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China's shipping emissions governance: status and prospects under the dual carbon goal

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In the context of the global response to climate change, the shipping industry is facing unprecedented pressure and challenges to reduce emissions. Under the unified leadership of International Maritime Organization (IMO), the international community has begun to take actions to promote the development of the shipping industry in a more environmentally friendly and sustainable direction. As an IMO category (a) member, China is promulgating a series of emission reduction policies to guide the green transformation of its shipping industry. This study first examines China's recent shipping emission reduction policy post "dual carbon" proposal, assessing its key focus and the current efficacy of China's shipping emission reduction governance. Based on this, the study examines the challenges China face in reducing shipping emissions. By drawing on global emission reduction practices, we suggest policy measures for China to enhance its efforts and help the shipping industry move towards achieving net-zero emissions.

KEYWORDS

shipping emission reduction, China, maritime policy, dual carbon, carbon emissions trading system

1 Introduction

The shipping industry is the artery of global trade and plays an important role in promoting world economic and trade development and stabilizing the global supply chain. However, as the impact of climate change on human beings becomes increasingly severe, the international community has begun to re-examine the shipping industry, which was once considered an "environmentally friendly" means of transportation. According to IMO "Fourth Greenhouse Gas Study 2020", The greenhouse gas (GHG) emissions — including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), expressed in CO_2e — of total shipping (international, domestic and fishing) have increased from 977 million tons in 2012 to 1,076 million tons in 2018 (IMO, 2020). The international community has recognized the need to take relevant

measures to control greenhouse gas emissions from the shipping industry and has proposed the goal of achieving net-zero emissions from the shipping industry by 2050. China is a major maritime and shipbuilding country. China has a fleet of 249.2 million gross tons, and maritime transport accounts for about 95% of China's foreign trade transportation volume (The State Council of The People's Republic of China, 2023a). As an IMO category (a) member and a party to the Paris Agreement, China is actively participating in emission reductions in the global shipping industry. Under the guidance of China's "dual carbon" goal, China has promulgated a series of policies and regulations for shipping emission reduction to guide the green transformation of the shipping industry. This study provides clear policy guidance for China in ship construction, clean energy research and development, pollution monitoring and prevention and control, and participation in international emission reduction cooperation by sorting out and analyzing the latest policies on China's shipping emission reduction. At the same time, the study found that China's shipping companies are implementing relevant policies to reduce shipping emissions. China's shipping emissions reduction has achieved remarkable results, but there is still a certain gap between achieving the goal of net-zero emissions. Therefore, this study summarizes the advanced experiences in international shipping emission reduction, and proposes to promote the formulation of laws addressing climate change, accelerate the inclusion of shipping industry research into the national carbon emission trading system, and introduce incentive policies to encourage, support, and guide the innovation and development of green and low-carbon shipping technologies. This is to further advance the process of emission reduction in China's shipping industry.

2 Latest trends in China's shipping emission reduction policies

Since China proposed the "dual carbon" goals of achieving carbon peak and carbon neutrality, China has begun to strengthen top-level design, incorporating climate change response into the overall layout of ecological civilization construction and the overall development of the economy and society. The green development of the shipping industry is an important direction of the new round of technological revolution and industrial transformation in global maritime affairs, and it is also an inevitable path for China's shipping industry to achieve high-quality development and realize the "dual carbon" goals. Against the backdrop of addressing climate change and seeking sustainable development, China is implementing a series of emission reduction policies to promote the green and low-carbon development of the shipping industry.

2.1 The necessity of reducing carbon emissions in China's shipping industry

As an important component of the integrated transportation system, the shipping industry serves as a vital support for the economic and social development, major national strategies, and the realization of Chinese-style modernization. Currently, China's waterway freight volume and goods turnover volume account for 16.9% and 53.5%, respectively, of the integrated transportation system. At the same time, the shipping industry handles about 95% of China's foreign trade transportation volume. Looking at port freight volume, China's port cargo throughput and container throughput have ranked first in the world for many consecutive years. Among the top ten ports in the world in terms of cargo and container throughput, China accounts for eight and seven seats, respectively. In 2022, the national port cargo throughput reached 15.685 billion tons, and the container throughput was 296 million TEUs. Looking at inland waterway freight volume, China's inland waterway freight volume has been the world's largest for many consecutive years, with the longest navigable mileage in the world. The Yangtze River mainline has been the busiest and largest golden waterway in global inland water transportation for many consecutive years. In 2022, China's inland water transport completed a freight volume of 4.402 billion tons and a goods turnover volume of 1.9 trillion ton-kilometers (Ministry of Transport of the People's Republic of China, 2023).

The shipping industry plays a significant role in ensuring the safety, stability, and smooth operation of both international and domestic logistics supply chains in China. However, the industry has not yet achieved the ideal state of net-zero emissions. According to statistics, Chinese shipping companies' vessels emit about 78 million tons of carbon dioxide annually. Of this, domestic shipping vessels in China emit about 34 million tons of carbon dioxide per year, while vessels operated by Chinese shipping companies for international voyages emit about 44 million tons of carbon dioxide annually (Peng, 2022). China's shipping emission reduction is facing dual pressures: domestically, to achieve the "dual carbon" goals, and internationally, to achieve the net-zero emissions target by 2050 for the shipping industry (Liu et al., 2023). Based on the responsibility to promote the construction of a community with a shared future for mankind, jointly address climate change, and the need to enhance its voice in global climate governance, China actively participates in international shipping emission reduction and has introduced corresponding policies to align with international shipping emission reduction rules.

2.2 Analysis of the content of China's shipping emission reduction policies

Policy and strategic planning are the greatest driving forces behind the reduction of greenhouse gas emissions in the shipping industry. Among the key tasks in the "Action Plan for Carbon Peaking Before 2030", it explicitly requires the implementation of "Ten Actions for Carbon Peaking", including actions for green and low-carbon transportation (The State Council of The People's Republic of China, 2021a). Under the overall guidance of the "dual carbon" goal, China has promulgated a series of shipping emission reduction policies.

2.2.1 Overall goal: achieve green and low-carbon development of the shipping industry and establish a high-quality shipping development system

Implementing the new development concepts of innovation, coordination, green, openness, and sharing is key to the transportation development in the new era of China. The "Guidelines on Vigorously Promoting the High-Quality Development of the Maritime Industry" in China clearly set the overall requirements: by 2025, to fundamentally establish a high-quality development system for the maritime industry, and by 2050, to fully achieve the modernization of the maritime governance system and governance capabilities (Ministry of Transport of the People's Republic of China, 2020).

As a developing country, China, despite still facing the important task of economic development and the need to maintain the pivotal role of shipping in trade development, has shifted away from the extensive shipping development model of the past. It now places more emphasis on enhancing the comprehensive competitiveness and innovation capability of the shipping industry, considering green, intelligent, and safe development as its important dimensions. Currently, a series of related policies for the low-carbon and green development of the shipping industry, such as the "Marine Environment Law of the People's Republic of China" "Regulations on the Prevention and Control of Marine Environmental Pollution by Ships and Their Related Operations," "Green Development Action Plan for Shipbuilding Industry (2024—2030)," and "Opinions on Accelerating the Green and Intelligent Development of Inland Vessels," have been intensively introduced or updated. The overall development principle is to focus on carbon reduction in shipping as a strategic direction, promote the synergistic increase of pollution reduction and carbon reduction, and achieve a comprehensive green transformation of the shipping industry while promoting the steady development of the shipping economy.

2.2.2 Optimize the energy structure and give full play to the supporting role of scientific and technological innovation in emission reduction

Clean fuels are widely considered to be the fundamental solution for the shipping industry to meet emission reduction targets on schedule (Hoang et al., 2022; Vakili et al., 2022; Wang and Wright, 2021). China's shipping emission reduction policies encourage the development of new energy and clean energy-powered vessels, vigorously promote the use of shore power by ships while at port, and encourage the acceleration of the construction and renovation of port shore power facilities and ship power receiving facilities, aiming to increase the coverage and utilization rates of shore power facilities. In January 2022, China's Ministry of Transport released the "14th Five-Year Plan for Water Transport Development," proposing the establishment of a clean, low-carbon energy system for ports and ships, promoting the normalized use of shore power facilities, and encouraging the research and application of new energy and clean energy vessels powered by liquefied natural gas (LNG), electricity, hydrogen, etc (Ministry of Transport of the People's Republic of China, 2022). Furthermore, to promote the clean, low-carbon, safe, and efficient use of energy, China also considers the utilization of clean energy as an important means of prevention and control in the three major ship emission control areas. According to the provisions of the "Implementation Plan for Ship Emission Control Areas," ships can use clean energy, new energy, onboard energy storage devices, or exhaust gas after-treatment and other alternative measures to meet the ship emission control requirements (Ministry of Transport of the People's Republic of China, 2018).

China's shipping policies emphasize the role of technological innovation in supporting and leading emission reduction efforts. China takes major scientific and technological projects as the leverage, aiming at the forefront of green, low-carbon, and intelligent technologies, and strongly supports research institutions, universities, and enterprises in forming innovative consortia. Together, they engage in research and development on onboard marine carbon capture, utilization and storage (CCUS), ship exhaust gas cleaning systems, and the optimization design of ship propulsion systems, while also driving the coordinated development of upstream and downstream industries along the supply chain.

2.2.3 Accelerate the green transformation of the shipbuilding industry, enhancing the green and low-carbon levels throughout the entire lifecycle of ships

On January 1, 2023, the mandatory measures of the IMO came into effect, introducing new requirements for the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII). To support the IMO's efforts in reducing emissions from shipping, the China Maritime Safety Administration issued the "Management Measures for Ship Energy Consumption Data and Carbon Intensity," which also set new requirements for the manufacturing of ships in China (Maritime Safety Administration of the People's Republic of China, 2022).

China is strengthening the top-level design of the green and low-carbon development standard system for the shipbuilding industry and establishing a comprehensive standard system. The "Green Development Action Plan for the Shipbuilding Industry (2024—2030)" clearly sets the goal of essentially establishing a green development system for the shipbuilding industry by 2030. It not only proposes to make full use of advanced energy-saving and emission-reduction technologies and to implement technological transformations of traditional power vessels to effectively enhance the green level of existing operational ships but also suggests accelerating the green transformation of the shipbuilding industry's product systems, manufacturing systems, and supply chain systems. Additionally, it calls for promoting green development throughout the entire industrial chain of ship design, manufacturing, repair, and dismantling (The State Council of The People's Republic of China, 2023b).

2.2.4 Adhere to the principle of common but differentiated responsibilities (CBDR) and actively participate in international shipping emission reduction cooperation

The principle of CBDR is a foundational principle in addressing climate change and is also an international principle that should be implemented in the reduction of shipping emissions. The principle of CBDR is a specific application of the principle of equity, its core

idea being that while recognizing the shared responsibility of developed and developing countries in reducing emissions, it fully considers comprehensive conditions such as historical carbon emissions, economic strength, technological level, and emission reduction capabilities, to bear different emission reduction responsibilities (Gao, 2018). As a developing country, China has always insisted and called on all countries to take climate actions to address climate change based on the principles of equity and CBDR, in accordance with their national circumstances, and to incorporate this principle into all areas of climate governance, including the reduction of shipping emissions. In the white paper "Policies and Actions for Addressing Climate Change," China reaffirmed the principle of CBDR, insisting on actively participating in global climate governance in accordance with the principles of openness, transparency, broad participation, party-driven, and consensus (The State Council of The People's Republic of China, 2021b).

Addressing climate change is a matter that concerns the fate of all humanity and cannot be achieved without the efforts of every individual (Mao and Zhang, 2024). Therefore, international cooperation is an essential path to achieving the overall goal of global shipping emission reduction. "International cooperation" is almost included as an important component in all of China's shipping emission reduction policies. For example, China's "14th Five-Year Plan for Green Transportation Development" explicitly identifies "improving cooperation mechanisms, deepening international exchanges and cooperation" as one of its main tasks. It proposes to deeply participate in international negotiations on the reduction of greenhouse gas emissions from maritime transport, strengthen international cooperation on low-carbon ship technology, and guide the alignment of international rules with domestic development goals; to consolidate the existing international cooperation network, and to continue to play a positive role in bilateral and regional cooperation mechanisms such as China-US, China-Germany, and China-Japan-Korea (Ministry of Transport of the People's Republic of China, 2021). The "Guidelines on Vigorously Promoting the High-Quality Development of the Maritime Industry" highlight the importance of strengthening cooperation with the IMO, actively participating in global maritime governance, and contributing China's wisdom and strength. It emphasizes enhancing research on maritime safety, green and intelligent technologies, increasing technological contributions, and promoting the alignment of maritime regulations, policies, rules, and standards with countries and regions along the Belt and Road Initiative (Ministry of Transport of the People's Republic of China, 2020).

3 Governance achievements and challenges of China's shipping emissions reduction

3.1 The governance achievements of China's shipping emission reduction

Under the guidance of shipping emission reduction policies, China has continuously achieved new breakthroughs in reducing emissions from shipping. Chinese shipowners are actively fulfilling the mission of green development in shipping, actively planning for carbon emission reduction, reducing carbon emissions through technological energy saving, management energy saving, and technological innovation, vigorously promoting green shipping, and improving the level of energy efficiency management. Since 2021, a batch of 23,000 TEU dual-fuel powered container ships has been delivered, and the first 174,000 cubic meters liquefied natural gas floating storage and regasification unit has been delivered. Bulk carriers powered by 210,000 tons of LNG, dual-fuel stainless steel chemical ships, 7,000-car dual-fuel car carriers, 150,000-ton Suezmax ammonia-fuel ready oil tankers, and methanol-powered dual-fuel MR-type oil tankers and other green-powered vessels have been undertaken in batches (Xie et al., 2022). According to statistics from the China Classification Society, as of June 2022, the completion rate of shore power receiving facility modifications for coastal domestic dry bulk carriers reached 71%. The Energy Efficiency Operational Indicator (EEOI) of China's shipping industry has decreased by about 20% compared to 2010. At the same time, the emissions of NOx and SOx in China's shipping industry have decreased by about 30% and 40%, respectively, compared to 2010 (Xie, 2023). "Shipping Pioneers 2022: A Study on the Progress of Shipping Pollution Reduction and Carbon Reduction" shows that by the end of November 2022, the proportion of new ship orders applying energy-saving technologies and alternative fuels reached up to 40.6% and 37% of the shipping capacity, respectively (Clean Air Asia, 2022a).

Chinese ports are also undergoing a green transformation, with the application of renewable energy in ports having initially developed, and port shipping logistics operations and the fuel technology of gathering and distributing equipment are exploring greening. Represented by the construction of the "China Hydrogen Port" in Qingdao Port, the progress of green port construction ranks among the top in the world, having formed a momentum that leads the global construction of new energy ports (Shan, 2023); Ningbo Port has adopted the international standard ISO 14001 environmental management system and, in combination with local actual conditions, has developed a series of supporting management and operation regulations; Tianjin Port's Beijiang Port Area utilizes an "integrated wind-solar-storage-load" smart green energy system to achieve grid-connected power generation (Wang and Zhang, 2022); Shanghai Port is actively exploring technologies such as "oil to electricity" conversion for cranes, "oil to gas" and "oil to electricity" conversions for container trucks, energy feedback technology, and supercapacitors. By 2022, it has completed the electrification transformation of 75% of crane equipment. "Blue Port Pioneers 2022: Evaluation of Air and Climate Synergy in China's Typical Ports" shows that in 2021, the shore power coverage rate for specialized berths in China's inland ports basically reached 100%, effectively controlling the emission of air pollutants and greenhouse gases from auxiliary engines of ships at port. The process of cleaning up some ports is accelerating, with Qingdao Port, Jiujiang Port, Ningbo-Zhoushan Port, and Wuhan Port having more than 50% of their energy consumption coming from electricity (Clean Air Asia, 2022b).

Overall, China has achieved significant emission reduction results in the shipping sector through a series of innovative

policies and technological measures. China has successfully reduced the carbon emissions of the shipping industry, promoting a green and low-carbon transformation of the industry. These efforts not only help alleviate the pressure of climate change but also lay a solid foundation for the sustainable development of China's shipping industry.

3.2 Challenges facing China's shipping emissions reduction

Emission reduction in shipping poses a protracted and difficult challenge. Although China has already achieved significant results, it is important to note that the overall level of emission reduction in China's shipping industry has not yet reached the world-leading standard. Key emission reduction technologies such as the application of clean energy, efficient engines, and new ship design methods are still in the hands of traditional maritime powers like Europe, America, Japan, and South Korea. Moreover, given the massive scale of China's shipping industry, the country still faces significant pressure and challenges in the process of reducing emissions in shipping.

On one hand, current international shipping policies and regulations are becoming increasingly stringent. The 75th meeting of the IMO Marine Environment Protection Committee approved a mandatory document, namely the draft amendments to MARPOL Annex VI regarding the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) among other short-term measures for reducing emissions in the shipping industry. These amendments, from a technical perspective, have reduced the leeway of developing countries in global greenhouse gas reduction, to some extent constituting a violation of the principle of CBDR, which has significantly increased the pressure on shipping emission reduction for developing countries like China (Lee, 2012). Furthermore, different regions and industries, such as the European Union, the International Association of Classification Societies, and others, are actively promoting the reduction of greenhouse gas emissions in international shipping, raising emission reduction standards to accelerate the emission reduction process.

On the other hand, there are also challenges related to policy, economy, and technology for shipping emission reduction within China. Firstly, the current policies for emission reduction in China's shipping sector have not yet formed a unified system, with legal norms regulating green shipping being at a lower level and the means for reducing emissions in shipping being relatively singular. The regulation of carbon reduction in shipping in China is mainly concentrated in the low-level departmental normative documents and other policies, which has strong characteristics of soft-law (Yang et al., 2023). Secondly, the green transformation of shipping involves precise technological research and development as well as substantial financial investment. China's efforts to reduce emissions in shipping need to take into account the basic national conditions and the needs of economic development, while also appropriately considering the cost of green transformation for shipowners. For example, the International Renewable Energy Agency's publication, "Pathways to Decarbonize Shipping by 2050," provides predictive analyses on the costs, implementation periods, and safety aspects of various fuels and energy sources for shipping emission reduction. It is not difficult to see from the report that reducing emissions in shipping requires substantial financial investment, high technical requirements, and significant time costs (DNV, 2021).

4 Recommendations for the development path of emission reduction in China's shipping industry

Considering the governance effectiveness and challenges faced by China in reducing shipping emissions, this section, based on summarizing the advanced policy management experiences of international shipping emission reduction from the European Union, the United States, Norway, South Korea, and other countries, proposes recommendations for China to further promote its path to shipping emission reduction.

4.1 Research and formulate a climate change response law, and incorporate shipping emission reduction into it

After the Paris Agreement entered the substantive implementation phase, the focus of global climate governance has shifted from international legislation to domestic legislation. Promoting the process of addressing climate change through the construction of legal systems has become a consensus among many countries (Tian and Zheng, 2020). Currently, many countries including the United Kingdom, Japan, and South Korea have enacted climate change laws, completing the transformation from national climate policies to national climate legislation. However, China has only introduced specific laws such as the "Air Pollution Prevention and Control Law" and the "Energy Conservation Law," without establishing a unified climate change law. Formulating a climate change law could lead the various legislations on climate change response in China, further perfecting China's legal system for addressing climate change (Li, 2010). Therefore, it is necessary to draw on the legislative experience from abroad to formulate a climate change law that regulates carbon emissions, integrating fragmented relevant regulations. This approach will better guide the emission reduction process across all sectors, including the shipping industry, to achieve the "dual carbon" targets.

To formulate a climate change law with Chinese characteristics, it is first necessary to scientifically establish the legislative objectives, purposes, and principles. It is recommended to incorporate the "dual carbon" targets into the legislative objectives, comprehensively integrate fragmented regulations of key areas and industries, and make specific provisions in dedicated chapters. Secondly, it is necessary to improve the corresponding supporting measures, establish a carbon budget system and monitoring and evaluation systems, clearly define the responsibilities of each department and the coordination among them, and set up a cross-sectoral climate change

committee to revise and adjust the emission reduction targets and regularly assess the effects of emission reduction.

4.2 Integrate the shipping industry into the national carbon emissions trading system

The carbon emissions trading system is considered an important mechanism for addressing climate change. China's carbon emissions trading system officially went into operation in 2021. Studies have shown that the carbon emissions trading system can effectively decrease the total carbon emissions (Li et al., 2024). However, China's carbon emissions trading system mainly covers key industrial sectors such as steel, power, chemicals, building materials, paper-making, and non-ferrous metals, and does not include the shipping industry.

According to the IMO's "Initial Strategy on the Reduction of Greenhouse Gas Emissions from Ships," market mechanisms have been widely discussed as a medium to long-term emission reduction policy. In this regard, the European Union appears to be more aggressive. According to the EU Directive 2023/959, starting from January 1, 2024, the shipping industry will be included in the EU carbon emissions trading system. The EU advocates market-based mechanisms alongside technological and operational measures for the shipping industry. This is because the future increase in global trade will be positively correlated with increasing carbon emissions caused by an increasing number of ships, which could offset the reduction in carbon emissions resulting from the improved energy efficiency of ships (Mao et al., 2023). Currently, Shanghai, China, has initiated a pilot project to include the shipping industry in the carbon trading market system, based on the completion of preliminary research and the solicitation of opinions from relevant departments and enterprises. China should promptly, based on the actual effects of the Shanghai pilot, draw on the experience of the European Union to accurately develop a complete shipping carbon emission trading system. This includes setting the total amount of shipping carbon emissions, devising a reasonable initial carbon emission allocation plan, improving the carbon emission rights regulation system, implementing a unified and flexible compliance mechanism for carbon emission rights, etc., and integrating it into the national carbon emissions trading system.

4.3 Formulate incentive policies to encourage, support, and guide the innovative development of green and low-carbon shipping

Incentivizing market entities to rationally allocate environmental resources driven by the pursuit of maximizing their own interests can truly activate the carbon emission reduction market in shipping. Research shows that government incentives for both ports and shipping enterprises can increase the emission reduction efforts of both parties (Meng et al., 2022). Longer term, deeper decarbonization will require strong financial incentives (Paul et al., 2019).

The International Chamber of Shipping (ICS) stated at the Global Sustainable Transport Forum held in Beijing on September 26, 2023, that if the IMO wants to achieve the zero emissions goal, it is urgently necessary to adopt a "fund and incentive" mechanism to encourage the production of green ship fuels. The United Kingdom, the European Union, and other countries have invested substantial funds to support the development of shipping zero emissions and green maritime technologies. Currently, economic incentives for China's shipping industry have not been fully implemented nationwide, with only some provinces and cities having introduced economic incentives for shipping, such as the "Interim Measures for the Management of Subsidy Funds for the Construction of Green and Low-Carbon Ports in Shenzhen" and the "Shanghai Port Shore Power Construction Scheme," among others. Furthermore, the financial support mechanism for green shipping in our country is relatively scarce, which is not conducive to the research, development, and innovation of energy-saving and emission-reduction technologies. Some policy documents and local legislations are only principled regulations, lacking guidance on specific content (Jiang, 2022). Therefore, it is essential for China to issue incentive policies at the national level, exploring diverse and comprehensive green shipping financial service schemes to encourage, support, and guide the innovative development of green and low-carbon shipping. It is particularly necessary to mobilize enthusiasm across all aspects and the entire industry chain of shipping emission reduction, including research and development of clean energy, optimization of ship and port construction, among others.

5 Conclusions

Amid the increasingly severe global climate change, achieving carbon neutrality has become a common goal for the global shipping industry. As one of the most important shipping markets in the world, China plays a crucial role in the emission reduction governance of the shipping industry. This study explores the current status and prospects of China's shipping emission reduction governance and finds that under the dual drive of the "dual carbon" goals and global shipping emission reduction targets, the Chinese shipping industry has begun to take active measures, such as optimizing the energy structure, accelerating the green transformation of the shipbuilding industry, and participating in international cooperation on emission reduction. These efforts have significantly reduced carbon emissions and made an important contribution to the global shipping industry's emission reduction. However, compared to the ultimate goal of achieving net-zero emissions in the global shipping industry, China's efforts in shipping emission reduction still face numerous challenges in terms of policy, economy, and technology. This study suggests that, while continuing to uphold the IMO's leadership in global shipping emission reduction, China should, based on its own national conditions and the development status of the shipping industry, draw on the advanced experiences of current international, regional, and national emission reductions. By improving legislation, extending the national carbon emission trading system to the shipping industry, and establishing incentive systems, China can provide clearer guidance and stronger support for the green transformation of its shipping industry.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

MH: Conceptualization, Writing – original draft. YD: Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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