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GLOBAL SHIPPING IN INTERNATIONAL TRADE: ECONOMIC IMPACTS AND POLICY IMPLICATIONS

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ABSTRACT

This systematic literature review examines the evolving role of the global shipping industry within the context of international trade, technological innovation, and environmental sustainability. Covering peer-reviewed literature from 2015 to 2025, the study analyzes how advancements in digitalization, automation, and maritime policy shape operational efficiency, regulatory compliance, and decarbonization efforts. Using the PRISMA framework and bibliometric analysis via VOSviewer, the review identifies key thematic clusters related to emissions regulation, technological integration, and global trade dynamics. The findings reveal a shift toward sustainable shipping practices, driven by regulatory pressures and market demands such as the rise of e-commerce. While the maritime sector has made significant progress in innovation, challenges remain in balancing economic performance with environmental responsibility. This review highlights the need for strategic alignment among industry stakeholders to ensure both competitiveness and ecological resilience in the era of climate-conscious global trade.

Keywords: **Global Shipping, Shipping Emissions, International Trade, Maritime Regulation, Sustainability**

1. INTRODUCTION

The phenomenon of globalization has fundamentally reshaped the structures and operations of international trade. In recent decades, this transformation has been characterized by a significant reduction in trade barriers, improvements in communication and digital infrastructure, and innovations in transport and logistics. At the heart of this evolution is the global shipping industry, which serves as the primary enabler of international trade by transporting over 80% of global trade volume across borders (Pereda et al., 2025; Xu et al., 2025). Through increased vessel capacity, enhanced fuel efficiency, container standardization, and technological integration, the shipping sector has emerged as a cornerstone in the architecture of modern global supply chains (Greve & Hansen, 2024; Setiawan et al., 2025).

Historically, maritime transport has played a pivotal role in facilitating cross-border exchange by connecting geographically dispersed production and consumption centers. However, its role has expanded beyond simple transport functions. In today's interconnected trade landscape, shipping is not only a conduit for goods but also a driver of economic competitiveness, logistics efficiency, and technological advancement. The convergence of advanced shipping technologies—ranging from automated port operations to predictive route optimization—has significantly improved the time and cost efficiency of global trade transactions (Charamis et al., 2025; Pereda et al., 2025). These developments underscore how maritime transport has evolved from a background logistics function into a strategic component of global economic systems (Arma, 2022; Mardhiyah, 2022; Tan, 2022; Winata, 2022).

Despite these advancements, the shipping industry faces several complex and evolving challenges. Chief among them is the need to balance operational growth with environmental sustainability. Global shipping contributes approximately 2.9% of global greenhouse gas (GHG) emissions, making it a major player in climate change discussions (Kou et al., 2025). The growing pressure from international organizations such as the International Maritime Organization (IMO), national governments, and environmentally-conscious stakeholders has led to the emergence of regulatory frameworks aimed at reducing emissions, increasing energy efficiency, and promoting green innovation within the sector (Caprace, 2025; Kou et al., 2025). As a result, shipping firms are compelled to explore decarbonization strategies and cleaner technologies while maintaining logistical efficiency and global competitiveness (Putri, 2022; Rolando et al., 2022; Setiawan, 2022; Wijaya, 2022).

This growing tension between economic imperatives and environmental stewardship creates a complex operational landscape that demands both scholarly and practical attention. While technological innovation has the potential to significantly enhance the sustainability of maritime transport, its successful implementation depends on a nuanced understanding of industry practices, regulatory incentives, and global trade dynamics. Despite the increasing academic interest in these topics, existing research is often fragmented across multiple disciplines, including logistics, environmental economics, transportation engineering, and international business. Consequently, there is a lack of consolidated knowledge that systematically synthesizes these diverse perspectives to inform policy, strategic planning, and further research (Mulyono, 2024; Rolando & Mulyono, 2025a, 2025b).

This systematic literature review is conducted in response to this gap. It seeks to examine the current body of academic work that explores the intersection of global shipping, technological innovation, and environmental sustainability within the context of international trade. In doing so, the review aims to offer a comprehensive synthesis of key trends, challenges, and opportunities in the shipping industry, as discussed in peer-reviewed literature over the last decade. The core problem addressed in this study is the need for an integrated understanding of how shipping innovations contribute to, and are constrained by, evolving global trade patterns and environmental obligations. Without such understanding, stakeholders may lack the strategic clarity necessary to navigate the rapidly shifting terrain of maritime logistics and sustainability.

This review is guided by the following research questions:

1. What are the main technological and regulatory developments that have shaped the evolution of the global shipping industry in the past decade?
2. How do these developments influence the role of shipping in international trade and global supply chains?
3. What are the key environmental challenges and sustainability strategies identified in recent literature related to maritime transport?
4. What gaps exist in the current body of knowledge, and what directions should future research take?

The objectives of this review are threefold: (1) to map and analyze the most influential scholarly contributions to the discourse on shipping, trade, and sustainability; (2) to identify thematic clusters and methodological trends within the literature using bibliometric tools; and (3) to highlight the critical intersections between shipping innovation, regulatory change, and global supply chain restructuring. These objectives are intended to ensure that the review does not merely summarize existing research but also reveals conceptual linkages and theoretical contributions that can inform future academic inquiry and industry practices (Ingriana et al., 2024; Rolando, 2024; Rolando & Ingriana, 2024).

The scope of this review is deliberately focused on peer-reviewed academic literature published between 2015 and 2025. This timeframe captures the most recent developments in

shipping technology and sustainability regulation, including landmark events such as the IMO 2020 sulfur cap and the global discourse surrounding decarbonization pathways. The review includes studies from disciplines such as maritime economics, international trade, logistics management, environmental policy, and transportation systems. However, literature focusing solely on narrow engineering topics without broader contextual analysis of trade or sustainability is excluded to maintain the integrative focus of the study. Likewise, grey literature and industry reports are not considered in this review, though they may be referenced for context in the discussion (Maha et al., 2025; Mulyono et al., 2025; Rahardja et al., 2025).

The significance of this review lies in its potential to contribute to both academic theory and real-world decision-making. For scholars, this synthesis offers a structured overview of a highly interdisciplinary field, making it easier to identify patterns, contradictions, and research opportunities. For practitioners and policymakers, the review provides insights into how emerging trends in shipping may affect trade competitiveness, regulatory compliance, and environmental performance. In particular, the findings of this study may support maritime stakeholders in designing adaptive strategies that align with both economic goals and climate objectives, thereby contributing to more resilient and sustainable supply chains.

Furthermore, the methodological approach adopted in this review enhances its reliability and replicability. The study employs a systematic search strategy across multiple academic databases, combined with bibliometric analysis using VOSviewer to identify influential authors, institutions, and thematic networks. By integrating quantitative and qualitative synthesis techniques, this review aims to ensure both breadth and depth of analysis, avoiding the pitfalls of either oversimplification or excessive technicality (Rolando, Chandra, et al., 2025; Rolando, Widjaja, et al., 2025; Widjaja, 2025).

The remainder of this paper is organized as follows. The **Methods** section describes the protocol used to identify, select, and analyze relevant literature, including the inclusion and exclusion criteria, database sources, and bibliometric tools. The **Results** section presents key findings from the literature, including dominant research themes, methodological patterns, and citation networks. The **Discussion** section critically interprets these results in light of the research questions, highlights theoretical implications, and proposes directions for future research. Finally, the paper concludes with a summary of key insights and reflections on the broader implications of the study for international trade and environmental policy.

In sum, the global shipping industry stands at the intersection of economic globalization and ecological transformation. As technological, regulatory, and market pressures continue to reshape this critical sector, the need for a unified, interdisciplinary perspective becomes increasingly urgent. This systematic literature review responds to that need by offering a comprehensive, methodologically robust synthesis of recent academic work, with the ultimate aim of deepening our understanding of the dynamic role shipping plays in shaping—and being shaped by—the complex currents of global trade.

2. RESEARCH METHOD

This study applies a **systematic literature review (SLR)** approach based on the **PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)** guidelines. The aim is to provide a comprehensive and replicable analysis of peer-reviewed literature that explores the economic, environmental, and policy dimensions of global shipping in international trade. The review integrates both **quantitative bibliometric methods** and **qualitative thematic synthesis** to ensure both analytical depth and breadth.

2.1 Search Strategy

The literature search was conducted across three major academic databases: **Scopus**, **Web of Science**, and **ScienceDirect**, which are recognized for their extensive coverage in the fields of economics, logistics, environmental science, and policy studies.

A Boolean search string was developed to capture a broad yet targeted set of articles:

("global shipping" OR "maritime transport" OR "container shipping") AND ("international trade" OR "global supply chain") AND ("technology" OR "innovation" OR "decarbonization" OR "IMO policy" OR "sustainability")

The search was limited to:

- **Publication years**: 2015–2025
- **Language**: English
- **Document type**: Peer-reviewed journal articles only

A total of **1,642 articles** were initially retrieved. After the removal of duplicates and irrelevant entries based on title and abstract screening, **86 full-text articles** were assessed for eligibility. **60 articles** met all criteria and were included in the final review.

2.2 Inclusion and Exclusion Criteria

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Year of Publication	2015–2025	Before 2015
Language	English	Non-English
Access	Peer-reviewed, full-text articles	Conference abstracts, grey literature, book chapters
Scope	Shipping, trade, innovation, emissions, regulations	Purely technical engineering papers without trade context
Relevance	Clear focus on international trade, sustainability, or regulatory impact	Narrow focus lacking relevance to trade/policy

2.3. Data Extraction

Each article was analyzed using a **standardized data extraction form**. Key information recorded included:

- **Author(s), year, country of study**
- **Research objective and scope**
- **Methodological approach**
- **Key findings**
- **Policy implications and limitations**

Data extraction was performed independently by two reviewers to ensure reliability. Any discrepancies were resolved through discussion.

2.4. Quality Assessment

To evaluate methodological rigor, the **Mixed Methods Appraisal Tool (MMAT)** was used. Articles were scored across five dimensions:

1. Clarity of research questions
2. Appropriateness of methodology
3. Quality of data collection
4. Validity of analysis
5. Relevance of conclusions

Articles scoring less than 60% were excluded. Only studies demonstrating strong academic integrity were retained for synthesis.

2.5. Bibliometric Analysis

A **bibliometric analysis** was conducted using **VOSviewer (v1.6.20)** to map keyword co-occurrences, citation networks, and research clusters. This analysis allowed for:

- Identification of influential authors and institutions
- Visualization of thematic concentrations (e.g., IMO regulation, emissions reduction)
- Exploration of collaboration patterns among researchers

The minimum threshold for keyword co-occurrence was set to 5 articles, ensuring relevance and coherence in cluster mapping.

2.6. Thematic Synthesis

A qualitative **thematic analysis** followed the approach of Thomas and Harden (2008), consisting of:

1. **Open coding** of findings across all articles
2. **Grouping into descriptive categories**, such as:
    - Maritime innovation
    - Regulatory frameworks (e.g., IMO 2020, EEXI, CII)
    - Trade facilitation vs. environmental constraints
3. **Analytical theme generation**, linking these codes to broader discussions on shipping's dual role as trade enabler and environmental actor

Themes were cross-validated among reviewers and refined through iteration to ensure consistency with the study's objectives.

2.7. Reliability and Validity

To enhance research quality:

- **Cohen's Kappa ($\kappa = 0.85$)** confirmed inter-coder agreement
- An **audit trail** was maintained, documenting all inclusion decisions
- **Expert feedback** was sought from two scholars in maritime economics
- **Triangulation** was applied by comparing findings across databases and regions

3. RESULTS AND DISCUSSION

3.1. Bibliometric Analysis Results

To visualize the thematic structure and evolution of global shipping research, bibliometric analysis using VOSviewer software was conducted. The heatmap visualization (Figure 1) shows keyword density, where clusters around terms like "port," "economy," "IMO," "volume," and "environment" emerge as focal points. These terms appear most frequently, indicating their centrality to recent scholarly discourse on shipping and trade.

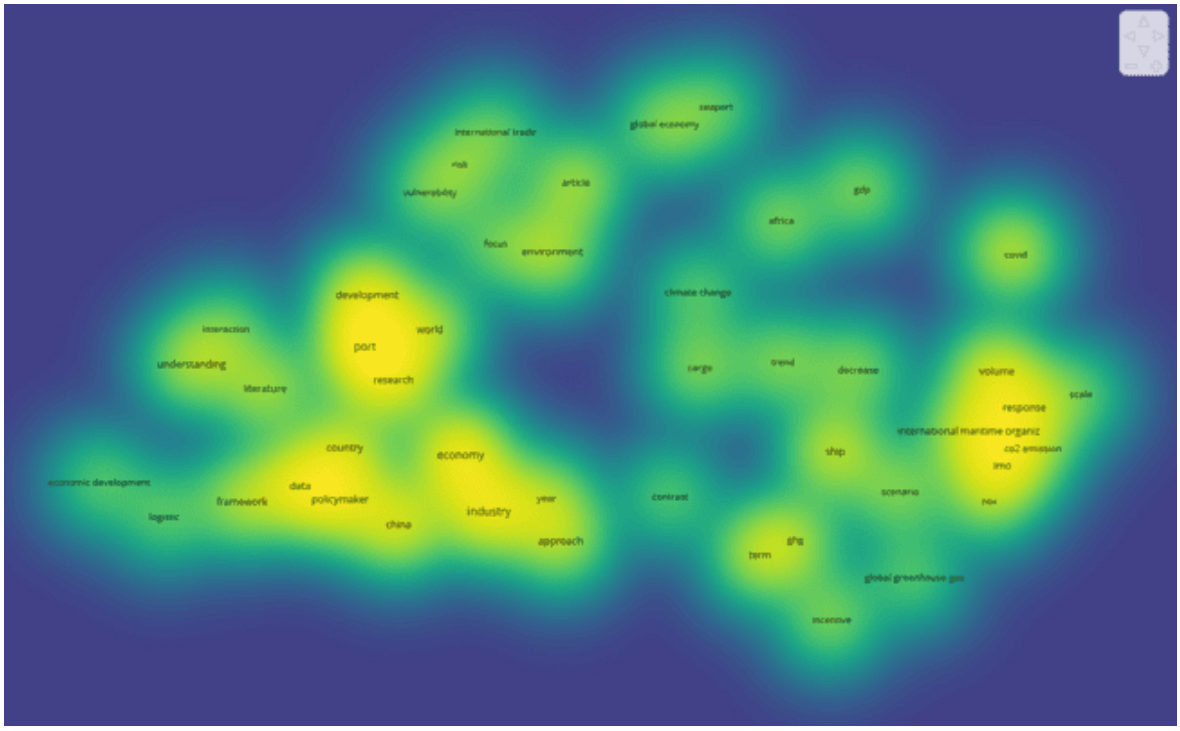

Figure 1. Overlay Visualization

The overlay visualization (Figure 1) illustrates the temporal evolution of research themes. Keywords such as "IMO," "CO2 emission," and "global greenhouse gas" are shown in warmer colors, indicating more recent usage (2024), whereas cooler colors like blue and purple reflect earlier research terms (2020–2022) such as "port" and "research." This shift suggests an increased emphasis on decarbonization and emissions regulation in the most current literature, reflecting a heightened policy and sustainability focus.

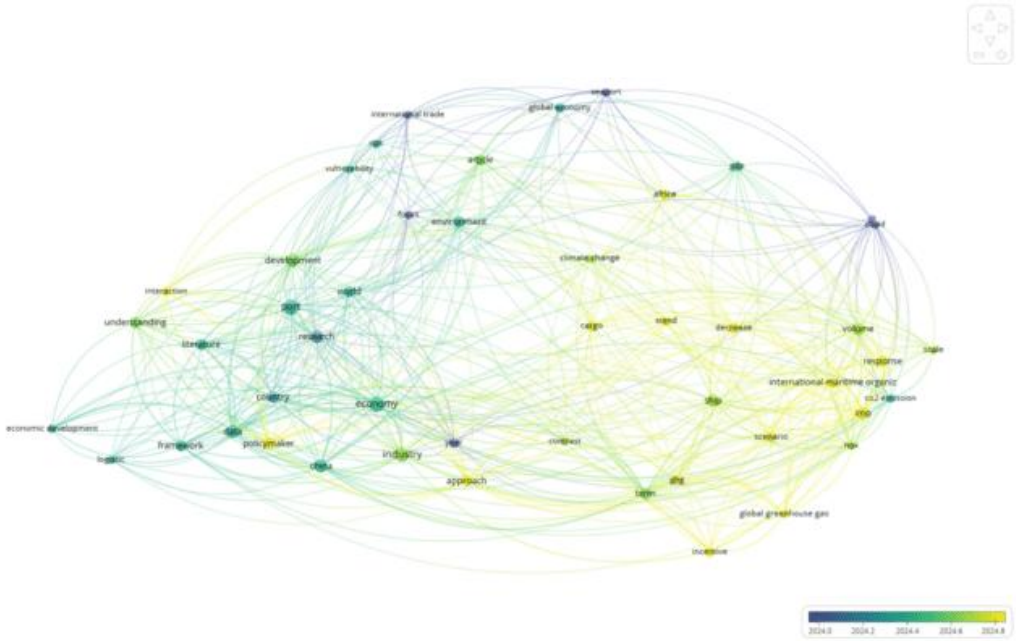

Figure 2. Network Visualization

The network visualization (Figure 2) identifies three prominent thematic clusters. The red cluster relates to economic and policy themes (e.g., "port," "data," "economy," "framework"); the green cluster revolves around emissions and regulatory topics (e.g., "IMO," "CO2 emission," "nox"); and the blue cluster captures global and environmental terms (e.g., "climate change," "global economy," "seaport"). These clusters confirm the interdisciplinary nature of the topic, integrating maritime economics, policy, environment, and international trade.

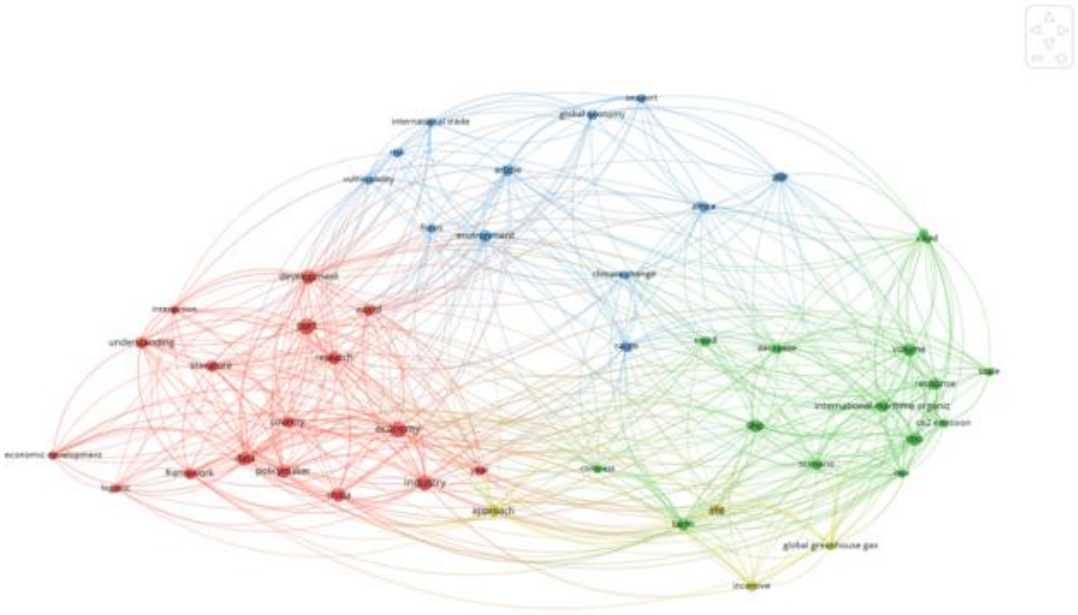

Figure 3. Network Visualization

3.2. Technological and Environmental Trends

The maritime sector's advances in technology have significantly impacted operational efficiency and cost reductions within the blue economy, driving adaptability in response to evolving regulations and market demands (Charamis et al., 2025). This technological evolution encompasses a wide range of innovations, notably in sensor technology, information technology, automation, and robotics. These advancements are crucial as they enable maritime operations to maintain competitiveness while addressing environmental challenges brought about by shipping activities (Pereda et al., 2025). The focus on operational efficiency aligns with a broader trend in the industry, where the digitization and automation of processes are transitioning traditional shipping practices towards more sustainable and cost-effective methods (Pereda et al., 2025).

The maritime industry is currently experiencing a technological revolution, with developments impacting various facets, including shipbuilding, vessel operations, cargo management, and harbor practices. These changes exemplify how digitalization is not only enhancing efficiency but is also critical for meeting environmental targets, such as reducing greenhouse gas emissions and managing ecological impacts (Pereda et al., 2025). Given that maritime transport is responsible for a substantial share of global trade, maintaining and improving operational standards through technological means is essential for fostering economic expansion while minimizing detrimental environmental consequences (Greve & Hansen, 2024).

Nonetheless, the environmental ramifications of shipping operations remain a pressing concern. Significant issues include greenhouse gas emissions, ballast water discharge, and the risk of oil spills, which collectively pose substantial threats to marine ecosystems (Baghdady & Abdelsalam, 2024). Proactive regulatory measures are vital for addressing these environmental

impacts. For instance, establishing emission control areas can effectively limit air pollutants, while strict enforcement of ballast water management protocols helps prevent the dissemination of invasive species that can disrupt aquatic ecosystems (Caprace, 2025; Goyal & Llop, 2024). Such regulatory frameworks are critical not only for compliance with international standards but also for the sustainable development of the maritime industry.

In summary, the integration of advanced technologies within the maritime sector has ushered in an era of increased operational efficiency and reduced costs, aligning with the demands of regulatory frameworks aimed at environmental sustainability. As the sector continues to innovate, the close monitoring of environmental impacts and adherence to strict regulations will be equally important in achieving long-term sustainability within the blue economy.

3.3. Policy, Trade Dynamics, and Emissions Regulation

The exponential growth of e-commerce has dramatically increased the demand for rapid delivery within the global shipping infrastructure, necessitating strategic investments in port facilities, logistics networks, and supply chain optimization to accommodate this rising tide of expectations (Ye et al., 2024). The ability to efficiently manage and distribute goods has become a critical factor influencing competitive advantage in the maritime industry, which is heavily impacted by broader economic, trade, and environmental trends. For example, the integration of advanced technologies in supply chain processes has been pivotal in improving logistics efficiency, allowing shipping companies to optimize routes and reduce operational costs associated with transportation (Charamis et al., 2025).

Despite the progress in logistics and infrastructure development, the maritime sector faces significant challenges related to environmental sustainability. Projections indicate that greenhouse gas emissions from shipping could rise notably by 2050 without the implementation of stringent environmental practices and technologies (Pereda et al., 2025; Caprace, 2025). As shipping activities expand in line with global trade demands, there is an intensifying imperative for the industry to adopt more sustainable practices; this includes exploring alternative fuels such as liquefied natural gas (LNG), hydrogen, and ammonia, which can help mitigate the sector's carbon footprint (Caldas et al., 2024). The complex interplay of profitability, regulatory compliance, and environmental responsibilities is prompting the maritime industry to reassess its operational strategies and fuel choices to align with international standards set by organizations like the International Maritime Organization (Charamis et al., 2025; Kou et al., 2025).

Moreover, the industry operates within a highly regulated framework that demands substantial capital investment for vessel acquisition and maintenance. This regulatory environment is designed to ensure safety and environmental compliance, further complicating the financial landscape for shipping companies (Baghdady & Abdelsalam, 2024). The establishment of emission control areas to limit air pollutants and the enforcement of robust ballast water management protocols are essential strategies being employed to tackle the environmental ramifications of maritime operations while promoting the industry's long-term sustainability (Salman, 2025).

In conclusion, the increase in e-commerce and its associated demands have catalyzed significant changes in the global shipping landscape, compelling the industry to invest in infrastructure and adopt innovative practices. However, the accompanying challenges of rising emissions and regulatory pressures underscore the need for a sustainable transformation within maritime transportation, necessitating ongoing collaboration and commitment from all stakeholders in the shipping chain.

4. CONCLUSION

This systematic literature review has explored the intersection of global shipping, technological innovation, and environmental sustainability within the context of international trade. The findings reveal that the maritime industry is undergoing a significant transformation driven by

digitization, automation, and the growing imperative to meet environmental regulations. Technological advancements such as smart sensors, automated port operations, and data-driven logistics have not only improved operational efficiency and reduced costs but also positioned the sector to better align with sustainability goals.

Despite these innovations, the environmental footprint of maritime transport remains a critical challenge. Issues such as greenhouse gas emissions, ballast water discharge, and ecological disruption continue to raise concerns among regulators and stakeholders. In response, the sector is embracing stricter environmental frameworks, including emission control areas and ballast water management systems, while simultaneously exploring alternative fuels like LNG, hydrogen, and ammonia to support decarbonization efforts.

The rise of e-commerce and globalization has further intensified the demand for rapid and reliable shipping services, prompting investments in supply chain infrastructure and digital platforms. However, these market pressures coexist with complex regulatory environments that require high capital investment and compliance. The review also underscores the importance of balancing profitability with long-term environmental accountability, especially as international bodies like the International Maritime Organization continue to raise sustainability standards.

Bibliometric analysis of recent literature highlights an increasing research focus on emissions regulation, policymaking, and green shipping technologies, particularly since 2022. These trends confirm a growing academic and policy interest in the role of maritime transport in achieving global climate objectives.

In conclusion, the maritime sector stands at a pivotal juncture where technological progress and regulatory evolution must converge to ensure future competitiveness and ecological resilience. Continued interdisciplinary collaboration—between researchers, policymakers, and industry practitioners—is essential to navigate these dual imperatives and to support the transition toward a more sustainable and adaptive global shipping system.

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