FOUNDATIONS AND FRONTIERS IN LINER SHIPPING RESILIENCE

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ABSTRACT
Purpose: Liner shipping serves as the backbone for international trade and global supply chains, facilitating the efficient movement of goods across global markets. However, the industry's resilience is increasingly challenged by unforeseen disruptions caused by a diverse range of events including cyber-attacks, geopolitical conflicts, regulatory changes, and global crises such as pandemics. This study explores the current state of liner shipping resilience literature by synthesizing the research methods used, analysing emerging trends and themes, and providing directions for future research on liner shipping resilience.
Design/methodology/approach: To achieve the purpose of the study, a systematic literature review was conducted on peer-reviewed articles exploring diverse topics related to liner shipping resilience. A defined inclusion/exclusion criteria was applied to an initial pool of 710 articles retrieved from Scopus and Web of Science, covering publications from 2010 to 2023. Following this screening process, 42 articles were included in the bibliometric analysis. Furthermore, an in-depth review of the articles was conducted to contextualise the identified themes shaping current and future research on liner shipping resilience.
Findings: The findings revealed a surge in the number of studies on liner shipping resilience between 2019 and 2022, with COVID-19 and risk assessment as main themes of interest. The findings revealed that liner shipping resilience research was mainly conducted using mathematical and optimisation models, and empirical research methods. The thematic structure of the literature centres on operations, modelling for optimisation, with technological solutions acting as cross-cutting enablers. Moreover, emerging themes point towards a shift from isolated solutions to system-oriented actionable measures.
Research limitations: The study was limited to publications available in Web of Science and Scopus databases based on a predefined inclusion/exclusion criteria that might omit non-indexed relevant literature.
Practical implications: This study underscores key foundations and emerging frontiers in liner shipping resilience, paving way for future research and supporting strategic decision-making within the industry.
Originality/value: This study provides a systematic and bibliometric review of research on liner shipping resilience between 2010 and 2023, highlighting the trends and actionable insights to support effective decision making for key stakeholders.

Keywords: Liner Shipping, Resilience, Unforeseen Disruptions, Systematic Review, Bibliometric Analysis

1. Introduction

Maritime transport plays a crucial role in the global economy, accounting for over 80 per cent of the total volume of goods traded (UNCTAD, 2022). This volume has been significantly facilitated by liner shipping which contributes nearly 60 per cent of the total value of all seaborne trade (WSC, 2023). For instance, a total of around 862 million twenty-foot equivalent units (TEU) of containerized merchandise were handled at ports globally in 2022 (Statista, 2023). Such a formidable share of world trade highlights the sheer capacity of liner shipping in handling large volumes of cargo (Christiansen et al., 2020).

However, the liner shipping industry conducts business in a highly volatile environment and is vulnerable to numerous external disruptions (Notteboom et al., 2021). These disruptive events, often unexpected, bring about risks, operational challenges, and uncertainty in the market which expose the vulnerability of liner shipping operations and underscore the urgent need to strengthen resilience within the industry (Lam and Wong, 2018). Notable disruptive events such as, the COVID-19 pandemic (Vo and Tran, 2021), the 2021 Suez Canal blockage (Özkanllsoy and Akkartal, 2022), and geopolitical tensions and armed conflicts like the Russia-Ukraine war (Cong et al., 2024), among others, have caused major shocks to liner shipping, underscoring the industry's vulnerability and dire need to build

resilience. Moreover, liner shipping as a system is inherently complex, with highly interconnected stakeholders. Disruptions at any particular node within the system can cascade across the entire supply chain, amplifying the need for enhanced resilience to address the downstream impacts of unforeseen disruptions (Sadat Hosseini Khajouei et al., 2022).

According to Wu et al. (2013), resilience is the ability to successfully withstand stress and adversity. Yang et al. (2024) and Landa (2024) highlighted robustness as a core dimension of resilience and emphasised the importance of preparedness and redundancy in withstanding disruptive events while maintaining functionality and stable operations. Contrary, Zhang and Sun (2021) emphasise adaptability, highlighting flexibility in organisational systems, learning from past experiences and the ability to adapt and change based on changing conditions. Other scholars like Shin et al. (2019) and Ayaz et al. (2022) view resilience as a transformative capacity where crises are embraced as opportunities to innovate, rebuild processes and structures, and reposition strategically. Therefore together, these perspectives illustrate that resilience is a dynamic capability that evolves in response to external stressors. Within the liner shipping industry, the notion of resilience translates into the ability of liner shipping companies to absorb, withstand and respond to unforeseen disruptive events while maintaining operational continuity.

Despite extensive studies on ports and the broader maritime and supply chain domains (Tsoulfas, 2025, Lau et al., 2024, Gu and Liu, 2023), literature lacks an updated systematic synthesis of research specific to the resilience of liner shipping. Therefore, this study explores the current state of literature on liner shipping resilience, highlights the commonly used research methods/approaches, and identifies the emerging trends and themes, providing directions for future research on liner shipping resilience. To guide this effort and achieve the aim of the study, two research questions (RQs) were formulated:

- RQ1: What is the current state of research on liner shipping resilience in recent years?
- RQ2: What are the emerging themes and trends in liner shipping resilience research?

2. Review Methodology

The study adopts the guidelines under Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) which is comprised of established and predetermined protocol and methods (Moher et al., 2009). Unlike author-centric or theme-centric narrative literature reviews which leave the readers to make sense of the reasons for consideration of certain studies, the systematic literature review gives a replicable and transparent scientific way to evaluate existent studies with minimal bias (Linnenluecke et al., 2020). Furthermore, content analysis of full articles was then done to answer the second research question. A defined inclusion/exclusion criteria was applied to an initial pool of 710 articles retrieved from Scopus and Web of Science, covering peer-reviewed publications from 2010 to 2023. The search strategy and exclusion/inclusion criteria are discussed below.

2.1 Search strategy

A structured search was conducted in two different databases, Web of Science (WoS) and Scopus, on the 23rd of August 2023. The results were limited to title, abstract, and keywords searches using Boolean combinations of “Organisation”, “Resilience”, “Disruptions” and “Liner Shipping” and their respective synonyms, with truncation (*) applied to capture term variants. The emphasis on broader phrases was deliberate, to avoid exclusion of any articles owing to constraints.

2.2 Eligibility (exclusion and exclusion criteria)

To ensure that the articles selected for the review were relevant to the study, they were screened against the pre-defined criteria where only full text, open access journal articles in English published between 2010 and 2023 with a focus on the resilience of liner shipping. The initial screening of the

retrieved articles was undertaken independently by a single researcher, who applied the predefined criteria to exclude irrelevant studies. To ensure methodological transparency and consistency, the screening decisions and resulting articles set were subsequently reviewed by three additional researchers. Any points of ambiguity were resolved through team discussion and consensus. Following this screening process, 42 articles were included in the bibliometric analysis.

2.3 Bibliometric analysis

This study employed a bibliometric analysis in R Studio to characterise the literature on liner-shipping resilience (2010–2023) and address the first research question. The selected articles were imported into biblioshiny where the annual scientific production, core sources by journal, the keyword co-occurrence networks to support later theme development, were analysed.

3. Results and Discussion

This section presents the outputs of the systematic literature review and discusses their implications for liner shipping resilience. The narrative has been structured to mirror the study's aims and thereby address the research questions.

3.1 Annual scientific production of articles

The distribution of published articles from 2013 to 2023 shows a rise in scholarly interest. Only 4 per cent of the selected articles were published between 2013 and 2016 but between 2017 and 2021, the annual contributions had a steady but modest growth, averaging between 7 per cent and 10 per cent of total output, as seen in figure 1. A significant increase in research interest and activity is seen in 2022, when 33 per cent of articles were published. This may be attributed to the COVID-19 pandemic, which posed significant threat to the liner shipping industry and triggered researchers to look into resilience. Since only part of articles from 2023 were included in this study, having 19 per cent of the total selection demonstrates sustained intellectual commitment to research in this area.

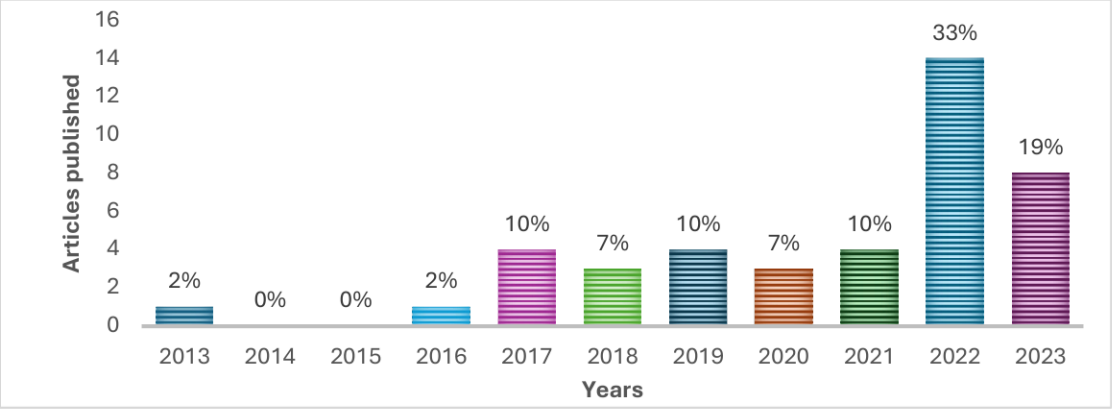

Figure 1. Annual publication of articles

3.2 Core journals in liner shipping resilience

The 42 articles reviewed span 34 journals. Maritime Business Review accounted for 10 per cent, the Journal of Marine Science and Engineering for 7 per cent, and Marine Policy, Maritime Economics & Logistics, and Transportation Research Part A: Policy and Practice for 5 per cent each. The remaining 29 journals each contributed 2 per cent of the total article selection. This distribution indicates that liner shipping resilience research is interdisciplinary and diverse, ranging from business, policy, engineering, and operations.

3.3 Research methods used in liner shipping resilience research.

As presented in Figure 2, the dominant research methodologies used in the reviewed articles were categorised into mathematical modelling and optimisation, empirical research and descriptive studies. To a smaller extent, case studies and simulation were also used. The predominant methodological approaches are discussed below.

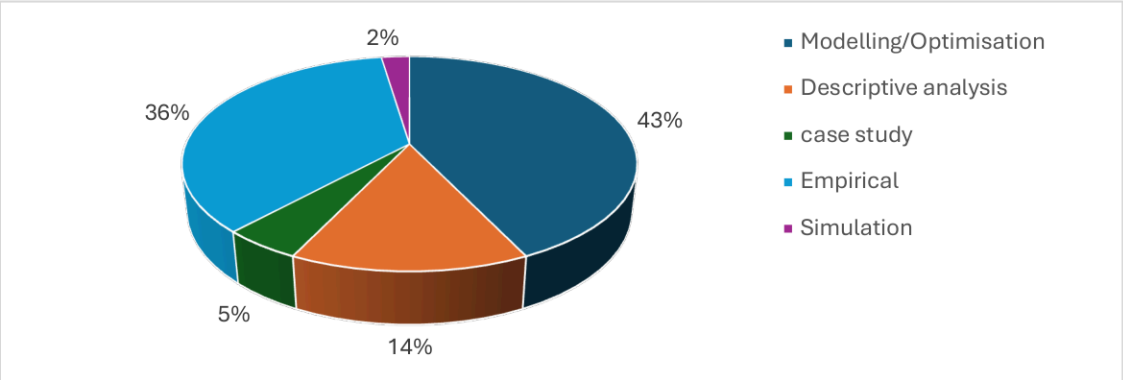

Figure 2: Ratio of the most relevant research methodologies

3.3.1 Mathematical modelling and optimisation method

Mathematical modelling and optimisation methods employ equations and algorithms to depict real-world systems, capture constraints, and examine relationships among variables (Witelski and Bowen, 2015). Zhao et al. (2022). De et al. (2021) employed a mathematical programming model using a heuristic Variable Neighbourhood Search (VNS) hybrid optimisation approach to examine profitability in liner shipping while accounting for fuel management, sustainability, and disruption. Wang et al. (2023) used bi-objective mixed-integer nonlinear programming model to examine fleet deployment optimisation, vessel speed adjustment, and bunkering strategies, aiming to minimise both total operational costs and CO_2 emissions. Abioye et al. (2019) developed a Mixed-Integer Programming (MIP) model examining vessel schedule recovery under uncertainty. Similarly, Zhu et al. (2018) used a two-stage stochastic mixed-integer linear programming (MILP) model to optimise fleet deployment and bunker purchasing under uncertainty. Mathematical modelling was also used in studies on container fleet deployment under uncertainty (Bukljaš et al., 2022), container routing under uncertain demand (Zhen et al. (2017), bankruptcy of Hanjin Shipping (Aydın and Kamal, 2022), container fleet renewal (Zhao et al. (2021).

3.3.2 Empirical research

Empirical research depends on observations, experiments, or data gathered from the real world to address an issue or evaluate a theory (Hedges, 2012). In contrast to theoretical or conceptual research, which formulates concepts or models, empirical research is based on measurable, recordable, and analysable evidence (McEwan, 2010). According to Gu and Liu (2023), most empirical studies on maritime resilience rely on survey data obtained through interviews and questionnaires due to the challenges in acquiring relevant information. Przybyłowski et al. (2022) used empirical data to evaluate how digitalized remote work affected organizational resilience during the COVID-19 pandemic. Jerebić and Pavlin (2018) utilised secondary data drawn from World Bank to examine the impact of the 2008 global financial crisis on container shipping. To analyse risk factors in container shipping and logistics services from both service providers' and customers' perspectives in Mediterranean emerging markets, Moslemi et al. (2016) used empirical data from interviews and surveys.

3.4 Emerging themes and topics in liner shipping resilience research

The thematic map for liner shipping resilience centres on a core operations theme linked to the broader supply chain. In addition, a strong management/model cluster shows a shift toward decision support and optimisation. Technological advancement acts as a cross-cutting enabler connecting models to real-world operations. Surrounding this core, eco-efficiency, commerce, and governance emerge as increasingly connected themes, indicating a field converging on actionable measures as the next frontier of liner shipping resilience. A detailed account for these themes is discussed in the below sub-sections.

3.4.1 Operational resilience in liner shipping

Operational resilience in this context refers to an organisation's ability to withstand, adapt to, and recover from disruptive events while maintaining continuity of critical services and day to day business activities (Akpinar and Özer-Çaylan, 2023). Based on this review, operational resilience in liner shipping has been mainly studied through the lenses of optimisation, systemic disruption management, and strategic preparedness. Brouer et al. (2017) demonstrated how key decision areas such as network design and vessel scheduling represent interconnected optimisation problems that push the limits of data-driven modelling. Abioye et al. (2019), Brouer et al. (2013) and De et al. (2021) examine vessel scheduling recovery strategies in consideration of factors such as bunker management, fuel consumption, speed deviations and sustainability practices. Other scholars such as Onishchenko et al. (2022) and Erstad et al. (2023) examine topics like cybersecurity in liner operations, fleet investment timing (Jeon and Yeo, 2017), and structural adjustments following systemic shocks (Jerebić and Pavlin, 2018).

3.4.2 Modelling in liner shipping resilience.

Liner shipping resilience has evolved from merely describing disruptions and their impacts to supporting stakeholders make data-driven decisions during network optimisation. Recent studies have developed tools to redesign routes and schedules, reposition empty containers, and adjust speed and fuel to keep services running (Sarmadi et al., 2020, Brouer et al., 2017). Beyond operations, several models link commercial controls such as bookings and slot allocation to operational recovery, aligning revenue protection with liner service continuity or resilience (Jeon and Yeo, 2017, Wong et al., 2022). Overall, modelling allows convergence towards practical interventions such as slow steaming optimisation, port call selection, bunker management, slot exchange, and targeted equipment repositioning to enhance the resilience of liner shipping networks during unforeseen disruptions.

3.4.3 Technology advancements and liner shipping resilience.

Technology is widely acknowledged as a fundamental enabler of resilience in the maritime industry, allowing enterprises to foresee, endure, and adjust to crises. Nguyen et al. (2023) examined blockchain technology to address the persistent inefficiencies that undermine the liner shipping resilience by highlighting barriers to blockchain adoption and providing strategies for effective implementation. Papadakis and Kopanaki (2022) and Pu and Lam (2021) emphasised the significance of blockchain technology for the broader maritime industry, asserting that as an emerging technology, it is poised to disrupt the industry as its adoption is constrained by technological complexity, legal ambiguity, substantial costs, and integration challenges. Additionally, Moreover Koh et al. (2022) emphasised the need for a well-equipped maritime workforce to unlock the full resilience potential of emerging technologies such as blockchain, big data analytics and Artificial Intelligence (AI). Przybyłowski et al. (2022) contend that the prompt shift to digital communication systems and data-driven supply chain tools during the Covid-19 pandemic enabled rapid employee adaptation to lockdown restrictions, highlighting the ability of digital technology to integrate flexibility and responsiveness into organisational practices. Urciuoli and Hintsa (2021) also emphasised that digital ecosystems such as real-time tracking, automated reporting, and alerts help reduce the costs and

risks of disruptions. In contrast, Caprolu et al. (2020) and Nguyen et al. (2023) caution the increasing reliance on digital technologies as they introduce significant cybersecurity vulnerabilities. Scholars such as Onishchenko et al. (2022) and Erstad et al. (2023) emphasise the rapidly evolving cyber vulnerabilities and advocate for the development of competencies, standardization of procedures and the redirection of discussions on resilience towards digital risk governance.

As the next frontiers in liner shipping resilience, eco-efficiency, capacity, commerce, and governance are increasingly getting interconnected. Together, these emerging themes frame a practical agenda for emission reduction in shipping, capacity optimisation, financial performance, and transparent decision making based on collaboration and accountability. Advancing resilience will therefore hinge on integrated models and metrics that link these domains, as supported by technological advancements. This systematic literature review and synthesis contributes to the overall liner shipping resilience literature by encouraging a shift from isolated solutions to system-level, actionable measures that enhance resilience during disruptions.

4. Conclusion

This study employed a systematic literature review to examine 42 journal articles published in liner shipping resilience research between 2010 and 2023. The review shows that liner shipping resilience has gained prominence due to occurrence of unprecedented disruptive events such as COVID19. Current scholarship in liner shipping resilience research remains dominated by mathematical modelling, optimisation, and empirical studies, with growing attention to digitalisation and technological innovation such as blockchain and AI, and operational resilience. To further advance the liner shipping domain, future studies should link operations, commerce, and governance in integrated resilience models and frameworks that co-optimise recovery, energy efficiency, and financial performance. Priority gaps that could be explored include but are not limited to, socio-technical and human aspects of liner shipping companies including leadership; organisational culture and workforce and how they impact resilience; stakeholder collaboration and governance; financial and risk-sharing mechanisms during disruptive events; resilience under geopolitical events such as the Russia-Ukraine and Israel-Palestine conflict; and, environmental and sustainability dimensions. Moreover, existing literature is also heavily skewed toward developed economies, overlooking resilience challenges in developing regions. Additionally, most analyses are short-term or crisis-specific, with little longitudinal assessment of resilience across different phases of resilience. The findings of this study serve as a foundation for further research on liner shipping resilience.

Data Availability: *The data set used in this paper is available upon request from the first author.*

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