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Analytical review of shipping carbon emissions trading scheme and the impacts on the Chinese shipping sector

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ANALYTICAL REVIEW OF SHIPPING CARBON EMISSIONS TRADING SCHEME AND THE IMPACTS ON THE CHINESE SHIPPING SECTOR

By

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The People's Republic of China

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Date: …………………2022.6.28……..……………….

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Supervisor's affiliation: .…………Dalian Maritime University…………

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At this point, after more than a year of study, my postgraduate studies will come to an end. It started in early summer and ended in mid-autumn festival, this thesis ends in Chapter 5, but this learning experience, will give my future career countless possibilities.

As a member of the China MSA system, I would like to thank the organization and leadership for their trust and support, and for this opportunity to study. After returning to work, I will actively apply the knowledge I have learned, stand on the post, face the future, and contribute to the construction of Chinese maritime industry.

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Road ahead is long and hard. Persist, success is in card. I am grateful for all the encounters and differences. Romain Rolland said that “There is only one heroism in

the world: to see the world as it is, and to love it." May we all be strong, kind and brave, and become a better version of ourselves. The sky is far away, we shall meet again someday.

ABSTRACT

Title of Dissertation: **Analytical review of shipping carbon emissions trading scheme and the impacts on the Chinese shipping sector**

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The advent of steamships in the 19th Century made fossil-fuel ships the primary means of transporting goods around the world. However, carbon emissions from shipping have been outside the international climate negotiations, and the major international climate conventions based on UNFCCC have not made clear constraints and regulations. In order to reduce shipping carbon emissions, IMO has made a series of efforts, including entry into force of the Initial IMO Strategy on Reduction of GHG Emission from ships, progressive amendments of Annex VI of MARPOL etc. However, IMO has not yet completed discussions on shipping MBMs.

In order to achieve higher carbon reduction ambitions, the EU proposed a legislative package in July 2021 to unilaterally include international shipping in the EU-ETS from 2023, which has caused widespread controversy in the international maritime community. This paper reviews the history of the development and main mechanisms of EU-ETS and concludes that EU-ETS has certain advantages in terms of system, trading and promoting the development of emission reduction technology, but it also has obvious shortcomings and risks in economic, political, legal aspects and carbon leakage, which has caused the embarrassing situation of EU-ETS.

This paper elaborates on the basic status of the Chinese shipping sector. Based on data calculation and analysis, the inclusion of international shipping sector into EU-ETS will impose a huge cost burden on Chinese shipping sector and will have a chain effect on the competitiveness of the Chinese goods and the sustainable development of China-EU trade. The author offers suggestions for response in three areas: diplomacy, litigation, and domestic institution construction. For the global ETS which is still under discussion, this paper mainly uses SWOT analysis to make a hypothetical analysis on the possible internal and external environment faced by Chinese shipping sector, and discusses the opportunities and risks that Chinese shipping sector will face as a result. Finally, it is considered that Chinese shipping sector may face more risks and challenges under the global ETS, so this paper also proposes suggestions for improvement and development from both national and enterprise levels.

KEYWORDS: maritime transportation; shipping CO2 emission; Chinese shipping sector; EU ETS; SWOT; MBMs

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LIST OF ABBREVIATIONS

BIMCO	Baltic and International Maritime Council Organization
CBDR	Common But Differentiated Responsibilities
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
COP	Conference of the Parties
COSCO	China Ocean Shipping (Group) Company
COSCON	COSCO Container Lines
COVID-19	Corona Virus Disease 2019
CSCL	China Shipping Container Lines
DCS	Data Collection System
EC	European Commission
ECA	Emission Control Areas
ECSA	European Community Shipowners' Associations
EEA	European Economic Area
EEDI	Energy Efficiency Design Index
EEOI	Efficiency Operational Indicator
ETS	Emission Trading System
EU	European Union
EUA	European Union Allowance
GDP	Gross Domestic Product
GHG	Greenhouse Gas

GRT	Gross Register Tonnage
ICS	International Chamber of Shipping
IET	International Emission Trading
IMO	International Maritime Organization
IMRF	International Maritime Research Fund
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation Mechanism
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MBM	Market-Based Measure
MEPC	Environmental Protection Committee
METS	Market Emission Trading System
MRV	Monitoring, Reporting and Verification
NMFT	No More Favorable Treatment
SEEMP	Ship Energy Efficiency Management Plan
SME	Small and Medium Enterprise
SIDS	Small Island Developing States
UK	the United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate change
US	the United States
WMO	World Meteorological Organization
WSC	World Shipping Council

WTO	World Trade Organization

CHAPTER 1 INTRODUCTION

1.1 Background

Since the 1990s, the increase in Greenhouse Gases (GHGs) caused by the growth of the world economy has brought about increasingly serious environmental problems. The international community has begun to pay extensive attention to the issues of climate change and environmental protection. A series of international conventions, rules and standards have also emerged, such as the United Nations Framework Convention on Climate change (UNFCCC) to comprehensively control GHG emissions and deal with global warming, the supplement and improvement of UNFCCC, the legally binding Kyoto Protocol, and the Paris Agreement to make action arrangements to deal with global climate change. Although the international convention has set quantifiable and definite targets, in fact, a series of chain reactions caused by the continuous global warming are intensifying, and the world is about to miss the window to achieve the temperature control goals of the Paris Agreement. The United Nations Intergovernmental Panel on Climate Change (IPCC) "AR6 WG I report" believes that unless global carbon dioxide (CO_2) and other GHG emissions are cut deeply in the next few decades, the global surface temperature in the 21st Century will increase by more than 1.5 °C and 2 °C (FAN, QIN, & GAO, 2021, p. 44-48).

In addition to the international macro-level climate control goals, various industries have also begun to formulate GHG emission control systems within the industry. Raw materials and commodities Shipping around the world by sea has proven to be the most cost-effective and the least energy-intensive mode of transport compared to air, rail and road transport, with 90% of global trade being done by sea. However, shipping accounted for approximately 3.1% of annual global CO_2 and approximately 2.8% of annual GHGs on a CO_{2e} basis using 100-year global warming potential and the total amounts are still very large (International Maritime Organization, 2014). According to the statistics, in 2020, the transportation industry shared 20.1% of the global carbon dioxide emissions, which is 7.29 GT CO_2 (See Figure 1). Maritime transport accounts for 11% of total CO_2 emissions from the global transport industry (See Figure 2).

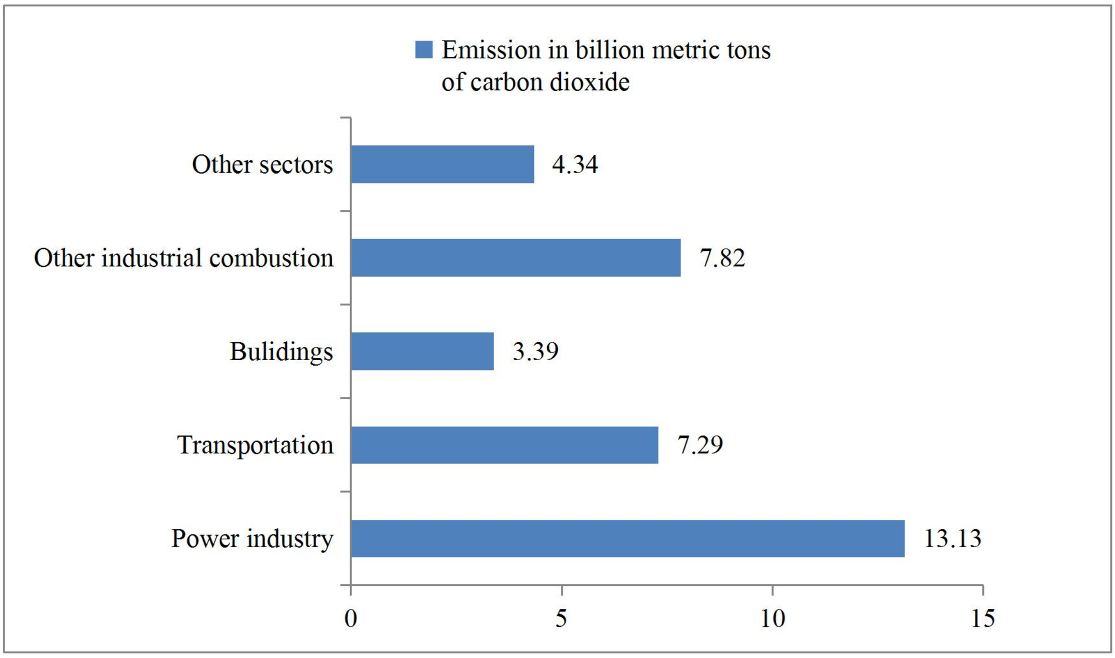

Figure 1 - Global carbon dioxide emissions in 2020, by sector (in billion metric tons of carbon dioxide)

Source: Tiseo, I. (2022, January 19). *Global carbon dioxide emissions in 2020, by sector (in billion metric tons of carbon dioxide).* Retrieved March 29, 2022 from the World Wide Web: https://www.statista.com/statistics/276480/world-carbon-dioxide-emissions-by-sector/

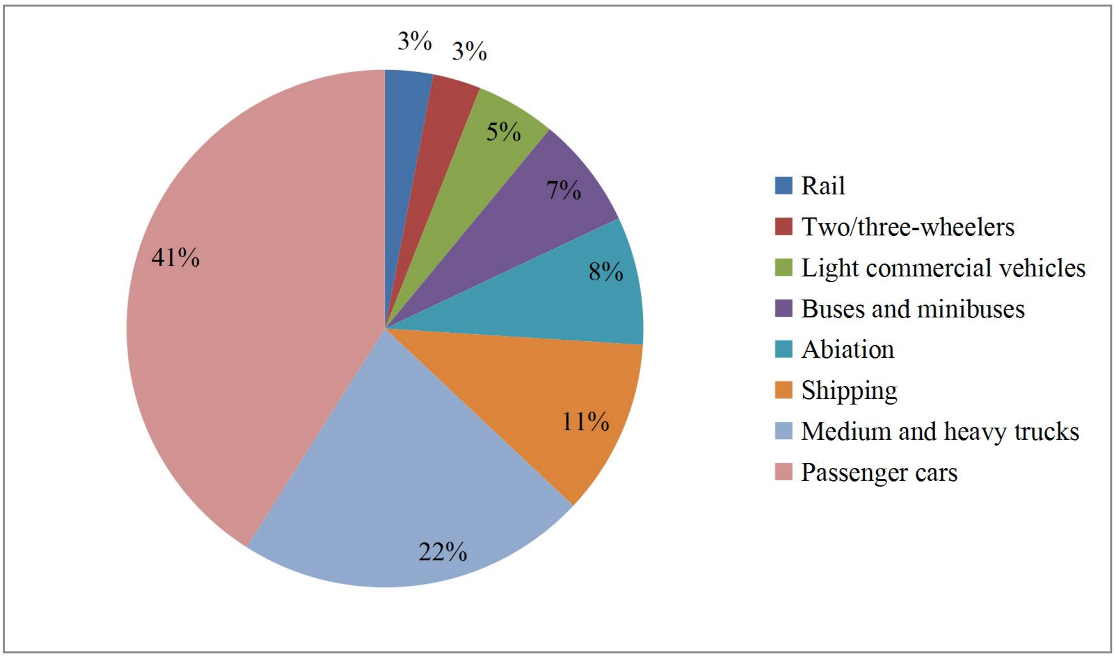

Figure 2 - Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2020, by subsector

Source: Tiseo, I. (2021, December 14). *Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2020, by subsector.* Retrieved March 29, 2022 from the World Wide Web: https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/

However, due to the global nature, mobility and open registration of the international shipping, carbon emissions from the international shipping industry have not been included in the UNFCCC. In the Kyoto Protocol, the management of carbon emissions from the international shipping industry was entrusted to the International Maritime Organization (IMO). Since then, IMO has commissioned the Marine Environmental Protection Committee (MEPC) to carry out relevant research work on emission reduction of shipping, and has continuously formulated and issued reports on GHG emissions from shipping and various mandatory regulations to prevent ships from polluting the environment. The fourth IMO GHG Emissions Report in 2020 pointed out that although there are fluctuations, the GHG emissions from shipping and the proportion of global emissions are generally on the rise (International Maritime Organization, 2021). The trend in global GHG emissions and seaborne trade grew largely in tandem during 2008-2009, after which the seaborne emissions decoupled from trade volumes, and although the annual emissions fluctuated, the carbon intensity of the seaborne emissions never exceeded the amount in 2008 again, with an overall declining trend. The total GHG emissions from maritime transport did not continue to increase between 2012 and 2018, but rather declined between 2012 and 2014, before rebounding and maintaining a modest increase in 2015, and then showed a slight decline in 2018 (See Figure 3). From 2012 to 2018, the global CO_2 emissions from shipping (including international, domestic and fishing vessel emissions) increased from 962 million tons to 1.056 billion tons, an increase of about 9.3% (the actual should be 9.8%), and the global share of emissions increased from 2.76% to 2.89% (International Maritime Organization, 2021). Report predicts that global CO_2 emissions are expected to reach 90% - 130% of 2008 levels by 2050, excluding the impact of COVID-19 (Corona Virus Disease 2019) (International Maritime Organization, 2021). The rebound in carbon emissions from international maritime transport in 2021 also shows that the task of reducing carbon emissions from international maritime transport is very difficult, and some scholars, after analyzing the forecast of shipping demand and applying carbon budgeting methods, believe that the Initial IMO Strategy on Reduction of GHG Emissions from Ships published in 2018 is no longer able to meet the standards of the Paris Agreement. Some countries and regions are therefore strongly calling for the introduction of market-based measures (MBMs) based on the IMO technical and operational targets to provide an economic incentive for ship owners and operators to improve their technology and operating models to further improve the energy efficiency of their ships and reduce maritime GHG emissions (Bullock, Mason, & Larkin, 2021).

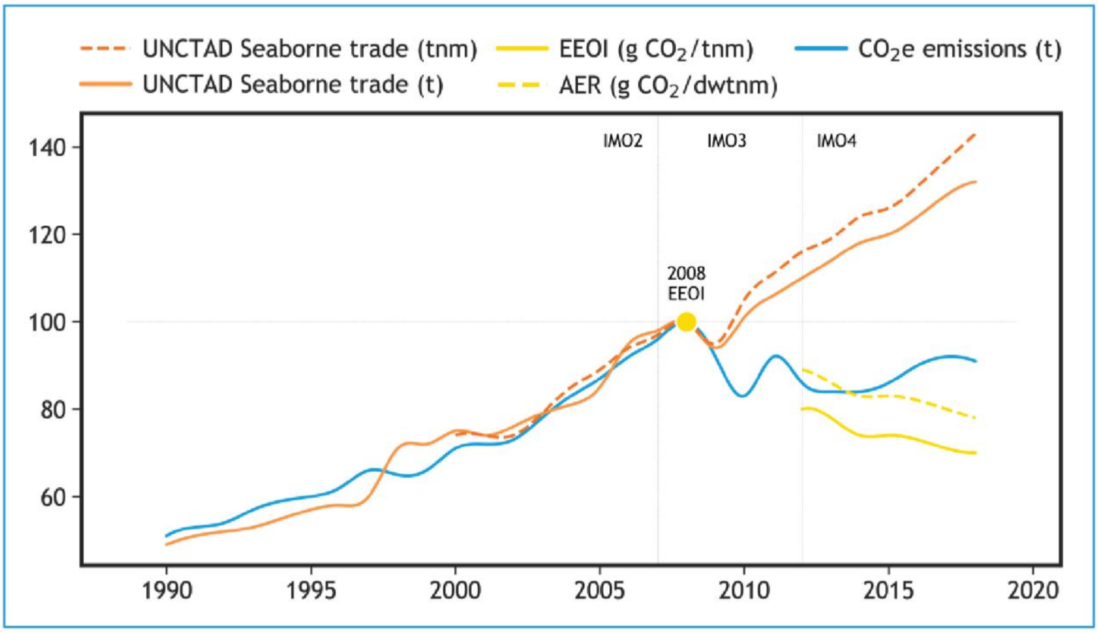

Figure 3: International shipping emissions and trade metrics, indexed in 2008, for the period 1990-2018, according to the voyage-based allocation of international emissions

Source: International Maritime Organization. (2021). *Fourth IMO GHG Study 2020 Full Report.* London: Author.

The European Union (EU) has long regarded itself as a global leader on climate issues and has greater ambitions to reduce emissions. Following the enactment of the EU

Aviation Directive in 2008 to include international air transport in its EU Emissions Trading System (EU-ETS), the EU has sought to include international shipping as well (Psaraftis, Zis, & Lagouvardou, 2021). In 2018, the EU issued a directive that if the IMO fails to make significant progress in 2023, it will take unilateral measures to include shipping in the European Emissions Trading System. On July 14, 2021, the "Fit for 50" legislative package submitted by the European Commission (EC) included the shipping industry in the EU-ETS in 2023, which caused great controversy in all walks of life around the world (European Commission, 2021).

China is the second largest economy in the world in terms of Gross Domestic Product (GDP) and the largest in terms of CO_2 emissions (ZHOU & CUI, 2021). China is also the world's largest shipping nation, with the second largest fleet in the world in terms of total capacity (Maritime China, 2021, p. 52+7). At the same time, China is also the largest economic and trade partner of the EU (European Union, 2021). In the context of the forthcoming inclusion of the shipping industry in the EU-ETS, the discussion of the possible impact on the Chinese shipping sector will help the Chinese government and shipping companies to make timely policy planning and operational adjustments. At the same time, the EU's decision has once again brought the possibility of establishing a global ETS for shipping into the international perspective. A comprehensive analysis of the operating principles of the ETS and the opportunities and challenges that the Chinese shipping sector may face the regional and global ETS will provide reference significance for the development of China's carbon trading market and the green transformation of Chinese shipping sector.

1.2 Literature review

(1) The legal validity of shipping ETS

Scholars and international organizations have studied the legal validity of shipping ETS, mainly focusing on the legal applicability of EU-ETS under the international environmental legal system, the international maritime legal system, the rules of the World Trade Organization (WTO), and how to build the legal framework of China's carbon emissions trading system. A study by the European Community Shipowners' Associations (ECSA) and International Chamber of Shipping (ICS) analyzed the relationship between the EU and the 1982 United Nations Convention on the Law of the Sea (UNCLOS 1982) and IMO and concluded that the EU's unilateral actions could lead to conflicts of international obligations (European Community Shippowners' Associations & International Chamber of Shipping, 2020). HU and HOU conducted a more comprehensive analysis from the legality, extraterritorial effect, climate change, and ship jurisdiction of EU-ETS, and they both came to the conclusion that the EU's unilateral measures would violate the relevant provisions of various international laws (HOU, 2019 ; HU, 2015). CAI and GAO believe that in the context of the increasing willingness to establish a shipping carbon emissions trading system internationally, a reasonable shipping carbon emissions trading legal system should be established (CAI, 2020 ; GAO, 2017). Although they all proposed that the identification of shipping carbon emissions entities is an important part of building a legal system, CAI believes that the trading entity of the shipping carbon emissions trading legal system should be the ship owner, while GAO believes that according to Coase's second theorem, "property rights" should be more appropriate to define the actual controller of the ship (CAI, 2020 ; GAO, 2017). But their shortcomings are that they did not summarize and formulate the basic legal framework, but only analyzed several key points.

(2) The economic impact of shipping ETS

Wang et al. found that both open ETS and market ETS (METS) will "wind down" the profits of shipping companies, and reduce the speed, volume and fuel consumption of the container and bulk sectors (WANG, FU, & LUO, 2015, p. 35-49). Scholars have different conclusions on the impact of fuel prices on carbon emissions. ZHU et al. argue that METS can provide incentives for shipping companies to use new technology to upgrade their fleets rather than retrofitting existing ships and that the higher the fuel price, the better the effect of METS on carbon emissions (ZHU, YUEN, GE, & LI, 2018, p. 474-488). However, GU et al. come to a different conclusion.

They argue that the impact of MEST on CO_2 emissions is greater at low fuel prices, and that in most cases METS do not guarantee short-term emission reductions and in some cases may even increase CO_2 emissions (GU, Wallace, & WANG, 2019, p. 318-338). Taking the China's iron ore trade as an example, KE's quantitative analysis also concluded that the lower the price of fuel, the greater the proportional reduction in trade and carbon emissions at the same level of carbon credit price, and believed that sacrificing 1% of trade to achieve a 6%-8% reduction in carbon emissions is more beneficial than detrimental (KE, 2017). This difference is mainly due to the fact that they used different assumptions and variables in the model construction, but failed to fully cover the factors affecting shipping carbon emissions, resulting in relatively one-sided conclusions. ZHU quantitatively evaluated the carbon emission reduction and industry economic impact after China's international shipping industry was included in the carbon trading market, and concluded that the lower the free quota, the less available, faster the price rises, the more serious the economic losses of the industry will be (ZHU, 2019). The shortcoming is that the internal carbon trading situation of the internal shipping enterprises has not been analyzed. If the internal autonomy of the enterprises is considered, the carbon emission reduction and economic impact need to be further discussed (ZHU, 2019).

(3) The institutional analysis of Shipping ETS

In studying the EU-ETS, ECSA, ICS and the World Shipping Council (WSC) have all concluded that the inclusion of international trade ships in the EU‐ETS will result in an increase in absolute carbon emissions outside the EU and may distort the shipping market (European Community Shippowners' Associations & International Chamber of Shipping, 2020 ; World Shipping Council, 2020). However, Christodoulou et al. have also proposed that by establishing different benchmarks in each sector, we can not only reward energy-saving ships in each sector, but also avoid competition distortions within the marine industry (Christodoulou, Dalaklis, Ölçer, & Masodzadeh, 2021). However, the author who came to this conclusion did not consider the size of the ship in the course of the study, which is a decisive factor affecting energy efficiency

(Christodoulou, Dalaklis, Ölçer, & Masodzadeh, 2021). In the study of global ETS, Psaraftis, Lagouvardou, GAUDIN, Chai, K.-H, Kachi et al. compared ETS with carbon tax to verify whether ETS should use the institutional advantages of the shipping industry. The conclusions reached by scholars are mostly negative. On the one hand they argue that the existing carbon trading systems shows that the lack of a method for adjusting prices in the ETS structure and the high volatility of carbon prices due to changes in many other factors not only influence investors' decisions and hinder the achievement of the objective of stimulating the development of emission reduction technologies, but also create distortions in the shipping market (Psaraftis & Lagouvardou, 2019 ; GAUDIN, 2019 ; Kachi, Mooldijk, & Warnecke, 2019). On the other hand, the complexity of ETS system is also a concern of scholars. They believe that ETS needs to establish a special operation and audit system, which has higher management costs than fuel tax, and has great obstacles in legal issues, administrative burden issues and business impact issues, so the feasibility will be lower than carbon tax (Psaraftis, Zis, & Lagouvardou, 2021 ; Chai, Lee, & Gaudin, 2022). YAN's " Emission Trading Policy for International Shipping: Design and Impact Assessment" has studied and designed a carbon emission reduction market mechanism that conforms to the characteristics of international shipping and evaluates the effect and impact of the established mechanism (YAN, 2020). The paper innovatively proposed new allocation rules, and provided some suggestions for policy makers and researchers of international shipping emissions reductions, but it considered less hypothetical factors affecting business operation strategies (YAN, 2020).

(4) The impact of EU-ETS on the Chinese shipping sector

The advantages and disadvantages of EU-ETS and the possible consequences of EU unilateral action were mainly studied (SUN, LIN, & CHANG, 2021, p. 64-68 ; SHEN, 2020, p. 54-57 ; GONG, 2021, p. 52-54). The conclusion of the literatures affirms the advantages of EU-ETS in terms of coercion, transaction flexibility and innovation, but also believes that the EU's unilateralism not only creates "IMO&EU" double standards for shipping companies, but also increases the complexity of shipping companies, risk of carbon leakage and increased management costs and international shipping costs pose challenges to China-EU economic relations (SUN, LIN, & CHANG, 2021, p. 64-68 ; SHEN, 2020, p. 54-57 ; GONG, 2021, p. 52-54). The downside is that it fails to provide an effective solution to the current situation.

(5) Evaluation of existing research

In general, the current research is mostly about the advantages and disadvantages of EU-ETS and global ETS compared with other MBMs, and there is also a macro analysis of the possible impact on global shipping, a few of which focus on one or two sectors of the shipping industry. There is a certain amount of research on the possible impact of EU-ETS on Chinese shipping sector in the Chinese literature, but the English literature is relatively insufficient in this regard. However, since the shipping global ETS are conceptual and under discussion, there are few studies on the opportunities and challenges that the Chinese shipping sector may face in the global ETS, both home and abroad.

1.3 Research contents and methodology

1.3.1 Research contents

This paper is divided into five parts. The first part is the introduction, which introduces the relevant research background, explains the importance and significance of studying the impact of carbon trading mechanism on Chinese shipping sector, then composes and analyses the relevant literature, and finally introduces the research content and the main methods of this paper. The second part is the theoretical basis, which introduces the current development of carbon emission reduction in the shipping industry, the main regulations at the international level in terms of GHG emission reduction and the analysis of the theoretical basis of ETS. The third part introduces the development process and main mechanism of EU-ETS, and analyzes the advantages and disadvantages of EU-ETS. The fourth part, after expounding the current situation of Chinese shipping sector, analyzes the possible economic impact on Chinese shipping sector after the shipping industry is included in the EU-ETS through data calculation, and puts forward some countermeasures. Then, using SWOT analysis model and PEST analysis method, it analyzes the advantages and disadvantages that Chinese shipping sector will face under the global ETS, and puts forward corresponding suggestions. The fifth part is the conclusion, which mainly summarizes the entire paper.

1.3.1 Research methodology

This paper mainly uses the following research methods:

Firstly, the literature analysis method. Literature induction is the basis of this study. This paper tries its best to collect the literature on the maritime carbon emission trading system, and strives to fully grasp the research situation, and analyzes and draws conclusions on this basis.

Secondly, conceptual analysis. It is mainly reflected in the concept elaboration of the second and third parts. By defining the definitions of relevant theories and mechanisms, it lays the foundation for the specific analysis in the following sections.

Thirdly, the comparative research method. This method is reflected in the second, third and fourth parts, mainly including system design and data comparative analysis, which provides support for the following conclusions.

Fourthly, SWOT analysis method, mainly used in the fourth part. The SWOT model can effectively help analyze the internal and external environment of Chinese shipping sector in the context of global ETS.

Finally, PEST analysis method, is mainly used in the fourth part. This method is one of the common methods to analyze the external environment in SWOT analysis.

CHAPTER 2 DEVELOPMENT OF SHIPPING CARBON EMISSION REDUCTION SYSTEM

2.1 International carbon emission reduction trends

Since the 1970s, extreme weather phenomena have been occurring in various countries around the world, bringing about a series of problems such as rising sea levels, loss of species, reduced food production and water crisis, posing threats to people's livelihoods around the world. From 12 to 23 February 1979, the World Meteorological Organization (WMO) convened the first World Climate Conference in Geneva, Switzerland, at which scientists warned that increasing atmospheric carbon dioxide concentrations would lead to a warming of the planet, and climate change was first put on the agenda as an issue of international concern and became a global issue. In 1988, the IPCC was established with a mandate to assess the state of climate change and its impacts.

2.1.1 United Nations Framework Convention on Climate Change

Climate knows no borders, and climate issues are global issues. To solve the problem of global climate change, it is unscientific and inadvisable for a single country to fight alone. All countries in the world must join together to negotiate and work together at the global level. In December 1990, the United Nations Standing Committee approved the negotiation of a climate change convention. The Intergovernmental Negotiating Committee for a Framework Convention on Climate Change held 5 meetings between February 1991 and May 1992, culminating in the adoption of the Convention, the UNFCCC, at the UN General Assembly on May 9, 1992. In June of the same year, it was opened for signature during the United Nations Conference on Environment and Development, which was held in Rio de Janeiro, Brazil, with the participation of heads of governments from all over the world.

The UNFCCC came into force on March 21, 1994. The purpose of the Convention is as stated in its Article II:" The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.” (United Nations, 1992) The Convention is authoritative, universal and comprehensive, and is a fundamental framework for international cooperation in addressing global climate change issues.

Although the UNFCCC is the legal basis for international cooperation, it does not impose specific obligations on individual Parties, nor does it provide an implementation mechanism. In this sense, the Convention lacks legally binding force. In order to achieve the objectives of the Convention, five basic principles are established in Article 3 of the Convention: the principle of common but differentiated responsibilities (CBDR), consideration of the special needs and circumstances of developing countries, prevention and mitigation of climate change, the principle of sustainable development and the principle of international cooperation (United Nations, 1992). Among them, the CBDR principle is the most important. It stipulates that all countries have the obligation to take action against climate change, but the responsibility for governance also differs. UNFCCC clarifies that the industrialized countries listed in Annex I have caused more carbon emissions in the long-term industrial development, and thus have to bear greater responsibilities. The CBDR principle is more widely accepted by developing countries, while developed countries have not unanimously accepted the principle. In previous global climate change conferences for decades, the inability of countries to reach agreement on emission reduction commitments, funding and other issues has led to increasing contradictions, and CBDR has been relatively marginalized in environmental governance debates.

The UNFCCC regulations cover all process or activity that releases GHGs, including the transport sector, however, the convention does not provide clear regulations and guidance on specific obligations for shipping (HOU, 2019). Although the Convention has no actual control over international shipping, the parties still acknowledge that the

UNFCCC has a positive effect on reducing carbon emissions for international shipping.

2.1.2 Kyoto Protocol

As a supplement to the UNFCCC, the Kyoto Protocol was formulated in Kyoto, Japan in December 1997 and entered into force on February 16, 2005. It is the first legally binding climate agreement. The Kyoto Protocol was signed to stabilize the level of GHGs in the atmosphere at an appropriate level to protect humanity from the threat of a warming climate. Unlike the UNFCCC, the Kyoto Protocol sets quantifiable targets for contracting parties. Article 3 requires Annex I countries "... to reduce their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012." which is the first commitment period (United Nations, 1998). On December 8, 2012, Doha Amendment passed its second commitment period to reduce GHG emissions by at least 18 percent below 1990 levels between 2013 and 2020. Like the UNFCCC, the Kyoto Protocol still continues the CBDR principles. In addition, in order to promote the completion of the GHG emission reduction targets of the contracting parties, the Kyoto Agreement has also formulated three market-based mechanisms, including International Emissions Trading, which is stipulated in Article 17 (United Nations, 1998). Similarly, although the Kyoto Protocol includes the transportation sector among the sectors listed in Annex A, Article 2.2 stipulates that “The Parties included in Annex I shall pursue limitation or reduction of emissions of GHGs not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively” (United Nations, 1998) . In the author's view, although the GHG emissions from shipping are not included in the GHG emissions statistics of the Contracting Parties, the Kyoto Protocol Act on carbon trading can be applied to shipping, which is part of the transport sector, but due to the global nature of GHG emissions from shipping, the Kyoto Protocol recognizes the voice of IMO and does not exclude IMO from establishing a worldwide legal regime on carbon emissions trading suitable for shipping.

2.1.3 Paris Agreement

The Paris Agreement was adopted on December 12, 2015 and entered into force on April 22, 2016. Like the Kyoto Protocol, it is legally binding. In terms of environmental protection, the biggest contribution of the Paris Agreement is to clarify the "hard target" that the world is pursuing, that is, "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" (United Nations, 2015) . From the perspective of human development, the Paris agreement continues the CBDR principles while also requiring countries to act autonomously according to their national circumstances and capacities, which is conducive to international multilateral cooperation and the cultivation of the idea of a community of human destiny. On the economic front, the Paris Agreement also promotes capital markets towards green energy and a low-carbon economy. Although IMO invited the ICS, the United Nations Development Programme and other institutions to participate in the conference focusing on ship technical cooperation during the meeting, but due to the opposition of most developing countries, the shipping industry was not included in the Paris Agreement.

In 2009, the 15th Conference of the Parties (COP 15) included shipping in carbon emission control for the first time. At COP26 in 2021, 14 countries signed the 2050 Declaration on Zero Emission Shipping, acknowledging that climate change requires efforts from all sectors of the global fleet and the international shipping sector. But the declaration is only an initiative and is not included in the content of the formal conference convention. In summary, the international legal texts of the United Nations Climate Change Conference do not regulate and guide the reduction of GHG emissions in shipping, but only the CBDR principle, the "respective capacity" principle and Article 2.2 of the Kyoto Protocol are directly relevant to the international shipping industry.

2.2 IMO carbon emission reduction system trend

2.2.1 Main progresses of IMO carbon emission reduction

IMO is the United Nations specialized agency responsible for the safety of maritime navigation and the prevention of marine pollution from ships, and now has 175 member states. UNCLOS 1982 requires countries to develop international rules and standards through IMO to prevent, reduce and control pollution of the marine environment from ships and through the atmosphere. The 1997 Kyoto Protocol stipulates that contracting parties should seek to control GHG emissions from the IMO. It indicates that the prevention and reduction of atmospheric pollution from ships is an important responsibility of the IMO.

At the stage of emission reduction system exploration stage (1990s - 2008), IMO mainly explores and discusses GHG emission reduction systems and measures (ZHU, 2019). In 1990, MEPC 29 put air pollution on the agenda for the first time, and in 1991, the 17th IMO Assembly officially started the legislative work to prevent air pollution. In 1997, IMO added Annex VI to the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). However, Annex VI mainly regulates the emissions of SOX, NOX and ODS, and does not impose legislative constraints on carbon emissions. In 2000, a research report on GHG emissions from ships was submitted at MEPC 45, and the report considered that the implementation of prescribed operational measures on the basis of market mechanisms requires the participation of various stakeholders. This is also the first discussion on the application of MBMs to GHG emission reduction in shipping. Resolution A.963 (23) was adopted at the IMO Assembly in 2003. The resolution requires the MEPC to develop a GHG emissions benchmark, a method to describe the GHG emissions index, and guidelines for the GHG emissions index scheme. In 2006, MEPC 55 considered that IMO should work closely with other UN organizations to avoid unilateral actions while playing a leading role in reducing GHG emissions from international shipping. In 2008, MEPC 57 identified nine basic principles, but was opposed by many developing countries because it excluded the CBDR principle.

The emission reduction system began the mandatory regulation stage (2009-2013), during which some technical guidelines were issued, and two types of shipping carbon emission reduction measures were mandated by law (ZHU, 2019). In 2009, member states conducted in-depth discussions on the new ship Energy Efficiency Design Index (EEDI) formula to be launched by IMO. In the same year, MEPC released its second GHG emissions study, which pointed out that technical and operational measures has great potential in dealing with maritime GHG emissions. If these measures are implemented together, they can be more efficient and reduce emissions by 25% and 75% from current levels. At the same time, the working group also proposed that the market mechanism is one of the most effective means to reduce emissions from shipping in the future, with high cost-effectiveness and environmental benefits. In 2011, MEPC62 passed the amendments to MARPOL (73/78) ANNEX VI on ship energy efficiency rules, and established two global mandatory emission reduction standards for the first time, EEDI and Ship Energy Efficiency Management Plan (SEEMP). In 2010, the panel discussed eleven MBM proposals at MEPC 60, but the final report did not compare the various MBMs, nor did it recommend what steps to take further. In 2013, amendments to ship energy efficiency rules came into effect. In the same year, IMO suspended discussions on shipping MBMs due to political factors and other reasons.

Data collection and strategy formulation stage (2014-), at this stage, IMO focuses on data collection and formulation of future emission reduction strategies (ZHU, 2019). In 2014, MEPC 67 published the IMO's third GHG emission study report. The report believes that if no effective measures are taken, the total carbon dioxide emissions of shipping will increase by 50%-250% by 2050 (Masodzadeh, et al., 2022, p. 123-142). In 2016, MEPC 70 adopted Resolution MEPC.278(70) and the IMO Data Collection System (IMO-DCS) which came into effect on 1 March 2018, requiring ships of 5,000 gross tons and above on international voyages to collect and report fuel oil consumption on a monthly calendar year cycle from 1 January 2019 . In 2018, MEPC 72 defined the Initial IMO Strategy on Reduction of GHG Emissions from Ships, which is the shipping industry's first global emissions reduction framework and the first industry-wide target (See Table 1). MBMs are seen as a candidate measure for the medium term, to be determined in 2023-2030. In 2020, MEPC 75 officially released the IMO's fourth GHG emissions study, which predicts that by 2050, CO_2 emissions will increase by approximately 50% compared to 2018 and by approximately 90-130% compared to 2008, as demand for maritime transport continues to grow (International Maritime Organization, 2021).

Table 1: Initial IMO Strategy on Reduction of GHG Emissions from Ships

Target	Strive to reach peak GHG emissions as soon as possible, reduce shipping GHG emissions by at least 50% from 2008 by 2050 and strive to achieve the goal of shipping GHG-free by this century.
Guiding Principles	Principles of non-discrimination and No More Favorable Treatment (NMFT), Principle of Common but Differentiated Responsibilities (CBDR).
Candidate Short-term Measure	It mainly includes improving the existing energy efficiency framework, developing energy efficiency technologies, formulating energy efficiency standards, formulating a national emission reduction strategy for 2018-2023, ship speed management, port emission reduction, new energy development, etc.
Candidate Medium-term Measure	New energy use, implementation of high-efficiency measures, market mechanisms (MBMs) and other innovative emission reduction mechanisms 2023-2030 determination system, technical cooperation, capacity building and establishment of feedback mechanisms, etc.
Candidate Long-term Measure	Develop and use new energy sources to allow the maritime industry to assess decarbonization in the second half of this century; after 2030, identify and encourage the full implementation of other innovative emission reduction mechanisms

Source: ZHU, S. (2019 May). *The impacts of Carbon Emission Trading on China's International Shipping Industry.* Unpublished master's thesis, Xiamen University, Xiamen, China

2.2.2 IMO MBMs related proposals

In 2010, IMO member states submitted a total of eleven MBMs proposals (one German proposal was excluded from the original MBMs list for administrative reasons and has now been reinstated as part of the MBMs list) (Psaraftis, Zis, & Lagouvardou, 2021). However, due to the complexity and sensitivity of the market mechanism and the high level of disagreement among member states, discussions on the market mechanism were suspended in 2013 and have been on hold ever since, with IMO's current focus remaining on developing short-term measures such as energy efficiency for ships. But with the EU set to formally include shipping in the EU-ETS in 2023, which will put pressure on the IMO, and with MBMs as an alternate medium-term measure to be identified under the IMO's initial strategy for GHG reductions dueinf 2023-2030, it is worth looking forward to the resumption of the MBMs discussion at the IMO. Eleven proposals for MBMs are summarized below, which can be roughly divided into 7 types (See Table 2).

Table 2: Seven Types of MBMs

Types	Countries and Organizations
Penalty on trade and development	Bahamas
Ship Efficiency and Credit Trading	The United States (US)
Port State arrangements utilizing the ship traffic, energy and environment model	Jamaica
A Rebate Mechanism	International Union for the Conservation of Nature
Efficiency Incentive Scheme (Combined by The Leveraged Incentive Scheme and Vessel Efficiency System)	Japan and WSC
The International Fund for GHG emissions from ships (GHG Fund)	Cyprus, Denmark, the Marshall Islands, Nigeria, the International Parcel Tanker Association

The Global Emission Trading System (ETS)	The United Kingdom (UK), Germany, France, Norway

Source: Adapted from SHI, Y. (2016) Reducing greenhouse gas emissions from international shipping: Is it time to consider market-based measures? *Marine Policy,* 64, 123-134

Since then, in 2018, France submitted a new proposal including a proposal for a progressive increase in the carbon price based on the carbon emissions of ships, and in the same year, Antigua and Barbuda et al. submitted a proposal for an easily enforceable and transparent carbon tax or levy on ship fuel. Norway also submitted a new proposal in 2019, hoping to meet the IMO's carbon emission requirements through a flexible compliance mechanism (Lagouvardou, Psaraftis, & Zis, 2020). In 2020 ICS and Baltic and International Maritime Council Organization (BIMCO) et al. submitted a proposal to establish a mandatory contribution fund for each ton of fuel and to use the fund for international maritime research (IMRF), which was briefly discussed by MEPC75 but did not result in an outcome and was not named MBM as its proponents saw it as a mere contribution to funding research and development (Wissner, et al, 2021). At MEPC76 in 2021, The Republic of the Marshall Islands and the Salomon Islands submitted a MBMs proposal for a fee and kickback system, which is mainly to increase the price of carbon-intensive fuel while subsidizing low-carbon fuel, zero-carbon fuel, transitional research and development and Small Island Developing States (SIDS) (Wissner, et al, 2021). Again, however, this proposal was not discussed in detail.

In general, although some member states have continued to propose new MBMs after 2010, they have not received much attention or discussion from the MEPC, so it is more likely that the current MBMs for shipping are still divided into three main types: carbon/fuel taxes, ETS and other MBMs.

2.3 Concept definition and theoretical basis of ETS

The concept of carbon emissions trading originated from the concept of emissions trading proposed by American economist Dales in 1968. It is to establish a legal right to discharge pollutants, expressed in the form of discharge permits, so that environmental resources can be bought and sold like commodities. Later, the Kyoto Protocol clarified 6 GHGs need to be controlled urgently, and proposed to commercialize carbon emission rights for the first time.

2.3.1 ETS concept

Carbon emissions trading, an important mechanism for using the market economy to promote environmental protection, is a market mechanism for national or international organizations to control the total amount of carbon dioxide emissions in order to promote the reduction of carbon dioxide emissions by enterprises and to meet the carbon dioxide emission targets.

In fact, carbon emission trading is to treat carbon dioxide emission rights as a commodity, allowing countries or companies to sell undischarged carbon emissions in the carbon emissions trading market without exceeding the prescribed total emissions. This is somewhat similar to the physical energy conservation rule. In the case of a fixed total amount, if company Z allocates 15 units of carbon emissions, company G allocates 12 units of carbon emissions, and if company Z emits 10 carbon emissions unit, G company emits 15 units, then Z company can sell its remaining 5 units of carbon emissions in the carbon emission market, while G company can buy 3 units of carbon emissions from Z company through the market.

2.3.2 ETS theoretical foundations

It can be explained by the negative externalities of economics. A negative externality is a phenomenon in which the production or consumption behavior of an economic agent damages the interests of some other economic agent and the former is unable to compensate the latter. In essence, the price of a product or service does not adequately reflect the marginal cost to society of producing or providing such a product or factor of production (YANG, 2021). For example, when a CO_2 emitter takes exclusive advantage of the benefits of CO_2 emissions, everyone on the planet and future generations will have to bear the negative consequences of that action together.

Arthur Cecil Pigou in The Economics Welfare explains externalities by analyzing the divergence of marginal net private output from marginal net social output. According to Pigou's theory, the negative externalities of carbon emissions are reflected in the fact that the social costs of carbon emissions are greater than the private costs and the social benefits are smaller than the individual benefits (YANG, 2021). The composition of social cost is the sum of private cost and external cost, and the difference between the social cost curve and the private cost curve is the cost of carbon emissions. In the presence of negative externalities, the intersection of the demand curve and the private cost curve, B, is the production equilibrium point chosen by the market, but is transitionally emitting and inefficient (KE, 2017). The intersection point A of the demand curve and social cost is the optimal production decision point (See Figure 4). Pigou believes that the government can correct the deviation through taxation and subsidies. The sewage charging system of "who pollutes, who controls" is based on Pigou tax. And Ronald H. Coase believes that externalities can be solved through a more flexible form of market transactions, that is, the voluntary principle to replace the Pigou tax method (YANG, 2021). A later application of the theory to the field of environmental protection is the carbon emissions trading system. Thus the carbon tax in MBMs and the ETS discussed in this paper are based on economic liberalism to correct market failures and optimize resource allocation by addressing negative externalities.

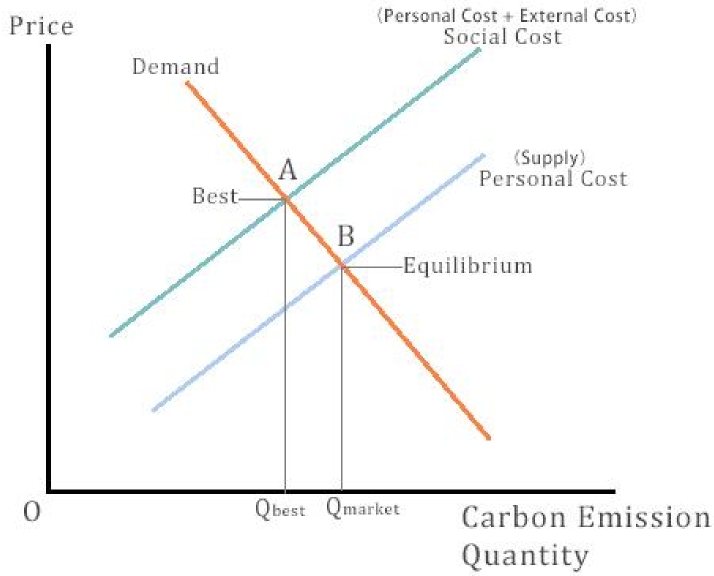

Figure 4: Negative externalities of carbon emissions

Source: Adapted from KE, W. (2017). *The impact of International Shipping ETS on bulk stock international trade-- A Case Study of China's iron ore trade.* Unpublished master's thesis, Wuhan University, Wuhan, China.

2.3.3 Shipping ETS

Shipping ETS refers to a market control mechanism that takes ships within a certain area as the main body and their carbon dioxide emissions as transaction objects through the method of total amount control. Others believe that shipping ETS is essentially a combination of administrative and market mechanisms: when the government issues allowances and implements regulation through administrative means, the market supply and demand regulates carbon prices (CAI, 2020). But in the final analysis, shipping ETS is to use economic means to pursue the CO_2 emission reduction goals of the shipping industry. However, shipping ETS also has special characteristics that cannot be ignored in terms of its industry.

First, the carbon emissions of the shipping industry are global. Shipping is the lifeblood of the global economy. Ships engaged in transnational transportation all over the world. The carbon dioxide emitted by a voyage may involve the flag state, port state, coastal state, high seas and other objects. As a result, the CO_2 emissions of ships will not be concentrated in a certain region, and it is difficult to divide them by region or country. While CO_2 emissions from ships will not cause a surge in CO_2 emissions from a region or country, it does increase the overall global CO_2 concentration.

Second, ships are subject to dual jurisdiction. On the one hand, ships are subject to the management of the flag state of the flag they fly, and on the other hand, they also need to be inspected by the port state where they are located when berthing. Under UNCLOS 1982 Article 211, both flag and port states are entitled to enact laws and regulations to manage pollution from ships (United Nations, 1982). At the same time, the "flags of convenience" regime allows ships to fly the flags of countries with which they have no physical connection, and which often do not exercise effective control over the countries that fly their flags. For example, 'flag of convenience' countries such as Panama, Malta and Liberia focus on the benefits of ship registration and do not effectively inspect and manage ships, which can lead to a loss of data on fuel consumption and GHG emissions (HOU, 2019).

Third, the actual controller of the ship is not easy to identify. The ordinary carbon trading market allocates carbon emissions to polluting units. When the carbon emissions of ships are controlled by different entities at the same time, such as ship owners and charterers, this may require internal allocation, which may increase the difficulty and cost of operation.

CHAPTER 3 IS IT FEASIBLE FOR GLOBAL SHIPPING TO INCORPORATE LOCAL ETS——EU ETS AS AN EXAMPLE ANALYSIS

3.1 EU-ETS

3.1.1 EU-ETS overview

In the 1997 Kyoto Protocol, the 15 member states of the EU committed to reducing their annual average emissions of six GHGs, including carbon dioxide, by 8% below 1990 levels over the period 2008-2012. To assist developed countries in meeting their emission reduction obligations, the Kyoto Protocol establishes three flexible mechanisms: the International Emission Trading (IET), Joint Implementation Mechanism (JI) and Clean Development Mechanism (CDM). In order to fulfill its commitments under the Kyoto Protocol, the EU published the possibility of carbon emissions trading in its Green Paper in 2000. In 2003, Directive 2003/87/EC was passed, and the study and establishment of the European Union Transmission Trading System was officially carried out (HOU, 2019). On January 1, 2005, the mechanism was officially launched, and its purpose is to "cost" the environment, transforming the environment into a paid production factor with the help of market forces, and by establishing an EU emission allowance (EUA) trading market, it can effectively allocate environmental resources, encourage the development of energy saving and emission reduction technologies, and minimize the operating costs of enterprises under the protection of climatic environment. The development of EU-ETS is divided into four stages, and its coverage, quota allocation method, trading rules and other related systems are constantly changing. This article 3.1.2 will introduce the characteristics and changes of each stage in detail. In 2008, the European Union promulgated Directive 2008/101/EC, which unilaterally included aviation carbon emissions into the EU-ETS, and the scope of control includes foreign aircraft operators, and it was officially implemented in January 2012. This has caused huge international controversy, and has been strongly opposed and boycotted by many countries including China and the US. In order to achieve the goal of climate neutrality in 2050, the Fit for 55 legislative package released by the European Union on July 14, 2021 sets a higher ambition to reduce GHG emissions by at least 55% from 1990 levels in 2030 (European Commission, 2021). At the same time, in order to achieve this ambition, the EU has decided to include maritime transport in the EU-ETS for a transitional period of three years. At the same time, in order to achieve this ambition, the EU decided in the bill to include maritime transport in the EU-ETS and to implement it from 2023 onwards, with a transitional period of three years. This unilateral decision has once again caused widespread controversy in the international community. China, Japan and South Korea have clearly opposed the inclusion of international maritime transport in the EU-ETS, while international organizations such as the ICS, the WSC, the BIMCO have also clearly expressed their opposition (GONG, 2021, p. 52-54).

3.1.2 EU-ETS developments and mechanisms

As the world's largest carbon emissions trading market, the EU-ETS is a key component of the EU's climate policy and the main instrument for meeting the EU's international climate commitment. Based on the principle of Cap & Trade, the EU determines the total amount of GHG emissions for each sector included in the EU-ETS, and each EU member state sets its own emissions cap based on the total amount required and allocates EUAs to companies through free allocation or auction. Depending on its actual emissions, a company can buy additional allowances on the emissions trading market or sell its own surplus allowances for a profit. If a company exceeds its emissions and does not buy additional EUAs, it will face severe penalties. The EU-ETS is also open to other trading systems. Companies can use emission reduction credits outside the EU up to a certain limit in accordance with the Directive. It is also possible to make the EU-ETS compatible with other countries' emissions trading systems under bilateral agreements.

The biggest difference between EU-ETS and other total volume trading systems is the decentralized governance. Each EU member state has a high degree of autonomy over the allocation of emission rights and the development of monitoring processes, while following the common standards and procedures issued by the EU, but at the same time, their autonomous allocation schemes are subject to review by the relevant directives of the European Commission before they become effective. In addition, the EU has established a central registry system for member states to register emissions and EUAs to be transferred between member states. This ability to balance between centralization and decentralization, taking into account the differences of each member state, effectively balances the interests of each member state and the EU, and is a model of an emissions trading system. However, as the first organization to implement a regional carbon emissions trading mechanism, the EU also realizes that the mechanism in practice needs to be improved step by step, so the EU implements it in stages, and has ended the third stage and entered the fourth stage.

(1) The four stages of development of the EU-ETS

Phase I (2005 - 2007). This phase was mainly a three-year experimental phase carried out by the EU to gain experience and included mainly energy-intensive industries in the scope of emissions trading, such as: electricity, petrochemicals, steel, cement, paper and other industries (HU, 2015). In this stage, from bottom to top, the emission cap is determined based on the total allocation of each member state, and almost all allowances are allocated to enterprises in the above-mentioned industries for free. In terms of offsets and credits, CDM and JI credits allow unlimited use, although they are not used in actual practice.

The industries covered in the first phase account for 50% of the EU's total emissions, which has accumulated experience for the EU to initially establish a carbon price. In practice, the EU found that the issuance of allowances was so oversupplied that in 2007 the carbon price fell to zero. As a result, the EU has also mastered relevant data on corporate carbon emissions, making preparations for subsequent adjustments.

Phase II (2008 - 2012). At this stage, the covered industry of emissions trading is expanded to other industries (transportation), and the covered GHG also increases nitrogen oxides. At the same time, Norway, Iceland and Liechtenstein also joined EU-ETS. The rules for setting the total cap are the same as in Phase I, with the free allocation of emissions reduced to 90% and the remaining credits needing to be obtained by companies through auctions. The second phase also allows for EUA through CDM credits and JI credits, but with a maximum usage limit, and unused rights can be carried over to the third phase (International Carbon Action Partnership, 2021). At this stage, companies have obtained nearly 140 million tons of EUA in this way (HU, 2015). Although the EU believes that this is to improve cost effectiveness, others believe that it is a transfer of pollution from developed countries to developing countries and regions, which does not help the overall global emission reduction.

At the end of the second phase, total EU emissions were reduced by around 6.5% compared to 2005 and 19% compared to 1980, while total economic growth amounted to 45% and energy consumption per unit of GDP was reduced by almost 50%. However, as a result of the global financial crisis in 2008, there was again an oversupply of emission allowances.

Phase III (2013-2020). At this stage, the EU began to carry out major reforms, which are reflected in many aspects. First of all, EU-ETS, the industries covered are further expanded, and the incorporation of shipping into the trading system has begun to be considered. At the same time, perfluorocarbons from the production of aluminum products are also included in the trading adjustment. Secondly, instead of continuing the practice of the first and second stages, the EU chose to uniformly regulate the total emission cap in the region, which is, 2084 Mt CO_2e in 2013, and then reduce it by a linear coefficient (1.74%) every year. In addition, the free allocation for this phase has been significantly reduced, with more than 50% of the credits being auctioned. Finally in terms of credits, after 2012, the EU will only allow new CDM and JI projects registered in developing countries and regions, while projects from developed countries will only be recognized for rights carried over from Phase II, i.e. registered for implementation before 31 December 2012. The credits are capped at 50% of the total emission reductions for that phase.

The third phase is the reform stage of EU-ETS, which has carried out comprehensive system improvement. In 2019, the EU's carbon emissions decreased by 23% compared with the amount of 1990, exceeding the third-stage emission reduction target. In 2020, the transaction volume of EU-ETS exceeded 8 billion tons, accounting for nearly 90% of the total global transaction volume.

Phase IV (2021-2030). The "Fit for 55" legislative package released in 2021 imposes stricter requirements on EU-ETS. In addition to setting higher emission reduction ambitions, the bill also decides to include carbon emissions from international shipping in the EU-ETS from 2023. Meanwhile, the EU capped 2021 emissions at 1,572 Mt CO_2e, with the annual decline increasing to 2.20% from 1.74% in the third phase. All international offset indicators will no longer be allowed in Phase IV.

As shown in Table 3, after the first three phases of experience accumulation, system building and reform improvement, the fourth phase of EU-ETS will enter a stable phase of regular development, with the ultimate goal of achieving climate neutrality by 2050. As of phase IV, the EU-ETS already covers 45% of the EU's GHG emissions, 28 EU member states, Norway, Iceland, Liechtenstein, 13,500 companies in the EU and all flights within the EU, and by 2023 will also cover international maritime transport (Swan, 2020).

Table 3: The four phases of EU-ETS

Phase	Period	Characteristics	Major changes
I	2005 – 2007	It is a period of accumulation of experience, where members draw up their own allowances, and the total emission cap is calculated from the bottom up, and allowances are almost entirely allocated free of charge.	Only power plants and energy-intensive industries with high energy consumption are covered

II	2008 – 2012	It is the construction phase of the system, and the emission cap is set in the same way as the first phase, with the free allocation reduced to 90% and the rest used for auctions.	Added three countries (Norway, Iceland and Liechtenstein) and expanded coverage to include the transportation industry (aviation)
III	2013 – 2020	It is the reform phase, the EU began to control the total amount, the quota is distributed on the basis of the total amount of average annual decreasing by a linear factor of 1.74%, the proportion of auction quota gradually increased (about 50%).	Adjustment of credit rules and inclusion of carbon capture and storage installations and other sectors and thresholds.
IV	2021 – 2030	It is a normal development stage. Under the total amount control, the quota is distributed evenly according to the total amount. The linear coefficient of annual decrease increases from 1.74% to 2.20%, and the use of offset indicators is no longer allowed.	Inclusion of the shipping industry in the EU-ETS from 2023

Source: Adapted from International Carbon Action Partnership. (2021, November). EU Emissions Trading System (EU ETS). Retrieved April 15, 2022 from the World Wide Web: https://icapcarbonaction.com/system/files/ets_pdfs/icap-etsmap-factsheet-43.pdf

(2) Monitoring, Reporting and Verification Mechanism

In the EU-ETS system, Monitoring, Reporting and Verification (MRV) is an important supporting mechanism. Through this mechanism, the EU can acquire the data of

GHGs emitted by ships entering and exiting the ports of EU member states, so as to make scientific and evidence-based decisions in setting emission caps and issuing emission quotas. The MRV database covers about 90% of the EU's shipping emissions. It can be said that it is an important preparation procedure for incorporating shipping into the EU-ETS, and it is also the core link of the EU's implementation of maritime emission reductions. The Bali Action Plan adopted by the UN Climate Change Conference in 2007 proposed the concept of "MRV" as Measurable, Reportable, Verifiable, and then the EU and the US successively proposed to IMO to establish MRV for international shipping. In 2011, the EU proposed in the Transportation White Paper: "…overall, the EU CO_2 emissions from maritime transport should be cut by 40% (if feasible 50%) by 2050 compared to 2005 levels." (European Commission, 2011) In order to achieve this goal, the European Commission issued "Integrating maritime transport emissions in the EU's GHG reduction policies" in 2013, in which three main measures are proposed: the establishment of shipping GHG MRV mechanism, the formulation of shipping emission reduction targets, and effective market-based measure. In April 2015, the European Union formally adopted Regulation 2015/757 on the monitoring, reporting and verification of CO_2 emissions from maritime transport.

The establishment of maritime MRV mechanism is the first step for the EU to carry out maritime carbon emission reduction. Its purpose is: first, to provide data and information support for the subsequent establishment of international maritime emission reduction market mechanism through the comprehensive evaluation of fuel records, nautical logs and other data. Second, in addition to helping government departments to formulate and regulate policies, MRV data can also enable other stakeholders in the shipping industry to obtain the necessary information to provide information support for them to carry out self-regulatory carbon emission reduction in the industry. Third, the EU believes that the establishment of MRV is an effective and beneficial exploration of the global market-based measure of marine emission reduction, and will provide a large amount of data and demonstrations for the establishment of a global market-based measure of marine emission reduction in the future. In May 2018, the European Parliament released the first annual report on CO_2 emissions from shipping, which indicated that in 2018, ships applying MRVs in the European Economic Area (EEA) emitted 138 million tons of CO_2, accounting for 3.7% of the overall emissions from the global shipping industry.

MRV is applicable to ships of 5,000 Gross Register Tonnage (GRT) or more engaged in international trade that stop at ports of EU member states. MRV requires monitoring of four parameters: CO_2 emission/fuel consumption, voyage distance, sea voyage time and cargo capacity. Article 4 of the MRV Directive stipulates that monitoring and reporting shall be complete, consistent and comparable, and relevant data should be true, transparent and accurate (The European Parliament and of The Council, 2015). Article 5 sets out specific ways of monitoring and reporting on ship emissions data (The European Parliament and of The Council, 2015). The frequency of reporting is annual self-reporting by filling out an electronic template harmonized by the European Union, while certification is carried out by independently accredited certifiers by 31 March each year(The European Parliament and of The Council, 2015).

In general, some of the EU MRV requirements for ship operations and ship equipment, particularly in relation to ship-related record keeping, overlap with the provisions of MARPOL 73/78 Annex VI, but some go beyond MARPOL 73/78 and constitute regional unilateral measures (HU, 2015). However, the establishment and subsequent operation of the EU MRV has not been subject to significant opposition from other countries, so it can be considered that, to a certain extent, the EU’s actions in regulating the carbon emissions of ships in international trade that exceed the IMO-related conventions have been accepted by the world (European Community Shippowners' Associations & International Chamber of Shipping, 2020). At the same time, this may also increase the EU's confidence that it can continue to unilaterally include international shipping in the EU-ETS. But in any case, the establishment of the MRV mechanism still promotes the exploration process of international shipping ETS to a certain extent.

3.2 Embarrassment and conflict of EU-ETS

The EU is the world's third largest emitter of GHGs and was the first to take active action on GHG emissions after the signing of the Kyoto Protocol, and has been very proactive in climate change policy and legislation (HU, 2015). In terms of carbon emissions from maritime transport, the EU believes that without regulation of GHG emissions from maritime transport, the goal of stabilizing global temperature rise below 2℃ is likely to be missed. At the same time, the EU and its member states also recognize that, due to the particularity of shipping carbon emissions, a global agreement is the best option. Therefore, the EU has always suggested that IMO establish a global maritime market-based measure at the international level, but IMO has suspended the discussion on shipping MBMs since 2010, and has not restarted related research. Although IMO established EEDI and SEEMP two standards for ship emission reduction and operation in 2011, the EU believes that this move cannot cover the existing ships and operating procedures, so it is not enough to ensure that shipping emission reduction can reach the expected target. In the draft submitted on July 14, 2020, it was decided to unilaterally include international shipping in the EU-ETS from 2023. The EU-ETS, which has been in operation since 2005, has undoubtedly accumulated potential advantages in terms of system and experience, but at the same time the specificity of shipping makes the shortcomings of this regional system obvious, and this is the embarrassment that the EU-ETS is currently facing.

3.2.1 Potential advantages

First, have a basic institutional framework. On the one hand, the MRV system has been implemented for many years, and a large number of monitoring and collection of shipping carbon emission data have been carried out, which will become the data basis for international shipping to be included in the EU-ETS, and provide scientific support for the later decision-making of emission caps and emission quota allocation. . On the other hand, the EU-ETS imposes a total cap on carbon emissions. This mandatory emission reduction by setting a cap on total emissions can better enable all parties to achieve the overall goals set in the future. In addition, as the world's largest carbon trading market, EU-ETS has been implemented in many industries for many years, and has accumulated a lot of experience. The effectiveness of the carbon credit allocation system and carbon trading platform has been fully verified. Therefore, the extension of EU-ETS to international shipping has a positive impact on promoting carbon emission reduction of ships.

Second, enterprises under the EU-ETS system have transaction flexibility. EU-ETS allows carbon emissions trading within and across industries, including offsetting, which provides more choices and possibilities for companies to achieve policy goals. At the same time, some economists also believe that since carbon prices are regulated by the market, it may be the most cost-effective way to reduce carbon emissions through EU-ETS for some companies that are temporarily difficult to retrofit. In addition, EU-ETS can also be compatible with carbon trading markets in other countries according to bilateral agreements, and cross-market trading further enhances flexibility.

Third, it can effectively promote the development of new emission reduction technologies. At least 90% of the revenue from the EU-ETS auction of carbon emissions goes to climate and energy-related fields. In 2019, EU member states invested around 77% of their revenue funds for their domestic and international climate purposes. The fourth phase of the EU-ETS also established two new funds: the Innovation Fund and the Modernization Fund, both of which will be applied in areas such as decarbonization technological breakthroughs and energy modernization. At the same time, for individual carbon emitters, in order not to exceed the specified carbon emission quota, they can either choose to purchase additional carbon emission credits, or reduce carbon emissions through technological innovations that improve fuel efficiency or use of alternative fuels. In order to minimize the cost, enterprises will more actively carry out low-carbon technology innovation and inject vitality into the development of emission reduction technology.

3.2.2 Problems and disadvantages

(1) The economic aspect.

First of all, carbon prices are volatile. In EU-ETS transactions, the price of one ton of carbon dioxide is automatically adjusted by the market and is affected by changes in supply and demand in the market. For example, during the first and second phases of the EU-ETS, when there was a surplus of emission credits and the carbon price fell to zero, companies chose to buy additional credits rather than develop new emission reduction technologies internally to improve the energy efficiency of their ships, for lower cost. In the long run, it will be detrimental to long-term carbon emission reduction planning and the development of a low-carbon economy. Analysts pointed out that carbon prices need to reach a certain high standard in order to motivate the industry to actively reduce carbon emissions and promote energy transformation, and although carbon prices have recently hit record highs, they are still far below the level required to achieve the climate goals of the Paris Agreement (LI, 2021, May 21, p. 5). In addition, affected by factors such as COVID-19 and geopolitics, the global economic situation is not optimistic, which will inevitably lead to fluctuations in carbon prices. Secondly, the associated management costs are high. ICS has stated that most shipping companies are small and medium enterprises (SMEs) and they may have limited capacity to implement regulatory requirements imposed by international organizations or governments (Garcia, Foerster, & Lin, 2021, p. 85-112). Small and Medium-sized Enterprises manage a small number of ships, they have a clear competitive disadvantage in the carbon trading market compared to larger shipping companies, and the management costs will be higher as a percentage of the total costs. One of the reasons why the EU has not included land-based transport in the EU-ETS is that the land-based transport industry has many small and medium-sized enterprises, and management costs may be passed on to consumers. From this point of view, a similar situation exists in international shipping. In addition, according to the "Fit for 55" legislative package, in addition to voyages within the EU, the carbon emissions of the voyages from external ports to EU ports or from EU ports to external ports will also be calculated. Therefore, in order to reduce the amount of carbon emissions calculated emissions, shipping companies may re-route their voyages. The re-planning of routes will increase the management costs of shipping companies. Finally, the shipping market is complex. On the one hand, ships in the shipping industry are extremely complex, with complex ship types such as Tankers, container ships, passenger rollers, etc., and on the other hand, there are different contractual relationships such as Bareboat Charter Contract, Voyage Charter Contract (Schinas & Bergmann, 2021). The complex market economy of international shipping requires policy makers to provide a practical and realistic approach. The complexity of the land-based transport market was another important reason why the EU abandoned its inclusion in the EU-ETS.

(2) The political aspect.

On the one hand, the EU's local action will be a challenge to the authority of the IMO. In order to deal with shipping GHG emission, IMO has formulated a series of policies since 1997 (see 2.2 of this article for details), aiming to achieve absolute emission reduction of ships. But once international shipping is included in the EU-ETS, ships may exceed the IMO standards for emission reductions when conducting carbon trading. This goes against the main purpose of IMO emission reduction, and at the same time, shipping companies will be caught in the dilemma of double standards of "IMO & EU" (GONG, 2021, p. 52-54). On the other hand, it will cause dissatisfaction in the international community and lead to political tensions with third countries. Since the release of the Fit for 55" legislative package in July 2021, China, Japan, and South Korea have clearly raised objections, and the US, the UK and Canada have shown close attention. This shows that the international community does not welcome the EU's unilateral actions. Part of the reason is doubts about the EU's use of the funds raised. Between 2013 and 2015, EU member states collectively earned €11.7 billion from auctioning emissions, of which more than 80% went to their domestic action and only 9% to international climate action (European Community Shippowners' Associations & International Chamber of Shipping, 2020). Therefore, some third world countries questioned that this was the EU's disguised collection of trade taxes to restore the economy under the ravages of the epidemic. Carbon emissions from both international shipping and international aviation are in fact similarly international. In fact, international political tensions were raised when international aviation was included in the EU-ETS in 2012. At the time, many countries including China, US and Russia raised strong objections. The US even enacted a bill banning US operators from participating in the EU-ETS, while China threatened to withhold a huge order from Airbus as a way of putting pressure on the EU.

(3) The effect of emission reduction.

Due to the setup of the system, the problem of carbon leakage may not be avoided. The EU draft decides to apply EU-ETS to ships of 5000 GRT and above, so in order to dogge the constraints of EU-ETS, there may be a situation where more ships of 4900 GRT will be manufactured in the future, which will cause more carbon emissions. In addition, according to the legislative package, the carbon emissions included in EU-ETS equal the sum of 50% of the EU internal sailing segment, EU external sailing segment (from non-EU ports to EU ports or from EU ports to non-EU ports) and CO_2 emissions during calls at EU ports (European Commission, 2021). Shipping companies may choose to handle part or all of their cargo through non-EU ports close to EU member states, such as Beirut, Izmir in the Middle East, Casablanca, Algiers in North Africa, Kaliningrad in Russia, etc. Transshipment to Europe by transshipment at these ports, or transshipment by large oil tankers outside the port, are all areas that MRV cannot currently cover. In addition, shippers can also choose to switch to land-based transportation after unloading at a port close to the EU, which will also lead to more carbon emissions, because land-based transportation is far less energy-efficient than sea transportation. At the same time, it has also been noted that after the aviation industry was included in the EU-ETS, the carbon emissions of the aviation industry increased by 26% between 2012 and 2018 (SHEN, 2020). Given that the carbon emissions of the shipping industry share the same global nature as the aviation industry, concerns have been raised about the effect of international shipping's inclusion in the EU-ETS on the control of carbon emissions.

(4) The legal aspects.

According to the "Fit for 55" legislative package, emissions outside the territorial waters of EU member states are also included in the ship's carbon emissions, which means that ships are responsible for carbon emissions in third countries outside the EU or on the high seas. This unilateral measure makes the EU constitute extraterritorial jurisdiction. UNCLOS 1982 Article 212 “States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from or through the atmosphere, applicable to the air space under their sovereignty and to vessels flying their flag or vessels or aircraft of their registry” is clearly stipulated that the jurisdiction of the contracting states on air pollution is limited to its own airspace, its own ships and aircraft. Therefore, the EU has no right to regulate the GHGs of ships outside its territory. Under WTO rules, this may violate the principle of national treatment under the General Agreement on Trade in Services (GATS) due to differences in the allocation and cost of carbon emissions between operators inside and outside the EU. At the same time, due to different voyages, countries with longer voyages have to bear more costs, resulting in differential treatment in implementation, which also violates the principle of most-favored-nation treatment stipulated in Article 2 of GATS. Finally, EU-ETS breaks through the CBDR principles of the UNFCCC and the Kyoto Protocol, and does not fully consider the interests and capabilities of developing countries. Although IMO uses the NMFT principle in terms of international shipping emissions reduction, EU-ETS is a product under the framework of the Kyoto Protocol and should comply with the relevant provisions of the UNFCCC and the Kyoto Protocol. To sum up, the existence of these potential legal issues may exacerbate international political tensions and affect the global economic recovery from the epidemic.

CHAPTER 4 THE IMPACTS OF ETS ON THE CHINESE SHIPPING SECTOR

4.1 Development status of the Chinese shipping sector

China is the world's second largest economy, with a total GDP of 114.4 trillion yuan in 2021, accounting for more than 18% of the global economy (WANG, 2022). Since China joined the WTO in 2001, China's position in the global trade network has been greatly improved, and the volume of import and export trade has grown rapidly. From 2000 to 2010, China's GDP grew at an average annual rate of about 10.3% (Maritime China, 2020, p. 56+9). The rapid development of the economy has driven the rapid development of maritime trade, and Chinese shipping sector has also begun to develop steadily during this period. Since 2010, China's GDP growth has slowed down, and its economic model has shifted from high-speed development to high-quality development. In 2020, China's seaborne import and export trade volume has accounted for 30% of the global total, of which seaborne import trade volume accounts for 25% (QIU, 2022). Chinese shipping sector has also achieved many milestone breakthroughs.

4.1.1 Fleet size

In the 2010s, the fleet of Chinese shipowners developed rapidly, and the average expansion rate increased by 32.95% compared with 8.8% in the 2000s, or about 11.7% (QIU, 2022). In 2018, China surpassed Japan to become the world's second largest shipowner country after Greece. As of early August 2021, Chinese shipowners owned a total fleet of 10,495 vessels or 214 million gross tons, doubling the size of the fleet from 111 million gross tons in 2011, and accounting for 15% of the global fleet in terms of deadweight, second only to Greece with 17% (Maritime China, 2021, p.52+7). China's seaborne trade is dominated by bulk cargoes and containers, as the economy, energy demand, and manufacturing and industrial capacity continue to grow.

China has the largest number of bulk carriers and container ships in the world. These two types of ships contribute nearly 71% of the fleet capacity of Chinese shipowners in gross tonnage, and account for 22% and 15% of the total global bulk and container fleet capacity (Maritime China, 2021, p.52+7). At the same time, according to Clarkson's research, the overall Chinese fleet is younger, with an average age of 10.2 years (the global average is 12 years). However, 11% of the shipping capacity is still over 20 years old. Under the increasingly stringent carbon emission reduction requirements, to meet the needs of green transformation, the dismantling or transformation of these ships will be a decision that shipowners must make (See Figure 5).

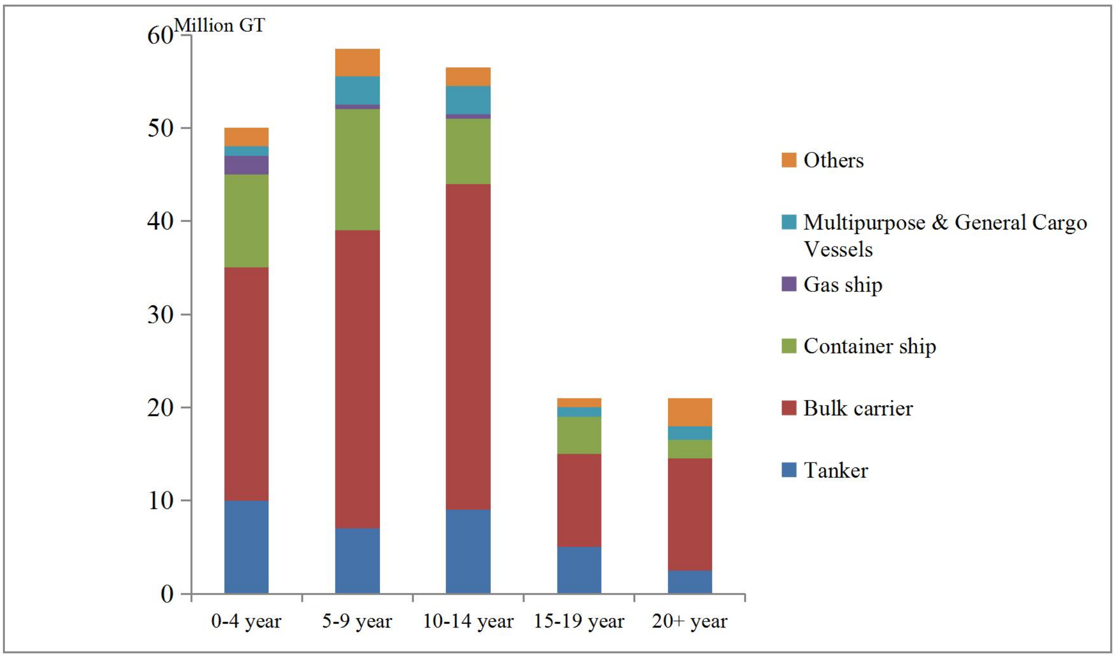

Figure 5: Age distribution of Chinese shipowners' fleet

Source: Maritime China. (2021). The Chinese owned fleet: analyzing the age profile. *Maritime China* (10), 52+7

4.1.2 Shipbuilding industry

The world's major shipbuilding countries are located in the Far East, and China, South Korea and Japan basically monopolize the world shipbuilding industry. During the decade of the 2010s, due to the financial crisis, overcapacity, the new corona-virus and other factors, the world shipbuilding industry was not prosperous or even sluggish.

During this period, China's shipbuilding capacity has also been consolidated. The number of active Chinese shipyards (with at least one vessel over 1,000 gross tonnage on order) fell to 120 from 392 a decade ago, as a large number of small-scale private shipyards exited the market (Maritime China, 2020, p. 56+9). In 2021, the global economy began to recover, while the continued spread and recurrence of COVID-19 has resulted in congestion and inefficiency of transshipment in ports around the world. Tight supply chains and a lack of capacity led to a supply-demand imbalance in the shipping market, and the high shipping rates brought shipowners plenty of cash while also greatly stimulating their desire to buy ships, and the shipbuilding industry began to experience a boom not seen in a decade. The China Association of the National Shipbuilding Industry has released annual operating data for the shipbuilding industry in 2021, showing that China's shipbuilding industry continues to be number one in the world in three major indicators. 41.64 million deadweight tons of shipbuilding were completed in 2021, up 8.07% year-on-year; new orders received for shipbuilding were 62.31 million deadweight tons, up 115.38% year-on-year; and handheld orders for shipbuilding were 97.98 million deadweight tons, up 37.79% year-on-year (ZHANG, 2022). The international market shares of the three main indicators were 48.40%, 52% and 48.10% of the world total, up 4.1, 5.0 and 2.9 percentage points respectively compared to 2020 (See Figure 6).

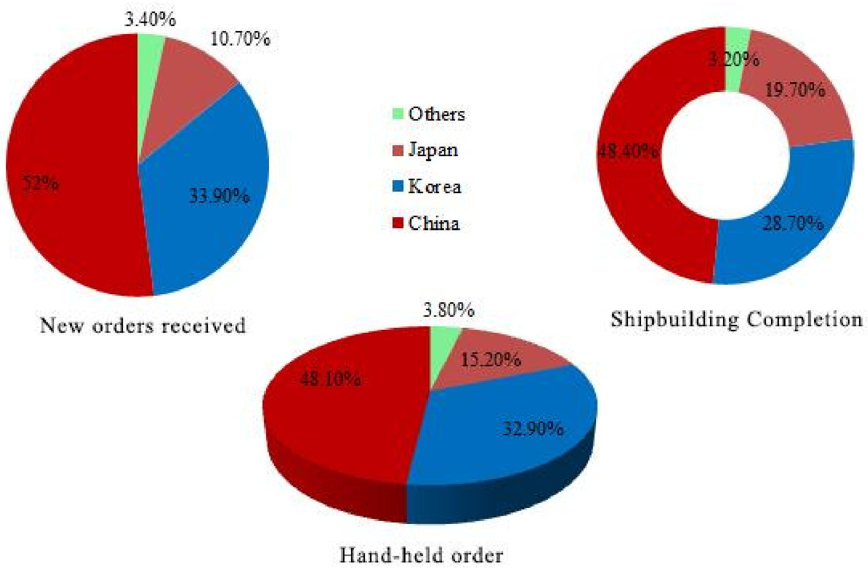

Figure 6: The main proportion of the three major indicators of the world's major

shipbuilding countries in 2021

Source: ZHANG, H. (2022 January 22). *Analysis of the status quo of the development of the global shipbuilding industry, which is in the rising period of the industry*. Retrieved April 20, 2022 from the World Wide Web:

http://www.huaon.com/channel/trend/779372.html

4.1.3 CO_2 emissions from the China's international shipping

The CO_2 emissions from China's international shipping show a trend of overall growth. From 1999 to 2018, CO_2 emissions increased from 25 million tons to 171 million tons, with an average annual growth rate of 10.53% (See Figure 7). Specifically, it can be divided into the following three stages:

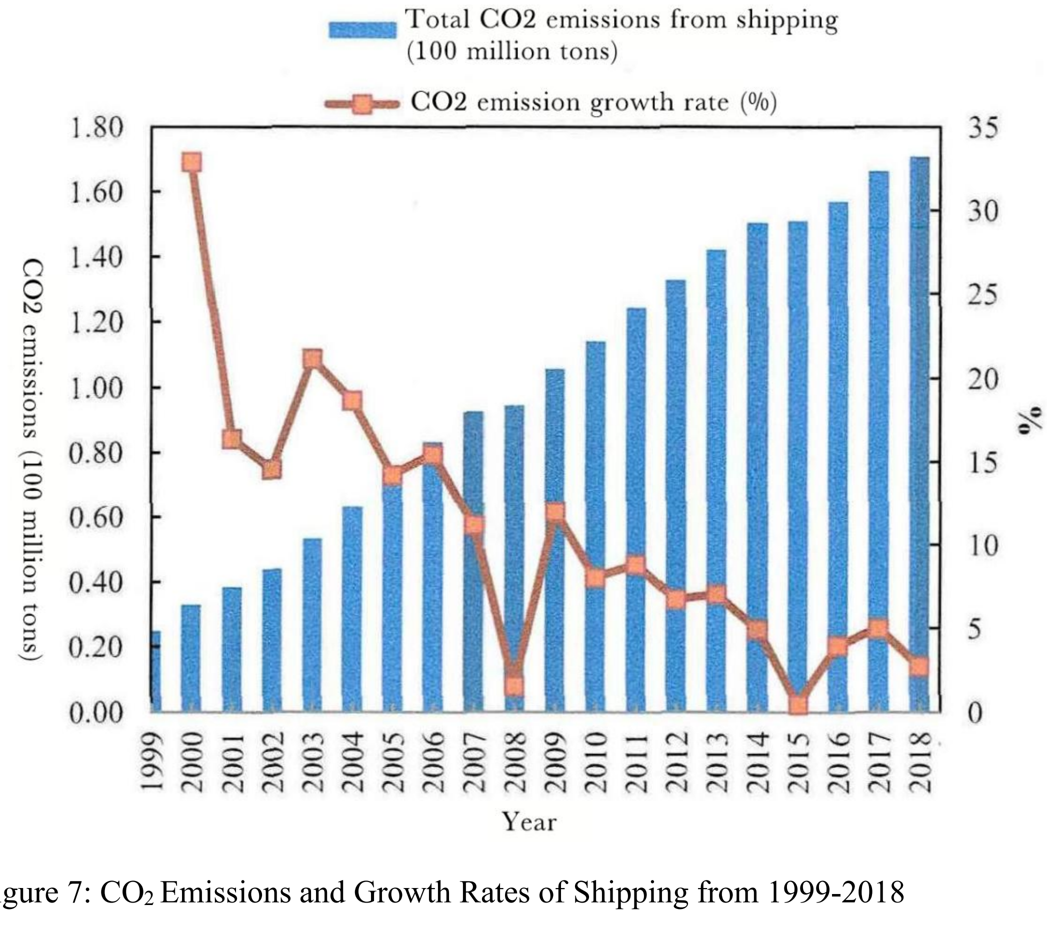

Figure 7: CO_2 Emissions and Growth Rates of Shipping from 1999-2018

Source: MA, X. (2020, June). *Study on driving factors and mitigation policies of CO_2 emissions from China's international seaborne freight transport*. Unpublished master's thesis, Dalian Maritime University, Dalian, China.

(1) Stage I: From 1999 to 2007

The CO_2 emissions from China's international shipping increased rapidly, from 25 million tons to 93 million tons, with an average annual growth rate of over 10% (MA, 2020). This is mainly due to China's entry into the WTO after entering the 21st century, which has accelerated the pace of China's economic globalization. The vigorous development of China's international trade has led to the growth of the emerging international maritime freight volume, and the CO_2 emissions generated by international shipping vessels have a tendency to grow .

(2) Stage II: From 2007 to 2014

Affected by international economic changes, the growth rate of CO_2 emissions in each year in this stage continued to fluctuate. The global financial crisis in 2007-2008 caused the shipping industry to fall into a downturn along with the economy. Therefore, the growth rate of China's international shipping CO_2 emissions dropped sharply from 11.18% in the previous stage to 1.53%. After 2009, the global economy began to recover, with an average annual growth rate of 6.1% between 2009 and 2014 (MA, 2020). Among them, the rise of the real estate industry from 2010 to 2013 has increased the demand for dry bulk and containerized cargoes such as iron ore and coal, which is also one of the reasons for the continuous increase in CO_2 emissions.

(3) Stage III: From 2014 to 2018

The CO2 emissions from China's international shipping grew slowly during this stage. On the one hand, the reason is that China imposed tariffs on imported coal at the end of 2014. Since 2015, the demand in the steel industry has decreased, so the transportation volume of dry bulk cargoes such as iron ore and coal has declined (MA, 2020). On the other hand, the international community has begun to pay more and more attention to the issue of carbon emissions from shipping. IMO released the third GHG emission research report in 2014, passed the IMO-DCS in 2016, and determined the preliminary strategy for shipping GHG emission reduction in 2018. The international promotion of carbon emission reduction in the shipping industry has also led to the setting of emission reduction rules for the shipping industry in China. In 2012, China issued the "Limits and Verification Methods for Fuel Consumption of Operating Vessels" and "Limits and Verification Methods for CO_2 Emissions of Operating Vessels". In the same year, China Classification Society also issued the "Green Ship Specifications", requiring ships to reduce energy consumption and reduce emissions. Drawing on the policy of "Emission Control Areas" (ECA) in the MARPOL 73/78, China began to establish ECAs in coastal waters in accordance with the Air Pollution Prevention and Control Law in 2015. In the same year, Shanghai included the shipping industry into the system of the Shanghai carbon trading market. In 2018, China MSA issued measures for data Collection and Administration of ship Energy consumption, requiring ships entering and leaving Chinese ports of 400t or more or the main propulsion plant 750kW and above to collect ship fuel consumption, voyage time, mileage, cargo turnover and other data according to prescribed methods and procedures, laying the foundation for building a carbon emission MRV system on China's ships.

Since 2019, COVID-19 has spread globally, and the world economy has been severely hit. A recent report by Simpson Spence & Young pointed out that the global seaborne trade volume in 2020 will drop by about 4% compared with 2019, and the carbon emissions of the global shipping industry have also reached a low point, but with the economic recovery in 2021, the carbon emissions of the shipping industry emissions rebounded sharply and even exceeded the 2019 level, reaching 833 million tons, a year-on-year increase of 49% (Simpson Spence Young, 2022).

4.2 The economic impact of EU-ETS on the Chinese shipping sector

4.2.1 Calculation of China-EU trade data

Apart from the US, China and the EU are the two largest economies in the world. China and the EU have a long-standing trade and economic relationship of significant amounts. The trade volume between China and the EU has been on a 10-year growth trend and in 2020 China replaces the US as the EU's largest trading partner with an overall share of 16.1% (Damen, 2021). According to Eurostat, the EU's largest import trading partner in 2020 is China, accounting for 22% of the EU's total imports; at the same time the EU exports 10% of its total exports to China, making China EU's third largest trade exporter (See Figure 8).

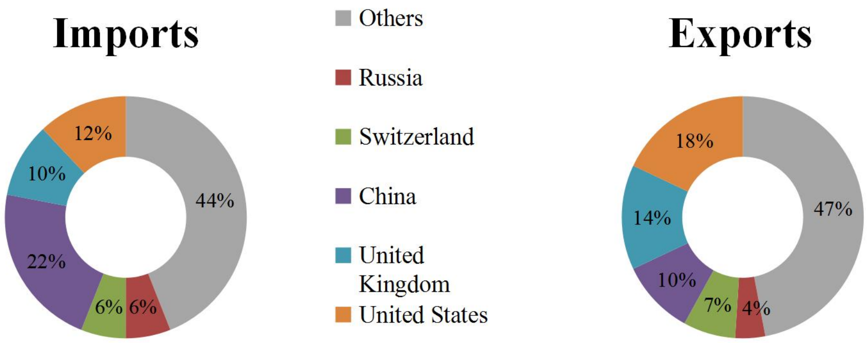

Figure 8:Trade in goods by top 5 partners, European Union, 2020

Source: European Union. (2021). *Trade in goods by top 5 partners, European Union*, 2020. Retrieved April 21, 2022 from the World Wide Web: https://ec.europa.eu/eurostat/cache/infographs/trade/trade_2020/

The geographical location of China and Europe determines that 90% of the freight volume in the trade between China and Europe is carried out by international shipping. In 2020, the value of seaborne goods in the total trade in goods between China and Europe was 343.8 billion euros, accounting for 58.5% (GONG, 2021, p. 52-54). At present, there are three main shipping routes between China and Europe: China-Suez Canal-Europe, China-Cape of Good Hope-Europe, China-Panama Canal-Europe. The Suez Canal route is the largest freight route between China and Europe, and is also the main route of "Belt and Road", with the shortest transport time and distance among the three routes, taking only 35 days and a total of about 10,762 nautical miles. The main seaports in China are Shanghai, Tianjin, Guangzhou, Ningbo, Dalian, Shenzhen, etc., while in Europe the main ones are Rotterdam, Hamburg, Amsterdam, etc. (DAI, 2020).

So how much will joining the EU-ETS affect the most basic costs of ocean-going vessels? The most important types of ships travelling to and from China and Europe are container ships and bulk carriers. Assuming a container ship carrying 10,000 containers sails from the port of Shanghai to the port of Rotterdam, the voyage will be approximately 10,500 nautical miles each way, which consumes 3,220 tons of conventional fuel oil, emits 10,027 tons of CO_2 and takes approximately 26 days, with less than 14% of the voyage taking place within the territorial waters of EU member states (World Shipping Council, 2020). The annual average price for the American InterContinental Exchange (ICE) EUA benchmark futures as of December 14, 2021 was EUR 52 per ton. The carbon emissions included in EU-ETS equal the sum of 50% of the EU internal sailing segment, EU external sailing segment (from non-EU ports to EU ports or from EU ports to non-EU ports) and CO_2 emissions during calls at EU ports(European Commission, 2021). At the same time, according to the legislative package, in addition to the transition period of the first three years, from 2026, the full amount of emissions must be purchased (European Commission, 2021). Assuming that the carbon emissions of the ship at berthing are not accounted for, the added cost of the ship sailing to and from Shanghai and Rotterdam is approximately:

$$\begin{aligned}&\mathrm{CO_2}\ \text{emissions of ships in the intra} - \text{EU voyage}\\&= 10027 \times 0.14 \times 2 = 2807.56\mathrm{t}\end{aligned}$$

$$\begin{aligned}&\mathrm{CO_2}\text{emissions of ships in the outer} - \text{EU voyages}\\&= 10027 \times 0.86 \times 50\% \times 2 = 8623.22\mathrm{t}\end{aligned}$$

$$\text{Increase in costs} = (2807.56 + 8623.22) \times 52 = \text{€}\ 594{,}400.56$$

$$\text{Increase in cost per container} = 594400.56 \div 10000 = \text{€}59.44$$

It can be seen from the above that without calculating the carbon emissions of the port of call and other influencing factors, the cost of a single container ship traveling between Shanghai and Rotterdam will be close to 600,000 Euros. Christodoulou et al. (2021) analyzed the economic impact on different types of ships by using an economic impact assessment model to evaluate the inclusion of shipping in the EU-ETS and concluded that container ships had the largest cost increase, while tankers and bulk carriers had the third and fourth largest increases respectively (See Figure 9).

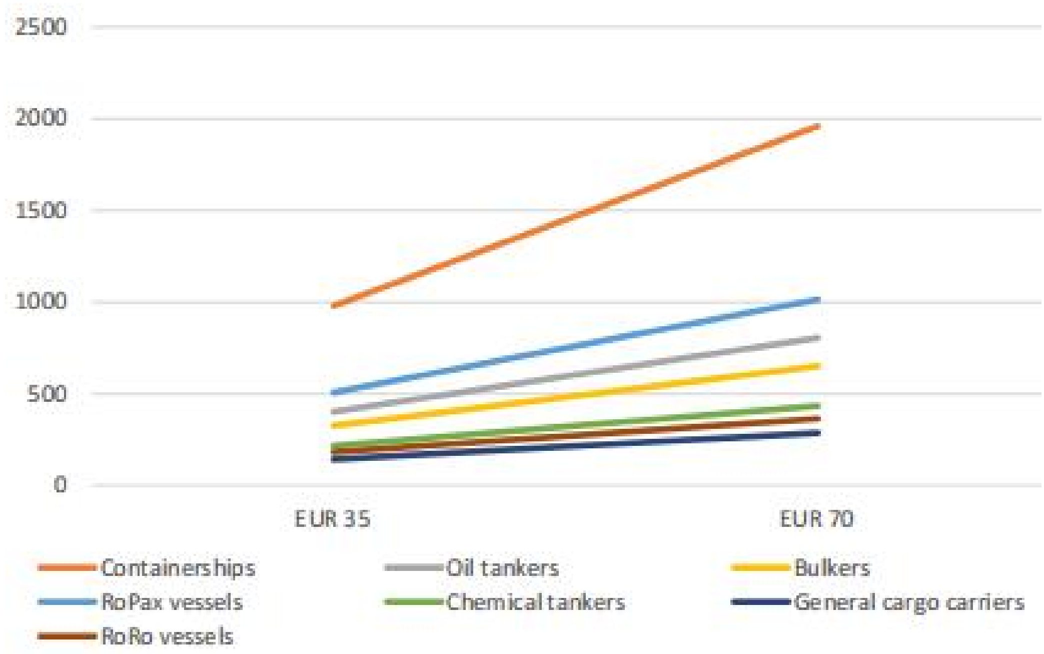

Figure 9: Cost increase per maritime segment assuming the inclusion of all internal EU voyages and 50% of incoming and outgoing voyages from to an EU port, expressed in MEUR

Source: Christodoulou, A et al. (2021). Inclusion of Shipping in the EU-ETS: Assessing the Direct Costs for the Maritime Sector Using the MRV Data. *Energies*, 14(13).

At present, COSCO Container Lines (COSCON) and China Shipping Container Lines (CSCL) are both involved in more than 10 Asia-Europe routes, with more than 100 container vessels of over 5,000 tons on board. It takes about 60 days for these ships to travel between China and Europe, and assuming that each ship makes 6 round trips per year, once the EU-ETS is applied to international shipping, COSCON and CSCL will theoretically be forced to bear the cost of more than 1 billion euros in carbon emissions each year, according to the above assumption. As the huge economic and trade relations between China and Europe continue to increase, the Chinese shipping sector may invest more capacity, which also means more pressures on costs. On the one hand, compared with the trade between the United States and the EU, the sailing distance between China and Europe is longer, and according to the calculation formula, the farther the voyage, the higher the cost. Chinese shipping companies will bear a higher cost burden than North America, South America or other European non-member countries. On the other hand, although China has a large-scale traditional shipbuilding industry, its main production equipment, core parts and technologies of ships still mainly rely on imports from developed countries, and there is still a big gap compared with Western countries such as Europe and the United States. Similarly, China is still in its infancy in terms of ship carbon reduction technology and clean energy utilization, and it is difficult to meet high-standard emission reduction requirements, and most shipping companies are small and medium-sized enterprises, which are difficult to update ships or use clean energy (HOU, 2019). Therefore, the inclusion of the shipping industry in EU-ETS will make Chinese shipping sector face severe tests and enormous pressure.

In terms of transported goods, whether it is EU exports to China or Chinese exports to the EU, the main types of goods need to be realized by sea. However, as the world's factory, the goods that China sends to the EU are mostly labor-intensive products, which are highly elastic in demand and very cost-sensitive. When shipping companies need to reduce their carbon emissions, whether by spending extra costs to buy carbon credits or developing low-carbon technologies, these additional costs will eventually be transferred to the goods, causing Chinese exports to lose their original price advantage and become less competitive, and lower sales will in turn lead to lower freight volumes, which will ultimately affect the business of shipping companies as well.

In summary, if the EU is allowed to incorporate the international shipping industry into the EU-ETS, China's shipping economy will face a huge impact, even on the trade between China and Europe, which concerns China's direct interests. Therefore, China must prepare a corresponding plan to deal with it.

4.2.2 China's response to EU-ETS

The first is to resolve the issue through diplomatic channels. China will not be the only country whose national interests may suffer as a result of the EU's unilateral expansion of jurisdiction, and there are already voices in the international community opposing the inclusion of international shipping in the EU-ETS. In 2011, 26 countries including China, the US and India, issued the Delhi Declaration in order to oppose the inclusion of the aviation industry in the EU-ETS, in order to put pressure on the EU, which also eventually achieved the goal of making the EU suspend the implementation of the aviation carbon emissions trading mechanism (European Community Shippowners' Associations & International Chamber of Shipping, 2020). Therefore, after China has clearly stated its opposition to the international community, on the one hand, it can seek countries and regions with the same demands in the world to boycott the EU's unilateral jurisdiction over carbon emissions from international shipping. On the other hand, China can negotiate with the EU and other diplomatic channels to reduce the impact of EU Shipping ETS on Chinese shipping sector and China's economy, and try to achieve a mutually beneficial and win-win situation in China-EU trade. China can support its demands on two main points: First, the UNFCCC is the basic framework for addressing global climate change, and the CBDR principle is the core principle, so the EU should face up to the gap between developing and developed countries and follow the CBDR principle. Second, the Agreement on Maritime Transportation between the Government of the People's Republic of China and the European Community and its Member States, which entered into force in 2008, stipulates that in the field of shipping services, each party undertakes to accord the other party treatment no less favorable than that enjoyed by its own ships, and at the same time undertakes not to take any administrative, technical or legislative measures that may discriminate against the ships of the other party. In the event of a dispute arising between the parties concerning the application of the agreement, it is to be resolved through diplomatic channels (HOU, 2019).

The second is to deal with it through litigation. As mentioned in 3.2.2, if the EU starts to implement the EU Shipping ETS, it may conflict with various existing laws and regulations, including UNCLOS 1982, WTO trade rules and the UNFCCC. UNCLOS 1982 and the WTO has clear dispute settlement mechanisms, while UNFCCC mentions dispute settlement in Article 14, but do not provide clear procedural norms. Also at the time of the EU's inclusion of the aviation industry in the EU-ETS, the American Airlines Association and other US airlines brought a lawsuit against the EU on the legality of the measure. Although the case was ultimately lost by the European Court of Justice, it will be of high reference and value to China if it chooses to go down the litigation route.

Third, seek immunity by establishing a domestic system. When the aviation industry was included in the EU-ETS in 2008, the EU proposed the concept of equivalent measures, that is, if the third country's carbon emission reduction measures for the aviation industry are consistent with the EU in terms of effect, then a bilateral agreement could be made to exempt flights from EU member states' airports to and from third countries (HU, 2015). This is mainly to avoid double taxation, and the same problem exists in the shipping sector. The construction of China's carbon market started late, with seven provinces and cities - Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen - launching the construction of a carbon trading pilot in 2011 (QIN & HOU, 2021, p. 77-81). Since 2015, the Shanghai carbon emissions trading system has been the first in the world to include the shipping industry in the carbon trading system after completing preliminary research and consulting relevant departments and enterprises (MA, 2021, p. 707-710). On 5 January 2021, China's Ministry of Ecology and Environment officially released the "Measures for the Administration of Carbon Emissions Trading (for Trial Implementation)" to regulate and manage carbon emissions trading and related activities nationwide, and the Chinese carbon trading market officially started trading from 16 July 2021. China can cooperate with the EU to carry out in-depth cooperation and exchanges in the areas of operation and maintenance management, technology development and mechanism setting for the carbon emissions trading market, consider including shipping in the Chinese ETS and seek exemptions in the EU Shipping ETS.

4.3 The impact of Global ETS on the Chinese shipping sector

When the IMO discussed MBMs for shipping in 2010, four countries - the UK, Germany, France and Norway - submitted a proposal for a global shipping ETS on cap-and-trade that would require ships to obtain emission allowances for their GHG emissions. After 2013, the IMO shelved all discussions on international shipping MBMs and instead focused on the development of rules on energy consumption by ships. However, with the recent decision by the EU to unilaterally include the international shipping industry in the EU-ETS, there has been widespread international opposition, in addition to urging IMO to introduce shipping MBMs at the international level as soon as possible. According to the discussions on international shipping MBMs in recent years, the carbon tax and the ETS are at the centere of comparisons and discussions and are considered to be the most likely shipping MBMs to be introduced at the international level. Stimulated by the unilateral action of the EU and the pressure of international calls, the possibility of IMO introducing global ETS in the future is greatly increased, but the details of the system setup of the possible global ETS remain unknown, so this paper will analyze the possible impact of global ETS on the Chinese shipping sector through a SWOT analysis model by making assumptions on the empirical background of the existing carbon trading market.

4.3.1 Concepts and steps of SWOT analysis model

SWOT analysis (See Table 4), also known as situational analysis, is a method of synthesizing and outlining all aspects of the internal and external conditions of the subject of study, arranging them in a matrix format and then systematically analyzing the strengths and weaknesses, opportunities and threats faced by the organization. The theory was formally introduced by Kenneth R. Andrews and developed by Heinz Weihrich, and is an important analytical and managerial approach in management (XU, 2022, p. 95-97). (S) are strengths, (W) are weaknesses, (O) are opportunities, and (T) are threats. Through the combination and matching of these specific factors, we can grasp the trends and possible decisions faced by the subject of the study as a whole. The main steps include:

The first is to investigate the internal and external environment of the subject of the study through research. The external environment consists of opportunities and threats, which are external and objective factors. Internal factors are also subjective and include the strengths and weaknesses that the subject of the study currently possesses.

The second is to construct a matrix model. The factors investigated in the first step were ranked in order of importance, relevance, and priority of direct importance and relevance, and were filled into the corresponding positions in the SWOT matrix.

The third formulates future development strategies and response strategies based on the four angles of formation SO, ST, WO and WT.

Table 4: SWOT Model Matrix

		Internal factors	
		S(Strengths)	W(Weaknesses)
External environment	O (Opportunities)	SO(Advantages that can be used)	WO(Opportunities, seizing them through improvement)
	T(Threats)	ST(Disadvantage, to monitor)	WT(Challenge, defense and reduction)

Source: Adapted from XU, Y. (2022). The Application of SWOT Analysis in Strategic Management of State-owned Enterprises. *China Market*(10), 95-97.

4.3.2 Integrating the Chinese shipping sector into SWOT analysis

Using the SWOT analysis model, a systematic analysis of the external environment and internal factors that the Chinese shipping sector may face in the context of global shipping ETS can help to collate the strengths and weaknesses, opportunities and challenges that the Chinese shipping sector possesses. By considering the matching combinations of these factors, it is possible to provide some action strategies for the Chinese shipping sector as a whole.

(1) Internal factors

First, advantages. Energy consumption is an important factor affecting carbon emissions. One of the key objectives of establishing the ETS is to incentivize shipping companies to innovate green energy technologies, improve energy utilization and the proportion of new energy used, thereby achieving a reduction in maritime carbon emissions. Therefore, if the energy consumption of shipping enterprises decreases faster, they will be able to afford a lower free allowance factor or sell more carbon allowances in the market, thus reducing their own carbon purchase costs or gaining revenue. By collating statistical bulletins on the development of the transport industry over the ten-year period from 2011 to 2021, it can be found that the overall actual energy consumption of Chinese ocean-going enterprises has declined at an average annual rate of about 6% (See Table 5).

Table 5: Unit turnover energy consumption of China International Shipping

Year	kg of standard coal per 1,000 tone nautical mile
2011	7.01
2012	6.20
2013	5.90
2014	5.10
2015	5.20
2016	5.00
2017	4.40

2018	4.10
2019	4.80
2020	No data
2021	No data

Source: Ministry of Transport of the People's Republic of China. (2021). 2011—2021 Statistical Bulletin of the Development of the Transportation Industry. Retrieved April 21, 2022 from the World Wide Web: https://www.mot.gov.cn/

China's explicit requirement in the 13th Five-Year Plan for the value of energy consumption reduction for ships is 1.4%. In addition IMO's current short-term measures call for an average annual efficiency improvement of 2% for the global fleet between 2020 and 2030. Therefore the current overall energy consumption reduction level of China's international shipping industry has a certain advantage when analyzed from previous years' data. In the future, it may be able to assume a lower carbon quota factor in the ETS system. At the same time, international shipping also remains the most dominant mode of transport for world trade, and as mentioned in 4.1.1, China has by far the largest fleet of bulk carriers and container ships, with a third of the global total for seaborne import and export trade, and this share is still on the rise. A study by ZHU (2019) concluded that the effect of carbon emissions from the inclusion of international shipping in the ETS is influenced by a number of variables such as technological management energy efficiency advances, carbon allowance prices, and freight growth, with growth in freight volumes benefiting shipping companies' emissions reductions (ZHU, 2019).

Second, weaknesses. The technical capability and environmental performance of ship supporting equipment largely affects the "green" level of the entire shipbuilding industry, but the Chinese shipping sector suffers from a lack of innovative technology and core technology in shipbuilding. As mentioned in 4.1.2, China is one of the largest shipbuilding countries in the world, and the three main indicators of the shipbuilding industry are among the leading ones in the international arena. However, it cannot be ignored that, on the one hand, China's shipbuilding industry lacks core technology, and still relies on imports from developed countries such as Europe and the US for some key ship components, especially core technology for core green ship equipment, such as dual-fuel engines, film enclosure systems, etc. On the other hand, in the field of green and intelligent ship construction, although the research on some new energy and new fuel technologies in Chinese shipping sector is at an advanced level in the world, the current development can only meet the relevant green and environmental protection requirements of IMO at the current stage, and there is still a certain gap between the EU, Japan and South Korea in the research of forward-looking technologies to cope with higher green and environmental protection requirements in the future (ZHENG, LIU, & LIN, 2020, p. 94-102). ZHU conducted a sensitivity analysis through the sensitivity coefficient and found that, in the ETS mechanism, technological progress made the greatest contribution to carbon emission reduction (ZHU, 2019). If global shipping ETS is established, in order to maintain market competitiveness, Chinese shipping sector must work hard to reduce the cost of carbon emissions, and the research and development of innovative carbon emission reduction technologies is a defect that Chinese shipping sector currently has to overcome.

(2) External environment

The external environment can be analyzed from different angles, the more common ones are PEST analysis and Porter five forces analysis. This paper will use the PEST analysis method to analyze the external environment that Chinese shipping sector may face in the context of global shipping ETS. The specific content of the analysis when using the PEST analysis method will be different, but it mainly corresponds to four aspects: P (Political), E (Economic), S (Social), and T (Technological).

First, political environment. Within China, the green development of the shipping industry is an important part of the country's overall energy saving and emission reduction. In terms of carbon trading market construction, China has been piloting carbon trading since 2013 and officially launched the national carbon emissions trading market on 16 July 2021 (4.8). In terms of bridging international policies, as can be seen from the discussion of the relevant content in 2.2.1 and 4.1.3 of this paper, since IMO entered the stage of mandatory regulation of emission reduction systems, the Chinese government and relevant accredited organizations have also been cooperating with the emission reduction strategies of international organizations to develop Chinese policies on emission reduction in the shipping industry. The latest 14th Five-Year Plan of China's maritime system also mentions the need to actively participate in the global governance of emissions reduction in the shipping industry and to enhance the institutional discourse of China's shipping emissions reduction. Therefore, this paper argues that if IMO constructs a global scale ETS from the international level, the Chinese government will actively participate in the framework construction and system management based on Shanghai's experience in integrating shipping into the carbon trading market, and give corresponding guidance and regulation to the Chinese shipping sector in terms of policy, which is an opportunity for the Chinese shipping sector.

At an international level, to establish a carbon trading market, it is necessary to determine a carbon allocation method. There are currently three main methods for carbon allocation: the grandfathering method, the historical intensity method and the baseline method, each of which has its advantages and disadvantages. The grandfathering method was used in the first and second phases of the EU-ETS, while in the third phase it was mainly used in the aviation sector. The carbon emission allocation method implemented for the shipping industry in the Shanghai 2017 Carbon Emission Allowance Allocation Scheme is also a grandfathering method. Allowances have been allocates to enterprises based on the average of their total emissions over the past three years. The advantages are that it is simple in terms of data requirements, easy to operate, and suitable for enterprises with many product types and large changes in production categories from year to year (MA, 2021, p. 707-710). The disadvantages are that it tends to produce an unfair punishment and the allocation process does not take into account emission efficiency, which is not conducive to generating incentives to reduce emissions in industries with rapid business and revenue growth (MA, 2021, p. 707-710). If IMO also adopts the grandfathering method of allocation, then it may be the case that larger shipping companies have limited scope for later emission reductions due to their financial and technological advantages to improve quickly, and smaller shipping companies have high emission reduction potential due to slow capital and technological updates. This means that shipping companies' baseline for emission reduction is not the industry average baseline but their own historical baseline, so that companies that actively reduce emissions in the early stages may face repeated emission reductions, and companies that reduce emissions in the later stages may escape the initial investment in emission reduction (ZHU, 2019). The determination of carbon allocation method is a huge challenge that has not yet been solved, so the issue of fairness is a potential threat to Chinese shipping sector (WU et al., 2022).

Second, Economic and Social environment. As shown by Wang et al (2015), in the context of ETS, carbon prices are positively correlated with ship emission reduction levels (WANG, FU, & LUO, 2015, p. 35-49). However, carbon prices under the ETS are highly volatile, and if emissions under the ETS scheme are too high, the carbon price will rise, causing greater market distortions (GAUDIN, 2019). For example, when the price of carbon rises sharply, the cost of carbon emissions to the shipping industry rises, and these costs are passed on to the cargo, which will cause freight rates to rise, thus causing market demand to fall, shipping companies to suffer a severe loss of profits, and investment in research and development of emission reduction technologies will decrease, and the carbon reduction of the shipping industry will be affected, which in turn will continue to keep the price of carbon high, which is a market distortion. And if the carbon emission balance is too low, the price of carbon will also be zero, which happened in the first and second stages of the EU-ETS. The volatility of carbon prices creates unpredictability for investors, who have to consider not only current fuel, production, etc., but also future development expectations when making decisions (Kachi, Mooldijk, & Warnecke, 2019). For example, the carbon price of EU-ETS will soar by 118% in 2021, which will be affected by many predictable and unpredictable factors such as US sanctions on Russia, the UK carbon market leaving the EU, and economic recovery after the epidemic. Therefore, against the current social backdrop of the global geopolitical crisis and the spread of the COVID-19 epidemic, the instability of the global trade supply chain and the price instability of the bunker market will cause volatility in the price of carbon, which will be a potential threat to the Chinese shipping sector (United Nations, 2021).

Third, Technological environment. In terms of the technology environment, there are both opportunities and threats. Shipping is a capital-intensive industry, and the development of decarburization technologies cannot be achieved without financial support. The World Bank report The Potential of Developing Countries to Produce Zero Carbon Ship Fuels predicts that the widespread use of zero carbon fuels will generate financing needs of over US$1 trillion for the ship fuel market (YANG, 2021). Twenty-six major shipping finance banks, including Citi, Societe Generale and Standard Figureered, have signed the Poseidon Code, which aims to promote carbon reduction in international shipping by favoring financing for energy-efficient and environmentally friendly ships (YANG, 2021). This is an opportunity for the shipping industry, especially for developing countries, to develop carbon reduction technologies. A friendlier technological environment will help the Chinese shipping sector to better meet the carbon reduction requirements in the ETS and reduce the cost of purchasing carbon. However, in terms of research and development, China currently lacks an incentive sharing mechanism between research units and enterprises, and the "scattering of troops" has led to small-scale research forces and weak integrated innovation capabilities (ZHENG, LIU, & LIN, 2020, p. 94-102). At the same time, the phenomenon of repetitive low-quality investment and construction by various ship enterprises and relevant research institutions has seriously restricted the efficient and intensive development of green ship technology (ZHENG, LIU, & LIN, 2020, p. 94-102).

(3) SWOT analysis

Table 6 lists the factors influencing the internal and external environment of China's international shipping industry under the global ETS, so that the opportunities and challenges that China's international shipping industry may face in the global ETS can be shown as a whole. This paper will analyze the four aspects of the table in an integrated manner, rather than simply combining them in a two-by-two approach to strategy formulation.

Table 6: SWOT analysis of the Chinese shipping sector

	Strengths	**Weaknesses**
Internal factors	1. Energy consumption in the shipping industry declines at a faster rate. 2. The freight volume accounts for a high proportion of the international total.	1. Lack of core technology for key ship parts. 2. The development of green and low-carbon technologies for ships lacks foresight.
	Opportunities	Threats
External environment	1. National policy support for emission reduction. 2. The financial industry provides financing tilt for the development of green shipping. 3. The Shanghai carbon trading market includes the shipping industry, and both the government and enterprises have relevant experience.	1. The unfairness of carbon allocation methods. 2. Carbon prices are volatile. 3. The scientific research force is scattered and the scale is small.

Source: Author made

Overall, the Chinese international shipping industry will probably face more challenges and risks under global ETS. The reasons are as follows:

Firstly, one of the current strengths of Chinese shipping sector is that energy consumption is declining at a faster rate as seen from past data. However, the rate of reduction in energy consumption will depend more on the application of new energy sources and the development and use of low-carbon technologies in the future. The lack of co-ordinated research and development of green ships, the short-sightedness of the low-carbon concept and the lack of core and innovative technologies may make the advantages possessed by the Chinese shipping sector cease to exist in the future, or even turned into disadvantages.

Secondly, China is a world leader in the volume of international shipping, largely due to its complete industrial system and supply chain, which gives Chinese commodities a competitive price advantage in the world. Under the global ETS, the cost of carbon to the shipowners will be passed on to the commodity itself in proportion to the cost of carbon purchased, which in turn is influenced by the price of carbon, so the unstable price of carbon and the compounding social factors that cause it will likely change the competitiveness of Chinese commodities and therefore affect the business of the international shipping industry.

Thirdly, China's national carbon trading market has only been in operation for less than a year and is not yet mature, and the shipping industry is only trading on a pilot basis in the Shanghai carbon trading market, which is relatively small and offers limited experience for reference. On the other hand, China believes that both the market mechanism and the IMO's right to deal with GHGs originate from the Kyoto Protocol and should comply with the CBDR principle, but the IMO's current work on MBMs does not reflect this principle and therefore has not submitted any MBM proposals to the IMO (ZHU, 2019). How China, as the largest developing country, balances the CBDR principle with the global ETS will likely affect whether the shipping industry in other developing countries, including China, will be subject to fairer and healthier market competition.

4.4 Advice for dealing with global ETS

4.4.1 National level

Firstly, China can strengthen government leadership, formulate development plans and promote resource integration. The green transformation of the shipbuilding industry is inseparable from the overall supervision, intervention and incentives of government departments, such as tax and fee concessions, special subsidies and other incentives can effectively mobilize and stimulate research institutions and shipowners to participate in low-carbon technology research and development, alternative fuel application, new energy ship construction and other activities. It is also important to benchmark domestic and international ambitions for carbon reduction and to formulate a systematic and operational green ship development plan at the national level as soon as possible (ZHU, 2019). The plan should guide domestic shipping enterprises and research institutions to cooperate, bring into play China's tradition of "concentrating efforts on major issues", integrate resources to focus on key difficulties, avoid repetitive and low-quality investments, and make break-throughs core technology of ship emissions reduction as soon as possible.

Secondly, the improvement of the technological level of the shipbuilding industry should be accelerated. Made in China 2025 points out that the world shipbuilding industry will remain a competitive pattern between China, South Korea and Japan for a period of time in the future, but the rate of localized ship loading of Chinese marine equipment is much lower than that of South Korea and Japan, and the problems of unbalanced, uncoordinated and unsustainable industrial development are prominent (MA, 2021, p. 707-710 ; QIN & HOU, 2021, p.77-81). To improve the international competitiveness of the shipbuilding industry, it is necessary to comprehensively promote structural transformation and upgrading, break the Western blockade on core technologies and equipment, and transform from a big shipbuilding country to a powerful shipbuilding country. In this process, both independent innovation and open communication are needed. As an international industry, the shipbuilding industry can focus on the construction of the "Maritime Silk Road", through the establishment of international joint development projects, scientific research cooperation special projects, personnel exchange and training programmes, etc., to learn from and absorb advanced experience, the introduction of the recruitment of outstanding high-tech talent.

Thirdly, China can improve the collection of energy consumption data in Chinese shipping sector and actively participate in international policy formulation. China's Administrative Measures for the Collection of Energy Consumption of Ships was promulgated in 2018 and formally implemented from 1 January 2019, almost one year later than IMO's DCS and almost four years later than EU's MRV. Ship energy consumption related data is an essential support for making scientific decisions when establishing shipping ETS. China is a late starter in this regard, and in order not to be in a passive position when IMO sets the industry's baseline in the future, it must complete the collection of data on energy consumption in Chinese shipping sector as soon as possible and establish a corresponding database. On the other hand, it is important to accelerate the development of a unified carbon trading market in China, so that China can accumulate more practical experience on carbon trading systems through the setting of detailed systems such as carbon prices, allocation methods and total volume setting. For example, the expected emissions per unit of cargo are set according to different vessel types, from which the amount of free allowances required for transport is calculated. This Cargo-based Allocation Rule is more in line with the actual needs of international shipping than the grandfathering method (YAN, 2020). At the same time there is active cooperation and communication with other countries. For example, Norway's proposal for an ETS proposes the inclusion of CBDR principles, although the proposal has been questioned as a risk of carbon leakage, but effective communication is always the basis for solving problems. This will enable China to submit innovative proposals that can break the current international deadlock and have more say in the future when the IMO formulates the global ETS.

4.4.1 Shipping company level

First, shipping companies should actively participate in pilot carbon trading. After the pilot program incorporated shipping into the Shanghai carbon trading system, through practice and exploration, the awareness of energy conservation was strengthened, and by sorting out business statistical calibers and statistical methods, fuel costs were reduced and excess carbon allowances could be profited (MA, 2021, p. 707-710). At the same time, it has also strengthened the understanding of carbon assets and carbon trading. For example, China Shipping Group Investment Co., Ltd., a subsidiary of COSCO SHIPPING, has specially set up a carbon asset department to undertake carbon asset management and consulting services for the group's shipping companies (MA, 2021, p. 707-710). Considering that the EU-ETS is about to be incorporated into the international shipping industry, and whether and how the IMO will set up the global ETS is yet to be determined, the Chinese shipping sector should seize the opportunity of the current Shanghai pilot mechanism, actively participate in it, and familiarize itself with the operation rules of the carbon trading market mechanism while figuring out its own emission reduction level and technical management level (ZHU, 2019). At the same time, shipping companies can also put forward improvement proposals and suggestions for the pilot market while identifying their own strengths and weaknesses, helping China to improve the relevant systems and institutions.

Second, the technical management of enterprises should be improved. On the one hand, shipping companies can develop an efficient SEEMP with Energy Efficiency Operational Indicator (EEOI) as the core, assess the current emission reduction capacity of enterprises and set up subsequent emission reduction plans through the indicators set by IMO. On the other hand, promote digital transformation and renovation to improve enterprise services, reduce costs and improve market competitiveness. Blockchain, Internet of Things and other technologies can effectively reduce the communication costs of enterprises and promote cross-border business synergy. For example, COSCO Shipping has created the Global Shipping Business Network Blockchain Alliance, which applies blockchain technology to provide higher transparency and visibility of information for shipping. Big data and AI decisions will replace empirical decisions, which will improve the market awareness, risk prevention and resource allocation capabilities of enterprises. Online approval and remote control can reduce manpower costs.

Third, shipping companies should optimize the fleet structure and develop emission reduction technology. From 4.1.1, we can know that although the Chinese fleet as a whole is relatively young, ships over fifteen years old still account for 22%, and half of these are ships over 20 years old. The high energy consumption of these vessels is bound to become a factor affecting the overall carbon emission level of shipping enterprises. The timely conversion of medium-old and old vessels, the elimination of old vessels and the construction of new energy vessels will be conducive to the rational optimization of the capacity structure, the reduction of carbon emission costs and the improvement of international market competitiveness.

CHAPTER 5 CONCLUSION

Since the announcement of the initial strategy to reduce GHG emissions, the IMO has introduced the typical technical measure EEDI as a short-term mitigation measure, but it does not seem to be as useful as it was initially expected. The application of MBMs for shipping has also turn up again under the pressure of shipping emission reduction targets, with ETS once again becoming a hot topic of international discussion due to the unilateral actions of the EU.

The EU's attempt to bring the shipping industry into the EU-ETS in order to achieve its own higher emission reduction ambitions has certain rationality. EU-ETS has the potential advantages of perfect institutional framework, flexible trading and promoting the development of new emission reduction technologies. However, this unilateral behavior directly violates the provisions of many international laws, which will lead to a bad impact on the world economy, politics and emission reduction, which also put EU-ETS in an embarrassing situation when it is included in international shipping. The amount of economic and trade cooperation between China and the EU is huge, and international routes are intensive. Based on the basic calculation of China-EU trade, this paper finds that once the shipping industry is included in the EU-ETS, the cost of Chinese shipping companies will be greatly increased, which will ultimately affect the international competitiveness of China's commodities and shipping industry, and affect China-EU trade cooperation. Therefore, this paper proposes that China should actively respond to it in three aspects: diplomacy, litigation, and domestic system establishment.

According to the SWOT model, this paper also analyzes the possible advantages and disadvantages of Chinese shipping sector and the opportunities and risks it may face under the shipping global ETS system. In the end, the analysis finds that he strengths that Chinese shipping sector possesses, such as rapid energy consumption decline and high cargo volumes, may be eroded by weaknesses and external threats such as volatile carbon prices, lack of core ship technology and emission reduction technology, and ultimately face more risks than opportunities under the shipping global ETS. This paper proposes corresponding countermeasures at both the national level and the shipping industry level. At the national level, the government should actively guide the formulation of development plans, integrate resources to improve the level of the shipbuilding industry and promote the development of carbon reduction technologies, and at the same time accelerate the collection of energy consumption data in the shipping industry. At the enterprise level, shipping companies should actively participate in the pilot work of shipping carbon trading in Shanghai in order to adapt to the carbon trading system in advance and find their own emission reduction priorities. Meanwhile, accelerating digital transformation, improving technical management level, optimizing fleet structure, and actively developing emission reduction technologies are also helpful.

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