime transport resilience is relatively well examined by previous studies. Sea-level rise and storms are the most discussed risks among all climate change-induced disasters. Earlier research predominantly uses qualitative methods, whereas later studies employ quantitative approaches, such as economic modeling and numerical simulations. Research groups in this stream of the literature are centered around some key scholars. In addition, research on the risk of public health events, such as pandemics, has emerged over the past 2 to 3 years. Such risk is primarily viewed from the perspective of global supply chain resilience, with maritime transport being a part of it. Research methods in this area still mainly involve qualitative or network analysis. However, more in-depth economic evaluations with analytical models or numerical simulations of the economic costs and benefits of related adaptations are still lacking. Research on geopolitical risks, which continue to threaten maritime transport resilience and thereby adversely affect international trade, is rather limited. The specific topics and corresponding research groups in this area are highly fragmented, suggesting insufficient attention paid to this important research direction. The recent outbreaks of significant geopolitical conflicts, such as the Sino–US trade conflict, Russia–Ukraine war, and Israeli–Palestinian conflict, have led to severe consequences for maritime transport resilience, international trade and transport, supply chain functioning, and the global economy. Future research efforts to address these gaps would be meaningful.

Overall, this research contributes to the existing body of knowledge by filling gaps in the literature and offering directions for further research. The insights gained from this study can inform future research endeavors to deepen our understanding of maritime transport resilience and its implications for international trade. As the world

becomes increasingly interconnected and reliant on maritime shipping transport, it is crucial to prioritize the development of strategies and policies that enhance the resilience of the maritime shipping sector. This includes the implementation of measures to mitigate the impacts of climate change, address geopolitical uncertainties, and strengthen the response to public health events. Overall, this study serves as a foundation for future research and provides a valuable resource for policymakers, industry practitioners, and researchers seeking to navigate the complexities of the maritime shipping sector and foster a robust global supply chain in the face of evolving challenges.

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Zheng, S., Wang, K., Chan, F. T. S., Fu, X., and Li, Z. C. 2022b. "Subsidy on Transport Adaptation Investment-Modeling Decisions under Incomplete Information and Ambiguity". *Transportation Research Part B: Methodological*, 162: 103-129. https://doi.org/10.1016/j.trb.2022.05.016

Zheng, S., Wang, K., Fu, X., Zhang, A., and Ge, Y. E. 2022c. "The Effects of Information Publicity and Government Subsidy on Port Climate Change Adaptation: Strategy and Social Welfare Analysis". *Transportation Research Part B: Methodological*, 166: 284-312. https://doi.org/10.1016/j.trb.2022.11.001

Zheng, S., Wang, K., Li, Z. C., Fu, X., and Chan, F. T. S. 2021c. "Subsidy or Minimum Requirement? Regulation of Port Adaptation Investment under Disaster Ambiguity". *Transportation Research Part B: Methodological*, 150: 457-481. https://doi.org/10.1016/j.trb.2021.04.006

Zheng, Y., Zhao, J., and Shao, G. 2020. "Port City Sustainability: A Review of Its Research Trends". *Sustainability (Basel, Switzerland)*, *12*(20): 8355. https://doi.org/10.3390/su12208355

Appendix A. Existing definitions of resilience in the maritime field[2]

Reference	Year	Definition of resilience	Research topic
Mansouri, M., Nilchiani, R., and Mostashari, A. 2010. "A Policy Making Framework for Resilient Port Infrastructure Systems". *Marine policy*, *34* (6): 1125-1134. https://doi.org/10.1016/j.marpol.2010.03.012	2010	A function of system's vulnerability against potential disruption, and its adaptive capacity in recovering to an acceptable level of service within a reasonable timeframe after being affected by disruptions.	Port infrastructure systems
Omer, M., Mostashari, A., Nilchiani, R., and Mansouri, M. 2012. "A Framework for Assessing Resiliency of Maritime Transportation Systems". *Maritime policy and management*, *39*(7): 685-703. https://doi.org/10.1080/03088839.2012.689878	2012	The ability of the system to absorb shocks as well as to recover from a disruption so that it can return back to its original service delivery levels or close to it.	Maritime transportation infrastructure systems
Nursey-Bray, M., Blackwell, B., Brooks, B., Campbell, M. L., Goldsworthy, L., Pateman, H., Rodrigues, I., Roome, M., Wright, J. T., Francis, J., and Hewitt, C. L. 2013. "Vulnerabilities and Adaptation of Ports to Climate Change". *Journal of Environmental Planning and Management*, *56* (7): 1021-1045. https://doi.org/10.1080/09640568.2012.716363	2013	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change.	Ports
Becker, A., Matson, P., Fischer, M., and Mastrandrea, M. D. 2015. "Towards Seaport Resilience for Climate Change Adaptation: Stakeholder Perceptions of Hurricane Impacts in Gulfport (Ms) and Providence (Ri)". *Progress in Planning*, *99*: 1-49. https://doi.org/10.1016/j.progress.2013.11.002	2015	The ability of a system to absorb disturbance and still retain its basic function and structure.	Seaports
Jiang, M., Lu, J., Qu, Z., and Yang, Z. 2021. "Port Vulnerability Assessment from a Supply Chain Perspective". *Ocean and Coastal Management*, *213*, 105851-. https://doi.org/10.1016/j.ocecoaman.2021.105851	2021	The concept of resilience, often used in a more positive context than vulnerability, is considered as the ability of systems to recover quickly from hazardous event or trend or disruptions.	Maritime supply chain resilience
Gu, B., and Liu, J. 2023. "A Systematic Review of Resilience in the Maritime Transport". *International Journal of Logistics Research and Applications*. https://doi.org/10.1080/13675567.2023.2165051	2023	The ability of the organization or segment in maritime transport to withstand disruption and return to a desirable performance level following disruptive events.	Maritime resilience

Appendix B. The list of journals with papers related to maritime transport resilience during the 2006-2023 period

No.	Journal Name	Categories	No. of papers

[2] Some of the information in the table was collected from Wan et al. (2018).

1	Maritime Policy & Management	TRANSPORTATION - SSCI	19
2	Ocean and Coastal Management	WATER RESOURCES - SCIE; OCEANOGRAPHY - SCIE	14
3	Sustainability	ENVIRONMENTAL STUDIES - SSCI GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY - SSCI ENVIRONMENTAL SCIENCES - SCIE GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY - SCIE	12
4	Climatic Change	METEOROLOGY & ATMOSPHERIC SCIENCES - SCIE ENVIRONMENTAL SCIENCES - SCIE	10
5	Marine Policy	INTERNATIONAL RELATIONS - SSCI ENVIRONMENTAL STUDIES - SSCI	10
6	Transportation Research Part D: Transport and Environment	ENVIRONMENTAL STUDIES - SSCI TRANSPORTATION SCIENCE & TECHNOLOGY - SCIE TRANSPORTATION - SSCI	10
7	Transport Policy	TRANSPORTATION - SSCI ECONOMICS - SSCI	8
8	Journal of Marine Science and Engineering	ENGINEERING, MARINE - SCIE ENGINEERING, OCEAN - SCIE OCEANOGRAPHY - SCIE	8
9	Transportation Research Record	TRANSPORTATION SCIENCE & TECHNOLOGY - SCIE ENGINEERING, CIVIL - SCIE	7
10	Transportation Research Part B: Methodological	OPERATIONS RESEARCH & MANAGEMENT SCIENCE - SCIE ENGINEERING, CIVIL - SCIE ECONOMICS - SSCI TRANSPORTATION - SSCI TRANSPORTATION SCIENCE & TECHNOLOGY - SCIE	6
11	International Journal of Disaster Risk Reduction	WATER RESOURCES - SCIE METEOROLOGY & ATMOSPHERIC SCIENCES - SCIE GEOSCIENCES, MULTIDISCIPLINARY - SCIE	7
12	Case Studies on Transport Policy	TRANSPORTATION - ESCI	7
13	Transportation Research Part A: Policy and Practice	ECONOMICS - SSCI TRANSPORTATION SCIENCE & TECHNOLOGY - SCIE TRANSPORTATION - SSCI	6
14	Natural Hazards	METEOROLOGY & ATMOSPHERIC SCIENCES - SCIE GEOSCIENCES, MULTIDISCIPLINARY - SCIE WATER RESOURCES - SCIE	6
15	Maritime Economics & Logistics	TRANSPORTATION - SSCI	6
16	Transportation Research Part E: Logistics and Transportation Review	TRANSPORTATION SCIENCE & TECHNOLOGY - SCIE ENGINEERING, CIVIL - SCIE ECONOMICS - SSCI OPERATIONS RESEARCH & MANAGEMENT SCIENCE - SCIE TRANSPORTATION - SSCI	5
17	Regional Environmental Change	ENVIRONMENTAL STUDIES - SSCI ENVIRONMENTAL SCIENCES - SCIE	4

18	Water (Switzerland)	ENVIRONMENTAL SCIENCES - SCIE WATER RESOURCES - SCIE	3
19	Transnav-International Journal on Marine Navigation and Safety of Sea Transportation	TRANSPORTATION SCIENCE & TECHNOLOGY - ESCI	3
20	Journal of Environmental Planning and Management	DEVELOPMENT STUDIES - SSCI REGIONAL & URBAN PLANNING - SSCI	3

Appendix C. The references of the most cited articles

1. The most cited articles related to climate change-related risks

No.	Reference
1	Becker, A., Inoue, S., Fischer, M., and Schwegler, B. 2012. "Climate Change Impacts on International Seaports: Knowledge, Perceptions, and Planning Efforts among Port Administrators". *Climatic Change*, 110(1-2): 5-29. https://doi.org/10.1007/s10584-011-0043-7
2	Rose, A., and Wei, D. 2013. "Estimating the Economic Consequences of a Port Shutdown: The Special Role of Resilience". *Economic Systems Research*, 25(2): 212-232. https://doi.org/10.1080/09535314.2012.731379
3	Becker, A., Acciaro, M., Asariotis, R., Cabrera, E., Cretegny, L., Crist, P., Esteban, M., Mather, A., Messner, S., Naruse, S., Ng, A. K. Y., Rahmstorf, S., Savonis, M., Song, D. W., Stenek, V., and Velegrakis, A. F. 2013. "A Note on Climate Change Adaptation for Seaports: A Challenge for Global Ports, a Challenge for Global Society". *Climatic Change*, 120(4): 683-695. https://doi.org/10.1007/s10584-013-0843-z
4	Verschuur, J., Koks, E. E., and Hall, J. W. 2020. "Port Disruptions Due to Natural Disasters: Insights into Port and Logistics Resilience". *Transportation Research Part D: Transport and Environment*, 85, 102393-. https://doi.org/10.1016/j.trd.2020.102393
5	Yang, Z., Ng, A. K. Y., Lee, P. T. W., Wang, T., Qu, Z., Sanchez Rodrigues, V., Pettit, S., Harris, I., Zhang, D., and Lau, Y. Y. 2018. "Risk and Cost Evaluation of Port Adaptation Measures to Climate Change Impacts". *Transportation Research Part D: Transport and Environment*, 61: 444-458. https://doi.org/10.1016/j.trd.2017.03.004
6	Lawrence, J. M., Ibne Hossain, N. U., Jaradat, R., and Hamilton, M. 2020. "Leveraging a Bayesian Network Approach to Model and Analyze Supplier Vulnerability to Severe Weather Risk: A Case Study of the U.S. Pharmaceutical Supply Chain Following Hurricane Maria". *International Journal of Disaster Risk Reduction*, 49, 101607-. https://doi.org/10.1016/j.ijdrr.2020.101607
7	Izaguirre, C., Losada, I. J., Camus, P., Vigh, J. L., and Stenek, V. 2021. "Climate change risk to global port operations". *Nature Climate Change*, 11(1): 14–20. https://doi.org/10.1038/s41558-020-00937-z
8	Ng, A. K. Y., Chen, S. L., Cahoon, S., Brooks, B., and Yang, Z. 2013. "Climate Change and the Adaptation Strategies of Ports: The Australian Experiences". *Research in Transportation Business and Management*, 8: 186-194. https://doi.org/10.1016/j.rtbm.2013.05.005
9	Wang, K., and Zhang, A. 2018. "Climate Change, Natural Disasters and Adaptation Investments: Inter- and Intra-Port Competition and Cooperation". *Transportation Research Part B: Methodological,* 117: 158-189. https://doi.org/10.1016/j.trb.2018.08.003
10	Asadabadi, A., and Miller-Hooks, E. 2018. "Co-opetition in enhancing global port network resiliency: A multi-leader, common-follower game theoretic approach". *Transportation Research. Part B: Methodological*, 108: 281–298. https://doi.org/10.1016/j.trb.2018.01.004

2. The most cited articles related to pandemic risks

No.	Reference
1	Notteboom, T., Pallis, T., and Rodrigue, J. P. 2021. “Disruptions and Resilience in Global Container Shipping and Ports: The Covid-19 Pandemic Versus the 2008–2009 Financial Crisis”. *Maritime Economics and Logistics*, 23(2): 179-210. https://doi.org/10.1057/s41278-020-00180-5
2	Guerrero, D., Letrouit, L., and Pais-Montes, C. 2022. “The Container Transport System During Covid-19: An Analysis through the Prism of Complex Networks”. *Transport Policy*, 115: 113-125. https://doi.org/10.1016/j.tranpol.2021.10.021
3	Praharsi, Y., Abu Jami'in, M., Suhardjito, G., and Wee, H. M. 2021a. “The Application of Lean Six Sigma and Supply Chain Resilience in Maritime Industry During the Era of Covid-19”. *International Journal of Lean Six Sigma*, 12(4): 800-834. https://doi.org/10.1108/IJLSS-11-2020-0196
4	Dirzka, C., and Acciaro, M. 2022. “Global Shipping Network Dynamics During the Covid-19 Pandemic's Initial Phases”. *Journal of Transport Geography*, 99, 103265-. https://doi.org/10.1016/j.jtrangeo.2021.103265
5	Jin, L., Chen, J., Chen, Z., Sun, X., and Yu, B. 2022. “Impact of Covid-19 on China's International Liner Shipping Network Based on Ais Data”. *Transport Policy*, 121: 90-99. https://doi.org/10.1016/j.tranpol.2022.04.006
6	Panahi, R., Sadeghi Gargari, N., Lau, Y. Y., and Ng, A. K. Y. 2022. “Developing a Resilience Assessment Model for Critical Infrastructures: The Case of Port in Tackling the Impacts Posed by the Covid-19 Pandemic”. *Ocean and Coastal Management*, 226, 106240-. https://doi.org/10.1016/j.ocecoaman.2022.106240
7	Gibson, C., Carr, C., Lyons, C., Taksa, L., and Warren, A. 2021. “Covid-19 and the Shifting Industrial Landscape”. *Geographical Research*, 59(2): 196-205. https://doi.org/10.1111/1745-5871.12462
8	Zhang, Y., and Sun, Z. K. 2021. “The Coevolutionary Process of Maritime Management of Shipping Industry in the Context of the Covid-19 Pandemic”. *Journal of Marine Science and Engineering*, 9(11), 1293-. https://doi.org/10.3390/jmse9111293
9	Bai, X., Ma, Z., and Zhou, Y. 2023. “Data-Driven Static and Dynamic Resilience Assessment of the Global Liner Shipping Network”. *Transportation Research Part E: Logistics and Transportation Review*, 170, 103016-. https://doi.org/10.1016/j.tre.2023.103016
10	Marobhe, M. I. 2022. “Investors' Reactions to Covid-19 Related Announcements: Evidence from the Cargo Shipping Industry”. *Review of Behavioral Finance*, 14(5): 833-853. https://doi.org/10.1108/RBF-04-2021-0071

3. The most cited articles regarding geopolitical risks

No.	Reference
1	Fu, X., Ng, A. K. Y., and Lau, Y. Y. 2010. “The Impacts of Maritime Piracy on Global Economic Development: The Case of Somalia”. *Maritime policy & management*, 37(7): 677-697. https://doi.org/10.1080/03088839.2010.524736
2	Notteboom, T. 2016. “The Adaptive Capacity of Container Ports in an Era of Mega Vessels: The Case of Upstream Seaports Antwerp and Hamburg”. *Journal of Transport Geography*, 54: 295-309. https://doi.org/10.1016/j.jtrangeo.2016.06.002
3	Mou, N., Sun, S., Yang, T., Wang, Z., Zheng, Y., Chen, J., and Zhang, L. 2020. “Assessment of the Resilience of a Complex Network for Crude Oil Transportation on the Maritime Silk Road”. *IEEE Access*, 8: 181311-181325. https://doi.org/10.1109/ACCESS.2020.3028214
4	Min, H. 2011. “Modern Maritime Piracy in Supply Chain Risk Management”. *International journal of logistics systems and management*, 10(1): 122-138. https://doi.org/10.1504/IJLSM.2011.042057
5	Ringsberg, A. H., and Cole, S. 2020. “Maritime Security Guidelines: A Study of Swedish Ports’ Perceived Barriers to Compliance”. *Maritime policy & management*, 47(3): 388-401. https://doi.org/10.1080/03088839.2020.1711977

6	Burns, M. G. 2018. “Participatory Operational & Security Assessment on Homeland Security Risks: An Empirical Research Method for Improving Security Beyond the Borders through Public/Private Partnerships”. *Journal of Transportation Security*, 11(3-4): 85-100. https://doi.org/10.1007/s12198-018-0193-1
7	Ažman Momirski, L. 2021. “The Resilience of the Port Cities of Trieste, Rijeka, and Koper”. *Journal of Urban History*, 47(2): 293-316. https://doi.org/10.1177/0096144220926600
8	Rabbani, M., Bahadornia, S. M., and Torabi, S. A. 2015. “Designing a Resilient Oil Supply Network with an Intelligent Solution Algorithm”. *Uncertain Supply Chain Management*, 3(3): 289-310. https://doi.org/10.5267/j.uscm.2015.3.001
9	He, Z., Wang, C., Gao, J., and Xie, Y. 2023. “Assessment of Global Shipping Risk Caused by Maritime Piracy”. *Heliyon*, 9(10): e20988-e20988. https://doi.org/10.1016/j.heliyon.2023.e20988
10	Ibrahim, A. M. 2022. “The Impact of Neurotechnology on Maritime Port Security-Hypothetical Port”. *Journal of Transportation Security*, 15(3-4): 119-139. https://doi.org/10.1007/s12198-022-00253-x
11	Nicolaisen, M. A., and Hansen, A. S. 2023. “Humor, Transparency, and the Management of Distrust among Business Rivals: A Case Study of Berthing Meetings at the Port of Tema in Ghana”. *Maritime Studies*, 22(2), 9-. https://doi.org/10.1007/s40152-023-00298-1
12	Muradian, A., Kuzkin, O., and Remzina, N. 2023. “Logistics of Smart Port in Ukraine: Problems and Prospects in the Conditions of Sustainable Development”. *Problemy Ekorozwoju*, 18(2): 229-241. https://doi.org/10.35784/preko.4036
13	Fan, H., Gong, X., and Lyu, J. 2023. “Resilience Assessment of Strait/Canal: A Rule-Based Bayesian Network Framework”. *Transportation Research Part D: Transport and Environment*, 124, 103960-. https://doi.org/10.1016/j.trd.2023.103960

4. All articles examining the influence of maritime transport resilience on international trade

No.	Reference
1	Becker, A., Acciaro, M., Asariotis, R., Cabrera, E., Cretegny, L., Crist, P., Esteban, M., Mather, A., Messner, S., Naruse, S., Ng, A. K. Y., Rahmstorf, S., Savonis, M., Song, D. W., Stenek, V., and Velegrakis, A. F. 2013. “A Note on Climate Change Adaptation for Seaports: A Challenge for Global Ports, a Challenge for Global Society”. *Climatic Change*, 120(4): 683-695. https://doi.org/10.1007/s10584-013-0843-z
2	Chen, H., Cullinane, K., and Liu, N. 2017. “Developing a Model for Measuring the Resilience of a Port-Hinterland Container Transportation Network”. *Transportation Research Part E: Logistics and Transportation Review*, 97: 282-301. https://doi.org/10.1016/j.tre.2016.10.008
3	Narasimha, P. T., Jena, P. R., and Majhi, R. 2021. “Impact of Covid-19 on the Indian Seaport Transportation and Maritime Supply Chain”. *Transport Policy*, 110: 191-203. https://doi.org/10.1016/j.tranpol.2021.05.011
4	Loh, H. S., Zhou, Q., Thai, V. V., Wong, Y. D., and Yuen, K. F. 2017. “Fuzzy Comprehensive Evaluation of Port-Centric Supply Chain Disruption Threats”. *Ocean* and *Coastal Management*, 148: 53-62. https://doi.org/10.1016/j.ocecoaman.2017.07.017
5	Rose, A., Wei, D., and Paul, D. 2018. “Economic Consequences of and Resilience to a Disruption of Petroleum Trade: The Role of Seaports in U.S. Energy Security”. *Energy Policy*, 115: 584-615. https://doi.org/10.1016/j.enpol.2017.12.052
6	Jiang, M., Lu, J., Qu, Z., and Yang, Z. 2021. “Port Vulnerability Assessment from a Supply Chain Perspective”. *Ocean and Coastal Management*, 213, 105851-. https://doi.org/10.1016/j.ocecoaman.2021.105851
7	Hanson, S. E., and Nicholls, R. J. 2020. “Demand for Ports to 2050: Climate Policy, Growing Trade and the Impacts of Sea-Level Rise”. *Earth's Future*, 8(8), e2020EF001543-. https://doi.org/10.1029/2020EF001543
8	Shepard, J. U., and Pratson, L. F. 2020. “Maritime Piracy in the Strait of Hormuz and Implications of Energy Export Security”. *Energy Policy*, 140, 111379-. https://doi.org/10.1016/j.enpol.2020.111379

9	Heijman, W., Gardebroek, C., and van Os, W. 2017. "The Impact of World Trade on the Port of Rotterdam and the Wider Region of Rotterdam-Rijnmond". *Case Studies on Transport Policy*, 5(2): 351-354. https://doi.org/10.1016/j.cstp.2017.03.005
10	Fahim, P., Rezaei, J., Jayaraman, R., Poulin, M., Montreuil, B., and Tavasszy, L. 2021. "The Physical Internet and Maritime Ports: Ready for the Future?". *IEEE Engineering Management Review*, 49(4): 136-149. https://doi.org/10.1109/EMR.2021.3113932
11	Shi, J., Jiao, Y., Chen, J., and Zhou, S. 2023b. "Construction of Resilience Mechanisms in Response to Container Shipping Market Volatility During the Pandemic Period: From the Perspective of Market Supervision". *Ocean and Coastal Management,* 240, 106642-. https://doi.org/10.1016/j.ocecoaman.2023.106642
12	Friedt, F. L. 2021. "Natural Disasters, Aggregate Trade Resilience, and Local Disruptions: Evidence from Hurricane Katrina". *Review of International Economics*, 29(5): 1081-1120. https://doi.org/10.1111/roie.12537
13	Przekota, G. 2022. "Do High Fuel Prices Pose an Obstacle to Economic Growth? A Study for Poland". *Energies*, 15(18), 6606-. https://doi.org/10.3390/en15186606
14	Qiao, W., Liu, Y., Ma, X., and Lan, H. 2021. "Cognitive Gap and Correlation of Safety-I and Safety-II: A Case of Maritime Shipping Safety Management". *Sustainability (Switzerland)*, 13(10), 5509-. https://doi.org/10.3390/su13105509
15	Gu, B., and Liu, J. 2023. "Port Resilience Analysis Based on the Hhm-Fcm Approach under Covid-19". *Ocean and Coastal Management*, 243, 106741-. https://doi.org/10.1016/j.ocecoaman.2023.106741
16	Verschuur, J., Koks, E. E., Li, S., and Hall, J. W. 2023. "Multi-Hazard Risk to Global Port Infrastructure and Resulting Trade and Logistics Losses". *Communications Earth and Environment*, 4(1), 5-. https://doi.org/10.1038/s43247-022-00656-7
17	Popovich, B., Wotherspoon, L., and Borrero, J. 2021. "An Assessment of Subduction Zone-Generated Tsunami Hazards in New Zealand Ports". *Natural Hazards*, 107(1): 171-193. https://doi.org/10.1007/s11069-021-04578-z
18	Tai, H. H., and Yang, C. C. 2016. "A Policy-Making Framework for Enhancing the Kaohsiung Port's Economic Resilience". *Transactions of the Royal Institution of Naval Architects Part A: International Journal of Maritime Engineering*, 158(A4): A347-A358. https://doi.org/10.5750/ijme.v158iA4.1004
19	Olapoju, O. M. 2022. "Cross Examinations of Maritime Trade Disruptions in Africa During Covid-19 Pandemic". *Pomorstvo-Scientific Journal of Maritime Research,* 36(2): 187-194. https://doi.org/10.31217/p.36.2.2
20	Kuhla, K., Willner, S. N., Otto, C., and Levermann, A. 2023. "Resilience of International Trade to Typhoon-Related Supply Disruptions". *Journal of Economic Dynamics and Control*, 151, 104663-. https://doi.org/10.1016/j.jedc.2023.104663
21	Sheikh, W., Chowdhury, M. M. H., and Mahmud, K. K. 2023. "A Comprehensive Performance Measurement Model for Maritime Logistics: Sustainability and Policy Approach". *Case Studies on Transport Policy*, 14, 101097-. https://doi.org/10.1016/j.cstp.2023.101097